Transportation Electrification Plan

SEPTEMBER 2019

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Acronyms

Acronym	Agency/Entity/Term	Acronym	Agency/Entity/Term
AC	alternating current	**MF**	multifamily
AMI	advanced meter infrastructure	**NRDC**	National Resources Defense Counsel
BNEF	Bloomberg New Energy Finance	**NREL**	National Renewable Energy Laboratory
CAP	Climate or Sustainability Action Plan	**O&M**	Operations & Maintenance
CFP	Clean Fuels Program	**OAR**	Oregon Administrative Rule
DCQC	Direct Current Quick Charge	**ODOE**	Oregon Department of Energy
DERs	distributed energy resources	**OEM**	original equipment manufacturers
DLC	direct load control	**OPUC/PUC**	Public Utility Commission of Oregon
DOE	U.S. Department of Energy	**ORS**	Oregon Revised Statute
DRP	distribution resource plan	**PAC**	Pacific Power
EEI	Edison Electric Institute	**PGE**	Portland General Electric
EPRI	Electric Power Research Institute	**PHEV**	plug-in hybrid vehicle
EV	electric vehicle	**RMI**	Rocky Mountain Institute
EVSE	electric vehicle supply equipment	**SB**	senate bill
EVSP	electric vehicle service provider	**SEPA**	Smart Electric Power Alliance
GHG	greenhouse gas	**SF**	single-family
HB	Oregon House Bill	**TCO**	Total Cost of Ownership
HDV	heavy-duty vehicle	**TE**	transportation electrification
ICE	Internal combustion engine	**TNC**	transportation network company
IOU	investor-owned utility	**TOU**	time of use rate
IRP	integrated resource plan	**V2G**	vehicle-to-grid
L2	Level 2 electric vehicle charger	**VW**	Volkswagen
LBNR	loading beyond nameplate rating	**WTC**	World Trade Center
LCFS	Low Carbon Fuel Standard	**ZCTA**	Zip Code Tabulation Areas
LDV	light-duty vehicle	**ZEV**	Zero-emission vehicle
MDV	medium-duty vehicle		

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Forward

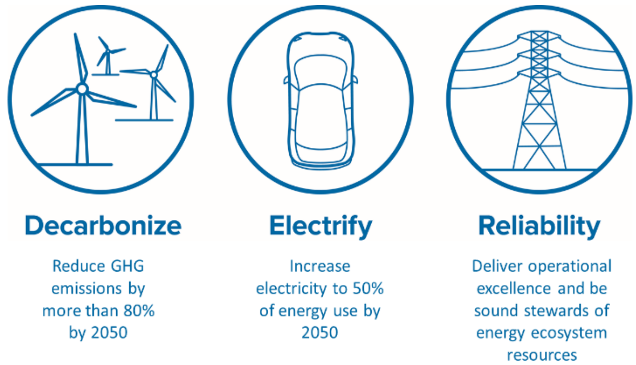
It is imperative that we rapidly reduce greenhouse gas (GHG) emissions from the transportation sector to fight climate change.

In support of state policy goals and concerns for action heard from our customers, Portland General Electric Company (PGE or Company) is working to drive Oregon's transformation into a clean energy economy. PGE is working to decarbonize our own electricity supply and support the transition of the transportation sector from carbon-intensive fossil fuels to a clean energy system. The automotive sector is undergoing a global transformation: auto manufacturers have committed billions of dollars to electrification and our customers are looking for more sustainable ways to move people and goods. In addition, various local and state policies demand fast change to address the climate crisis. It is imperative that we keep pace with our customers' and industries' expectations to deliver a carbon-free transportation sector.

Decarbonizing the transportation sector requires that our customers have access to reliable and affordable charging solutions, however they choose to travel. PGE embraces our role as a key partner in our customers' transition to electricity as a transportation fuel. We will make investments in infrastructure, design customer rates, and launch customer programs that remove customer friction, drive electric vehicle (EV) adoption, and reduce the cost to serve new EV loads. By maximizing benefits and minimizing costs, electric transportation will provide benefits to all our customers. We envision a future where the grid and transportation sectors work together harmoniously to create value for our communities through cleaner air, lower costs, increased renewable penetration, and enhanced reliability.

Electric Transportation is a Climate Imperative

Figure 1 – PGE's Imperatives



In 2018, we made a simple but daunting commitment to lead the transformation to a clean energy future for our customers and our corner of the country. We made that commitment to lead because we believe that combatting climate change, while ensuring universal access to reliable and affordable electricity, is a societal imperative and that it will not happen without leadership, vision, and commitment.[1]

We have an obligation to ensure that the transformation of the electric system does not leave anyone behind. All customers must share in the benefits and opportunities of a clean energy future. This includes access to clean, reliable, and affordable transportation fuel. Whether it is taking the bus to school or the grocery store, driving to work, or shipping products to stores and homes, transportation is a critical part of our economy and everyday lives. Because it represents about 40% of the state's GHG emissions, it is also a fundamental part of addressing climate change. At PGE, we believe affordable and clean electricity will logically become the fuel of choice for most transportation needs. We want to facilitate this transition by creating offerings that ensure all customers have unimpeded access to this fuel choice, which is critical to meeting Oregon's clean energy goals.

PGE is taking steps to fuel a transportation system powered by clean electricity--this Transportation Electrification Plan is an important step towards moving in that direction. To achieve Oregon's clean energy goals rapidly and at scale, PGE and other electric investor-owned utilities (IOUs) require the tools and oversight to make it happen. Working alongside policymakers, business leaders, environmental groups, social justice advocates, and our customers, we can create an ecosystem of carefully crafted policies, programs, pricing, and infrastructure to make this vision a reality. This is consistent with Governor Kate Brown's Executive Order No. 17-21 and Senate Bill (SB) 1044, which both set aggressive targets for EV adoption in the state. Furthermore, without PGE and other electric utilities taking a similar approach, there is little possibility for cities and counties to achieve their renewable energy goals or climate action plans in Oregon. Transportation electrification (TE) is central to our communities' goals of decarbonization.

GHG emissions from the utility sector *are* declining, and in PGE's case, trending below our proportional share of Oregon's GHG reduction goals. However, the same cannot be said of the transportation sector, which is the largest (at nearly 40% of total GHG) and fastest-growing contributor to GHG emissions in Oregon. PGE is enabling a transformation of the transportation sector so that it can meet or beat its GHG reduction goals.

[1] PGE's corporate imperatives provide a foundational framework for how PGE developed this Transportation Electrification Plan. More information about these imperatives and how they align with customer benefits are set forth in three PGE strategy papers, available on PGE's website: https://www.portlandgeneral.com/our-company/energy-strategy/oregons-clean-energy-future

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Transportation Electrification Creates Value for All Customers

Burning gasoline and diesel fuel also have significant impacts on our air and water quality, including generating regional haze, lung-affecting particulate matter, heavy metals in the water supply, and cancer-causing substances. These impacts disproportionally affect underserved communities that are already facing many barriers. Electrified transportation significantly reduces local air pollution caused by vehicles. It also helps the electricity system integrate renewable energy resources, reducing the cost to decarbonize our electricity supply.

Whatever the path to TE, we must ensure that all customers experience clean air and mobility benefits; whether they live in urban, suburban or rural communities. As we create this new path, we must also meet the needs of underserved communities, including people with disabilities, communities of color, and low-income families.

Transportation electrification also creates economic benefits for all customers. We estimate that in 2020, passenger EVs will contribute over $5 million in customer value by increasing revenue in excess of the cost of that energy and capacity. This will in turn put downward pressure on customer prices. We further estimate that passenger EVs can create nearly $1.4 billion in gross benefits for our customers through 2050 and over $450 million in net benefits.[2]

Utility Investment is Critical to Meeting Oregon's Decarbonization Goals

The automotive industry is on the cusp of a major transformation. Vehicle manufacturers are investing hundreds of billions of dollars, policymakers are establishing policies to accelerate the pace of change, and advances in technology are driving down costs - all driving toward an all-electric future that will create significant opportunity for our customers. Moreover, the State of Oregon has established a target of having 250,000 EVs registered by 2025 and 90% of new vehicle sales by 2035.[3]

As the fuel providers in an electric transportation ecosystem, the electric utilities' role in ensuring customers have access to electric fuel will continue to grow and be more integral to our customers' lives. Electric utilities must ensure that our communities are positioned to effectively transition to electric fuel; and do so in a manner that creates value for the electric grid. To do this, electric utilities must develop innovative rates, make planful investments in infrastructure, and deploy customer programs that:

1. Accelerate TE across all sectors (increase customer benefits from electric transportation); and
2. Deploy strategies to ensure efficient grid integration, reduce the cost to serve EVs, and integrate renewables in order to decrease costs to serve electric transportation.

To that end, we will continue to invest in electric transportation and support our customers' transition in the following ways:

[2] As calculated by subtracting energy and capacity costs from new EV revenues. Additional detail on benefits and costs are included in section 3.1.2.

[3] SB 1044 is available at: https://olis.leg.state.or.us/liz/2019R1/Downloads/MeasureDocument/SB1044/Enrolled

Develop rates and tariffs that:

- Empower customers to save money when switching from petrol fuels;
- Reflect equitable distribution of costs among EV and non-EV customers; and
- Permit the recovery of utility infrastructure costs and upgrades.

Update our traditional view of the distribution system to support the investments required to ensure that our customers have access to charging infrastructure (and that our region does not fall behind), including but not limited to ownership and operation of:

- Make-ready infrastructure from the utility meter up to new EV charging equipment;
- Charging infrastructure at transit agencies and schools, which serve the community at large; and
- Public charging to address gaps that impede market growth.

Create programs that maximize grid benefits and minimize costs to serve:

- Deploy smart EV charging programs designed to shift EV loads to off-peak hours and reduce peak demand;
- Market transformation and educational activities that empower our customers to embrace electricity as a transportation fuel;
- Expand access to underserved communities;
- Undertake integrated customer-grid infrastructure planning to minimize deployment costs and enable customer and grid benefits now and in the future (e.g. vehicle to grid (V2G)); and
- Integrate connected charging infrastructure into programs like our Energy Partner Program (demand response for business customers) to provide new value streams for charging hosts and service providers.

In this plan, we outline a roadmap for our future engagement in support of TE.

A Strong Utility Role in Transportation Electrification is Beneficial to All

PGE's unique role ensures that customers have affordable, reliable access to increasingly clean electric fuel. As a vertically-integrated electric utility, PGE creates value for Oregonians every day by demonstrating the following core competencies:

- Physical infrastructure asset management: plan, construct, build, operate, and maintain electrical infrastructure;
- Customer service (billing, pricing, metering, call center operations, customer experience, etc.);
- Supply and energy management;
- Distribution management/operations; and
- Demand and reliability management.

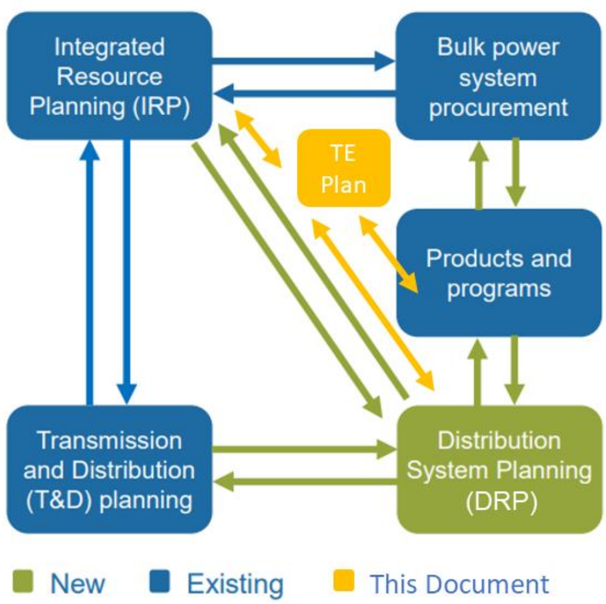
By leveraging our size and economies of scale, we can establish rates, programs, and infrastructure to do our part to accelerate TE and efficiently integrate it into the electrical grid. The skills and value we bring to the EV marketplace will enable our customers to adopt EVs with confidence and that, in turn, will support healthy market opportunity for vehicle and charging manufactures, mobility service providers, and charging service providers.

Ultimately, regulated utilities uphold their public interest obligations; their ability to help drive large-scale, beneficial changes to serve public policy and community interests should be preserved. Absent this, there is no guarantee that any provider in the market will remain to deliver on the core tenets of the electric system's intrinsic social compact: namely, clean, accessible, affordable, reliable, safe electric fuel for all.

About this Document

This is PGE's first TE Plan, produced in compliance with Public Utility Commission of Oregon (OPUC) Order No. 19-134 in OPUC Docket No. AR 609. The TE Plan outlines market trends in electric transportation, provides an update on PGE's TE initiatives, and plots a path for PGE to fulfil its obligation, as established under SB 1547.[4] This Plan complements other planning resources developed by PGE (e.g. the Integrated Resource Plan (IRP) and the Distribution Resource Plan (DRP)). Where the IRP identifies bulk system needs and DRP identifies local system needs, this document identifies customer-specific needs that may inform local and system planning.

Figure 2 – Relationship between PGE planning and operations initiatives



As illustrated above, the TE Plan informs and is informed by the IRP, the DRP, and our programs.

[4] In 2016, the Oregon Legislature adopted SB 1547, supporting electric company investment and participation in the EV marketplace through programs that accelerate TE, expand access to electric vehicles for customers, and ensure efficient grid integration.

These relationships are further detailed below:

- IRP – the TE Plan will inform the IRP regarding future program offerings and provide scenario assistance for load, capacity, and direct load control (DLC) modeling. The IRP informs the TE Plan by establishing load forecast scenarios, DLC targets, and EV forecasts.
- DRP – the TE Plan will inform the DRP where and how customer charging is expected to grow over time. The DRP may inform the TE Plan in the future by identifying local system constraints and thereby informing areas where TE smart charging programs could create distribution system value.
- Products and programs – the TE Plan outlines a roadmap for future TE programs. The Plan is informed by learnings from existing program offerings.

This plan is outlined in 6 sections:

- Section 1 discusses current market conditions, including: state and local policies, market barriers, EV adoption and forecast, charging ecosystem and needs, technology trends, and anticipated distribution system impacts.
- Section 2 outlines PGE's current and future transportation electrification activities related to rates, infrastructure, and programs.
- Section 3 provides supporting data and analysis, including: costs and benefits, rate design, a discussion of relationships with other PGE programs, and customer engagement.
- Section 4 discusses why the utility's role is important to accelerating and enabling EV adoption in Oregon.
- Section 5 discusses system impacts and renewables integration.
- Section 6 summarizes the carbon reduction and air quality benefits we expect from vehicle electrification.

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Section 1 Current Market Conditions

Though the industry still faces challenges, there is substantial opportunity for our customers to benefit from transportation electrification.

Many barriers to EV adoption and challenges to efficient grid integration exist: technologies are still emerging, customers lack familiarity, and current infrastructure is insufficient. However, the market is on the cusp of a major transformation: vehicle manufacturers are investing billions of dollars, policies are accelerating the pace of change, and innovations in technology are driving down costs—culminating in a rapid adoption of EVs in our service area. As vehicle adoption grows and as technologies evolve, we must monitor the change and manage the system impacts.

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to:*
>
> *A. A discussion of existing state policies and programs;*
>
> *B. Market barriers that the electric company can address and other barriers that are beyond the electric company's control, including any identified emerging challenges to transportation electrification;*
>
> *C. Existing data on the availability and usage patterns of charging stations;*
>
> *D. Number of electric vehicles of various sizes in the utility service territory and projected number of vehicles in the next five years;*
>
> *E. Other transportation electrification infrastructure, if applicable;*
>
> *F. Charging and vehicle technology updates; and*
>
> *G. Distribution system impacts and opportunities for efficient grid management;*

1.1 Existing State Policy & Programs

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to (A) discussion of existing state policies and programs;*

Decarbonizing the transportation sector is a top priority for Oregon's Governor, legislature, and local communities. The policies outlined in this section define an urgent need to transition our transportation sector from one fueled by fossil fuels to one powered by clean electricity. To meet these policies' goals, utilities must make investments in the grid and customer programs to ensure that customers can make that transition seamlessly.

Table 1 summarizes the state and local policies, from most recent to oldest, that we will discuss in this section.

The current state policy around GHG emissions is found in Oregon Revised Statute (ORS) 469A.205. In 2007, the Oregon Legislature adopted the goals described in Table 1.

Table 1 – Summary of Existing Policies and Programs

Year	Policy
2019	Oregon Senate Bill 1044 (Transportation Electrification Bill)
2019	Oregon House Bill 2020 (Climate Action Plan)
2018	Oregon Solutions Process (focused on accelerated Electric Transportation)
2017	Executive Order No. 17-21 (EV Targets)
2017	Oregon House Bill 2017 (EV Rebate)
2016	Senate Bill 1547 (Clean Energy Bill)
2016	Volkswagen Diesel Emissions Mitigation
2009	Low Carbon Fuels Standard
2007	Oregon Greenhouse Gas Emissions Targets
2005	Zero Emissions Vehicle Mandate
Various	Local municipalities' Climate Action Plans

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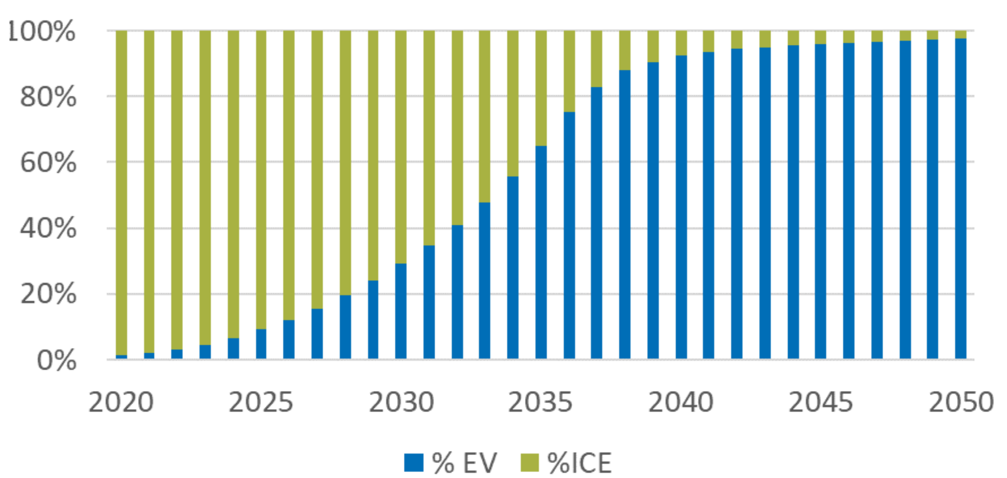
1.1.1 Senate Bill 1044: Transportation Electrification Bill[5]

SB 1044 established statewide goals for zero-emission vehicle (ZEV) adoption, including that the vehicle market must be transformed by 2035 to meet statewide GHG reduction goals. The Oregon Department of Energy (ODOE) is directed to provide a biennial assessment of the state's progress towards the goals and the marketplace for ZEVs. To the extent goals are not met, the bill directs the agency to submit suggestions for legislation to the Oregon Legislative Assembly. The bill also adopts the current Oregon Department of Administrative Services alternative fueled vehicle acquisition policy into statute, requiring at least 25% of all new leases and purchases of light-duty vehicles (also known as LDVs as defined in the bill) be ZEVs. The bill removes cost as a criterion for determining feasibility in the state's purchase or lease of vehicles. Finally, the bill broadens the ability of schools to utilize Public Purpose Charge funds received for energy efficiency on electric buses, fleet vehicles, and charging infrastructure.

Table 2 – SB 1044 ZEV Targets

Year	Target
2020	50,000 Registered ZEVs
2025	250,000 Registered ZEVs
2030	25% of Registered Vehicles are ZEVs 50% of new vehicle sales are ZEV
2035	90% of new motor vehicle sales will be ZEV

Figure 3 – Cumulative Target EV Penetration in Oregon by Year



[5] SB 1044 is available at: https://olis.leg.state.or.us/liz/2019R1/Downloads/MeasureDocument/SB1044/Enrolled

1.1.2 Oregon Solutions

In October 2018, Governor Kate Brown initiated an Oregon Solutions Process to meet the goals outlined in the Governor's Executive Order[6]. In April, the first meeting of the Oregon Electric Vehicle Collaborative was convened. This voluntary collaborative is facilitated by Oregon Solutions and has the imprimatur of the Governor. The goal is to bring together private interests, public agencies, non-governmental organizations, and individual interests to promote EVs. The group is seen as an adjunct effort to the Governor's Zero Emission Vehicle Interagency Working Group, but one that broadens the conversation to accelerate the adoption of EVs, contributes to Oregon's emission goals, and pursues voluntary commitments to advance the ZEV marketplace. PGE participates in the group and looks forward to future meetings.[7]

1.1.3 Oregon Executive Order No. 17-21

On November 6, 2017, Governor Kate Brown signed Executive Order No. 17-21 declaring that "Oregon is committed to meeting the international Paris Agreement targets to reduce greenhouse gas emissions by 26 to 28 percent below 2005 levels by 2025," and that "greater transition of internal combustion engines to zero emission vehicles, like electric cars, buses, and trucks, play a key role in helping Oregon achieve its climate change goals, improving the health of Oregon communities, and encouraging clean energy job development."[8] In that order, the Governor outlined a statewide goal to achieve "50,000 or more registered and operating electric vehicles by 2020." [9] Further, the order highlights several key considerations for utility programs:

> PUC, with input from interested stakeholders, is directed to implement the transportation electrification program, established in SB 1547 (2015), to support customer engagement in the investor-owned utilities' transportation electrification plans such that the transportation electrification program is designed to achieve the state goal" and "[w]herever possible, the PUC is directed to encourage programs that support greater electric vehicle adoption in moderate- and low-income communities.
>
> ODOT, working with ODOE, PUC, and DEQ, is directed to develop tools, information, and best practices to assist transit agencies when making decisions about zero emission vehicle bus technology adoption in transit fleets for their transit districts.
>
> Oregon Executive Order 17-21, November 6, 2017. Retrieved from:
> https://www.oregon.gov/gov/Documents/executive_orders/eo_17-21.pdf.

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[6] See: https://orsolutions.org/wp-content/uploads/2019/05/Governors-response-designation-letter-Oct-24-2018.pdf

[7] A summary of their activities can be found at: https://www.oregon.gov/energy/Get-Involved/Documents/ZEVIWG-Progress-Chart.pdf.

[8] Oregon Executive Order 17-21, November 6, 2017. Retrieved from:
https://www.oregon.gov/gov/Documents/executive_orders/eo_17-21.pdf

[9] Id.

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1.1.4 Oregon House Bill 2017

The 2017 Oregon Legislature signed HB 2017[10] into law, which, among many other transportation investments, establishes the Oregon Clean Vehicle Rebate Program to provide rebates to Oregonians who purchase or lease EVs (including plug-in hybrid electric vehicles or PHEVs). This program aims to encourage higher adoption of ZEVs, reduce air pollution, and advance progress toward the state's GHG reduction goals. The program establishes rebates based on a vehicle's battery size and additional rebates for income-qualified customers (Charge Ahead Rebate).

In May 2018, the Oregon Environmental Quality Commission[11] adopted the Zero Emission and Electric Vehicle Rebate rules, which established the program's requirements.[12]

DEQ has approximately $10.8 million[13] to distribute per year in rebates. The Current Oregon Clean Vehicle Rebate Program launched in Summer 2018 and will sunset on January 2, 2024.[14] Table 3 shows the rebate amounts available to EV purchasers or lessors in Oregon as part of the program:

Table 3 – Current Oregon Clean Vehicle Rebate Program Incentive Levels

Rebate Amount*	Qualification
Standard Rebate:	
$2,500	Purchase or lease of a new PHEV or battery EV with a battery capacity of 10 kWh or more
$1,500	Purchase or lease of a new PHEV or battery EV with a battery capacity of less than 10 kWh
$750	Purchase or lease of a zero-emission electric motorcycle
Charge Ahead Rebate (incremental to standard rebate for income-qualified customers)**:**	
$2,500	Purchase or lease of a new or used battery EV. *Note: PHEVs are not eligible for the Charge Ahead Rebate.*

** Note: Rebate amounts are subject to change. HB 2017 sets minimum and maximum values for rebate amounts.*

[10] OR HB 2017. Sections 148-155. Available at: https://olis.leg.state.or.us/liz/2017R1/Downloads/MeasureDocument/HB2017/Enrolled
[11] The Oregon Environmental Quality Commission regulates the Oregon Department of Environmental Quality, also known as DEQ.
[12] OAR 340-270-0120, available at: https://secure.sos.state.or.us/oard/viewSingleRule.action?ruleVrsnRsn=244925
[13] ODEQ. About Electric Vehicle Rebate Program. Accessed September 15, 2019. Available at: https://www.oregon.gov/deq/aq/programs/Pages/About-EV-Rebate.aspx
[14] Id.

1.1.5 Senate Bill 1547 (Chapter 28, Oregon Laws 2016)

In 2016, the Oregon Legislature adopted Chapter 28 of the Oregon Laws 2016[15] 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 IOUs to file applications with the OPUC for programs to accelerate TE. Such programs "may include prudent investments in or customer rebates for electric vehicle charging and related infrastructure."[16] These programs should be consistent with the Oregon Legislative Assembly's findings related to TE, including that electric companies "increase access to the use of electricity as a transportation fuel"[17]; that "electric vehicles should assist in managing the electrical grid"[18] 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."[19]

1.1.6 Volkswagen Settlement

On June 28, 2016, Volkswagen (VW) settled with the U.S. Department of Justice and the State of California[20] for $14.7 billion resulting from 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 an 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); and
- **ZEV infrastructure and promotion**: VW (through a subsidiary called Electrify America) 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.[21] The Portland Metro area was identified as a target city for Rounds 1 and 2 of infrastructure deployment.[22,23]

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[15] Oregon Laws 2016, Chapter 28. https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2016orLaw0028.pdf
[16] Oregon Laws 2016, Chapter 28, Section 20(3)
[17] Oregon Laws 2016, Chapter 28, Section 20 (2)(b)
[18] Oregon Laws 2016, Chapter 28, Section 20 (2)(e)
[19] Oregon Laws 2016, Chapter 28, Section 20(2)(f)
[20] Available at: https://www.epa.gov/enforcement/volkswagen-clean-air-act-civil-settlement
[21] See: http://www.deq.state.or.us/aq/vwsettlementfs.pdf
[22] Electrify America Phase 1 Plan, See: https://elam-cms-assets.s3.amazonaws.com/inline-files/National%20ZEV%20Investment%20Plan.pdf.
[23] Electrify America Phase 2 Plan, See: https://elam-cms-assets.s3.amazonaws.com/inline-files/Cycle%202%20National%20ZEV%20Investment%20Plan%20-%20Public%20Version%20vF.pdf.

1.1.7 Low Carbon Fuel Standard (LCFS)

The 2009 Oregon Legislature passed HB 2186 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.[24] The 2015 Oregon Legislature passed SB 324[25] allowing DEQ to fully implement the Clean Fuels Program (also known as CFP or the LCFS)[26] in 2016, and adopted in Oregon Administrative Rule (OAR) Chapter 340, Division 253,[27] as filed with the Secretary of State.[28] The rule allows electric utilities to register as a credit aggregator for electricity used as a transportation fuel.

In April 2017, the OPUC opened an investigation into the utilities' role regarding the LCFS.[29] The OPUC found that electric company participation in the CFP as a credit generator is in the public interest.[30] Further the OPUC adopted Credit Monetization Principles and Program Design Principles giving direction on how the program should be administered; however, because these programs are not funded by utility customers, programs will not be held to traditional cost effectiveness or prudence review processes.[31,32]

PGE is a registered credit aggregator for the credits generated by our residential customers. We also generate credits through the charging stations we own, operate, and/or maintain. A discussion about PGE's CFP implementation is included in Section 2.

1.1.8 Greenhouse Gas Emissions Targets

The current state policy around GHG emissions is found in Oregon Revised Statutes.[33] In 2007, the Oregon legislature adopted the goals described in Table 4 below:

Table 4 – Oregon's GHG emission targets

Year	Target
2010	Arrest the growth of Oregon's GHG emissions and begin to reduce emissions
2020	Achieve GHG emission levels that are 10% below 1990 levels
2050	Achieve GHG emission levels that are 75% below 1990 levels

[24] See: https://olis.leg.state.or.us/liz/2009R1/Downloads/MeasureDocument/HB2186/Enrolled
[25] Oregon SB 324 is available at: https://olis.leg.state.or.us/liz/2015R1/Downloads/MeasureDocument/SB324/Enrolled.
[26]Oregon Laws 2009, Chapter 754. Available at:
https://www.oregonlegislature.gov/bills_laws/lawsstatutes/2009orLaw0754.html
[27] Oregon Administrative Rules, Chapter 340, Division 253. Available at:
https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=1560.
[28] Oregon Clean Fuels Program. Available at: http://www.deq.state.or.us/aq/cleanFuel/.
[29] UM 1826. Available at: https://apps.puc.state.or.us/edockets/docket.asp?DocketID=20725.
[30] Order No. 17-250. Available at: https://apps.puc.state.or.us/orders/2017ords/17-250.pdf.
[31] Order No. 17-512. Available at: https://apps.puc.state.or.us/orders/2017ords/17-512.pdf.
[32] Order No. 18-376. Available at: https://apps.puc.state.or.us/orders/2018ords/18-376.pdf.
[33] ORS 469A.205

1.1.9 Zero-Emission Vehicle Mandate

In 2005, Oregon adopted California's ZEV mandate which requires a certain percentage of vehicle sales each year be 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. Minimum ZEV requirements for each manufacturer are outlined in Table 5 below, as a percentage of passenger car and light-duty truck sales:

Table 5 – General ZEV Percentage Requirements for Manufacturers

Model Year	Credit Percentage Requirement*
2018	4.5%
2019	7.0%
2020	9.5%
2021	12.0%
2022	14.5%
2023	17.0%
2024	19.5%
2025 (and subsequent)	22.0%

**Note: Manufactures may meet credit percentage requirement with a certain portion of transitional ZEVs and by trading ZEV credits.*

PGE continues to monitor changes to California's ZEV program, including targets for medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs).[34] PGE will closely monitor those activities to determine if recommended changes will impact EV forecast, pilot plans, or other parts of this proposal.

[34] California Air Resources Board. *Advanced Clean Trucks Regulatory Workshop.* April 2, 2019. Available at: https://ww2.arb.ca.gov/sites/default/files/2019-03/190402actpres.pdf. (Accessed 9/9/19)

1.1.10 Local Climate Action Plans

Several of our municipal customers have also created Climate or Sustainability Action Plans (CAP). Many of these plans outline clear decarbonization goals and include key targets or activities related to electric transportation. Table 6 summarizes the CAPs established within PGE's service area:

Table 6 – Local Climate Action Plans Summary

City/County	CAP Adopted/ Modified	Key Decarbonization Goals
City of Beaverton[35]	*Modified: January 2014*	*80% reduction by 2050*
Clackamas County[36]	*Adopted: November 2008*	*80% reduction by 2050*
City of Gresham[37]	*Adopted: 2011*	*100% renewables by 2030,* *80% reduction by 2050*
City of Hillsboro[38]	*Adopted: March 2012*	
City of Lake Oswego[39]	*Adopted: March 2014* *Modified: April 2018*	*50% reduction by 2030*
City of Milwaukie[40]	*Adopted: October 2018*	*15% reduction by 2020, 35% reduction by 2030, 100% reduction by 2050*
Multnomah County[41]	*Adopted: April 2001* *Modified: June 2015*	*80% reduction by 2050*
City of Portland[42]	*Adopted: April 2001* *Modified: June 2015*	*40% reduction by 2030,* *80% reduction by 2050*
City of West Linn[43]	*Adopted: December 2015*	*80% reduction by 2030*

Additionally, in 2016, the Portland City Council unanimously adopted an updated Electric Vehicle Strategy in an effort to meet their CAP goals.[44] PGE supports our communities' efforts and looks forward to collaborating with them on the rollout of future electric transportation initiatives.

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[35] See: https://www.beavertonoregon.gov/492/City-Operations
[36] See: https://dochub.clackamas.us/documents/drupal/04d0f867-f797-4ce5-a0ed-1c8905a6d01d
[37] See: https://greshamoregon.gov/city/city-departments/mayor-and-city-council/council-advisory-committees/Natural-Resource-and-Sustainability-Committee.aspx
[38] See: http://www.hillsboro-oregon.gov/home/showdocument?id=2375
[39] See: https://www.ci.oswego.or.us/sites/default/files/fileattachments/Climate%20Action%20Plan.pdf
[40] See: https://www.milwaukieoregon.gov/sites/default/files/fileattachments/sustainability/page/85191/2018_1003_climateactionplan.pdf
[41] See: https://www.portlandoregon.gov/bps/article/531984
[42] See: https://www.portlandoregon.gov/bps/article/531984
[43] See: https://westlinnoregon.gov/sites/default/files/fileattachments/economic_development/page/7619/sustainable_strategic_plan_adopted_12-14-15.pdf
[44] Press release is available at: https://www.portlandoregon.gov/bps/article/621016 (Accessed 9/9/19)

1.2 Market Barriers

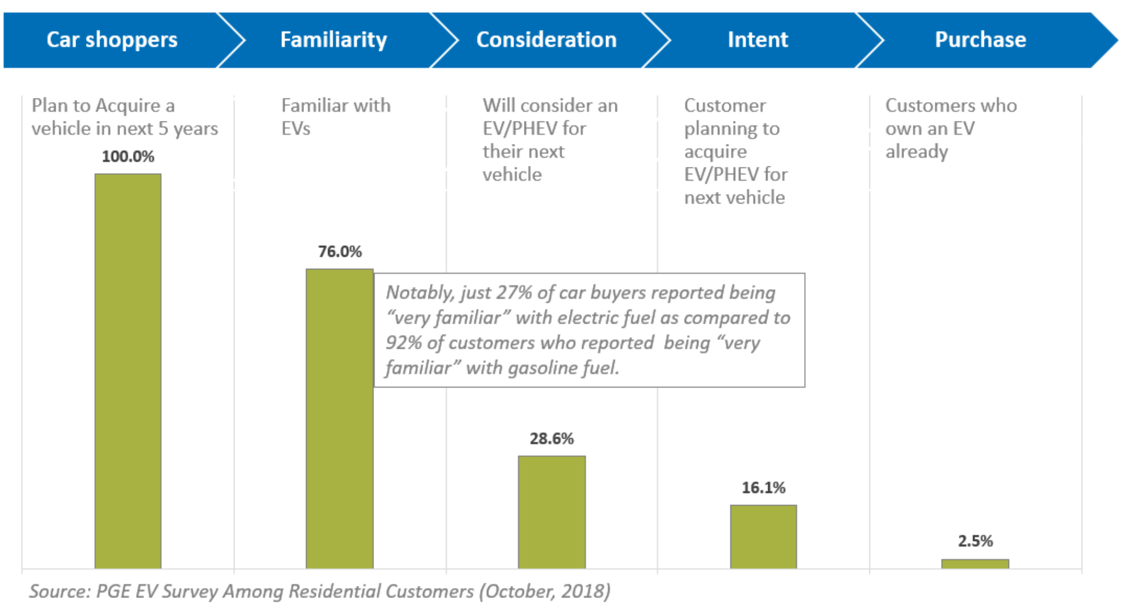
In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to:...(B) Market barriers that the electric company can address and other barriers that are beyond the electric company's control, including any identified emerging challenges to transportation electrification;*

The primary market barriers for TE are: 1) Customer Awareness; 2) Cost; 3) Infrastructure; 4) Fueling; 5) Infrastructure Availability; 6) Vehicle Range; 6) Channel/Sales Process; and 7) Equitable Access.

To better understand market barriers to adoption, we evaluate the purchase process (aka purchase funnel) for EV procurement. In 2018, PGE surveyed 1,700 of its residential customers to better understand their vehicle purchase plans and their knowledge and consideration of EVs. Half of the respondents planned to buy or lease a new car in the next five years, and three in four of those planned purchasers reported a level of familiarity with EVs, but only one in four indicated being "very familiar" with EVs (compared to 92% for gasoline vehicles). Just about one in three of those customers familiar were willing to consider an EV/PHEV for their next car, and about half of that subpopulation fully intended to procure an EV/PHEV.

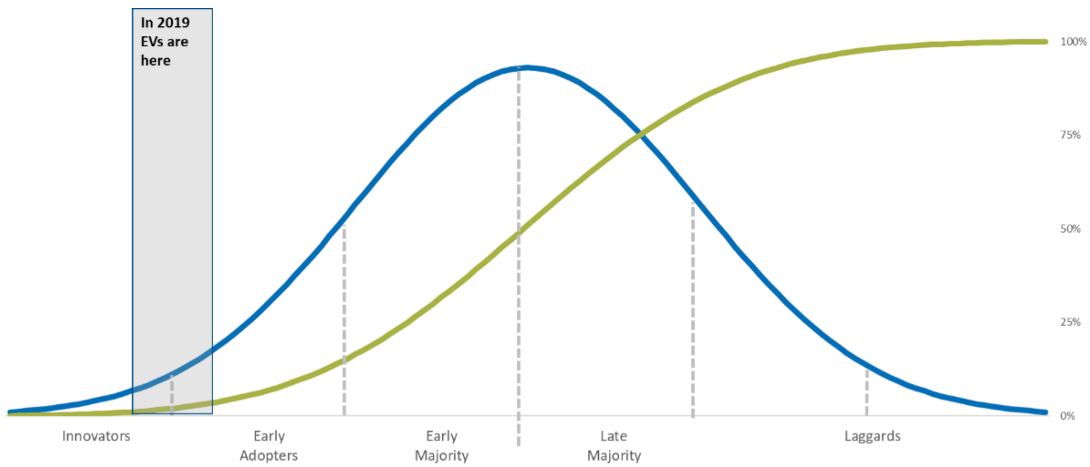
Figure 4 – EV Purchase Funnel, Car Buyers in PGE Service Area[45]



[45] PGE EV Survey Among Residential Customers (October 2018)

Figure 4 above illustrates a 2.5% rate of adoption of EVs in PGE's service area; this is generally-accepted as the threshold between Early Adopters and Innovators[46]. Given that national EV adoption rate has grown steadily between 2013-18 and is expected to continue to accelerate,[47] we appear at an inflection point in EV market where PGE and our partners across the state must be ready to act.

Figure 5 – Diffusion of innovation Curve



PGE currently focuses on mass market EV adoption and fleet electrification. These two primary segments for EV adoption have similar barriers. Though most of the discussion in this section will focus on residential customer EV adoption, similar concepts can be applied to fleet customers. A discussion of additional barriers fleet customers face is included later in this section.

[46] Rogers, 1971. Diffusion of Innovations
[47] IEA. Global EV Outlook 2019. See: https://www.iea.org/publications/reports/globalevoutlook2019/

Table 7 below summarizes key barriers to passenger EV adoption, the level of severity of that barrier in the Oregon market, and a ranking order of the electric utilities' ability to impact customers adoption of EVs:

Table 7 – Customer Considerations Regarding EV Adoption

Market Barriers	Details	Passenger LDV	MHDV Fleet
Cost	• First Cost • Total Cost of Ownership (TCO)	First cost to purchase vehicle and home charging equipment can be $10,000 more than an internal combustion vehicle. However, state and federal rebates offer up to $12,500 and vehicle prices are declining. Customers can save on total cost but need affordable rates to compete with gas/diesel.	First cost is often hundreds of thousands of dollars (with little government subsidy), and there is uncertainty in the residual value of e-trucks. Fuel prices fluctuate throughout the day (i.e. time of use or TOU) and have penalties for peak consumption (demand charge). Large fleets have experience and expectations of long-term fuel price hedging.
Product	• Model availability • Functionality (e.g. range) • Dealer Sales Process	Limited models exist today (including lack of truck or SUV), but increasing model and functionality, are expected to expand in five years. Dealer EV training is limited and opportunity for dealer upsells is limited (e.g. no oil changes).	Customer needs are heavily dependent on fleet type (e.g. short/long-haul cargo, delivery, construction). U.S. vehicle markets are secondary to Europe, China, and CA for many original equipment manufacturers (OEMs) – expected to expand in two to five years.
Awareness	• Awareness/ Familiarity • Consideration • Equitable Access	Notably, just 27% of car buyers reported being "very familiar" with EVs as compared to 92% of customers who reported being "very familiar" with gasoline. Further one half of likely vehicle purchasers have awareness of the financial incentives available for EV purchases. Additionally, while lower fuel cost is a motivator to buyers, most potential car buyers have no awareness of the actual fuel cost advantages of EVs/PHEVs over traditional internal combustion vehicles (ICEVs).	
Infrastructure	• Fueling Infrastructure • Fueling Capacity • Anxiety of the unknown	Customers have concern that they cannot get a charge when/where they need one. Customers may not have access to a home charger (or it is cost-prohibitive to install one). Customers have concern about what they do not know and what is new.	Infrastructure requirements for fleets are often large, costly, and complicated to determine (e.g. speeds, quantity of chargers needed). Fueling infrastructure will need to be financed and deployed to satisfy fleet requirements.

The remainder of this section will explore barriers specific to passenger vehicles and fleets, as well as those that PGE can and cannot address, and also identify additional emerging challenges in the TE market.

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1.2.1 Passenger Vehicle Barriers

One cannot understate the barriers that exist for customer EV adoption. They encompass concerns regarding cost and anxiety of the unknown, as well as inadequate products, lack of knowledge, and concerns around fueling infrastructure. Table 8 summarizes major barriers of light duty vehicle adoption and a relative rank to compare the utility's ability to impact. In order to illustrate PGE's relative ability to address each consideration, we have ranked each consideration from 1 to 5 (1 indicating low utility ability impact; 5 indicating a high ability to impact).

Table 8 – Customer Considerations Regarding EV Adoption (LDV)

<table>
<tr><th>Customer Considerations</th><th>Description</th><th>Utility
Ability to Impact
(1=low; 5=high)</th></tr>
<tr><td>First Cost</td><td>Significant price premiums for EVs/PHEVs continue to be a barrier to adoption for many. The price premium for an EV versus a conventional ICEV can range from $5,000 to more than $15,000. Bloomberg New Energy Finance (BNEF) estimates pre-tax price parity in the mid-2020s.[48] Further, many customers investing in EVs must also account for the cost of a new home charging station. Oregon is better off than most states due to the state's EV rebate program.</td><td>2 Rating: PGE can develop programs that reduce the cost to procure and install a home charging station. This is a small portion of the overall first cost.</td></tr>
<tr><td>Model availability</td><td>Though auto manufacturers have committed over $100B to developing dozens of new vehicle models over the next decade, today there is not enough vehicle diversity to meet all customers' needs.[49,50] For example, there is only a single PHEV mini-van, and there are no PHEV/EV pickup trucks on the market today.

Additional vehicle diversity will expand EV access to more customers. It's worth noting here that US EV policy and Oregon EV policy very much impact model availability for PGE customers. More favorable policies in China and Europe drive faster innovation for EV options overseas. Favorable state policies in California have driven auto manufacturers to focus much of their EV offerings in the state.</td><td rowspan="2">1 Rating: PGE alone has no impact on automotive supply chains. PGE can work with industry trade groups (e.g. Edison Electric Institute or EEI) to have a larger voice with OEMs.</td></tr>
<tr><td>Model functionality (e.g. vehicle range)</td><td>Today, many EVs have an approximate range of only 100 miles. Though this may be sufficient for some customers' driving needs, it is insufficient for other types of trips (e.g. Portland to Seattle is a 175-mile, one-way trip). Nearly two-thirds of all likely vehicle buyers desire a range of 200 miles or more from a single charge.[51]</td></tr>
<tr><td>Awareness</td><td>Notably, just 27% of car buyers reported being "very familiar" with EVs as compared to 92% of customers who reported being "very familiar" with gasoline. Further just one half of likely vehicle purchasers have awareness of the financial incentives available for EV purchases.[52] Additionally, while lower fuel cost is a motivator to buyers, most potential car buyers have no awareness of the actual fuel cost advantages of EVs/PHEVs over traditional gasoline vehicles.[53]</td><td>4 Rating: Electricity is our product-we can very much influence how customers learn and communicate about electricity and EV fueling.</td></tr>
<tr><td>Total Cost of Ownership (TCO)</td><td>The TCO of an EV includes first cost/lease cost, fuel cost, cost of installing charging infrastructure, incentives, and maintenance. In some cases, the TCO can be lower for EVs, largely due to low cost fuel and maintenance savings. Electric utilities can impact this through charging infrastructure, smart charging programs, and innovative rate designs.</td><td>5 Rating: PGE can simplify rates and make them easier to understand. PGE can develop rates that allow customers to reduce charging costs by charging intelligently.</td></tr>
</table>

[48] BNEF. When Will Electric Vehicles Be Cheaper than Conventional Vehicles? Mar 2018.
[49] BNEF. 2019 Electric Vehicle Outlook (Section 3.5: Automaker commitments to EVs). May 2019.
[50] MJB&A. Electric Vehicle Market Status: Manufacturer Commitments to Future Electric Mobility in the U.S. and Worldwide. May 2019.
[51] PGE EV Survey Among Residential Customers (October 2018).
[52] Id.
[53] Id.

Customer Considerations	Description	Utility Ability to Impact (1=low; 5=high)
Fueling infrastructure availability	Along with range anxiety, availability of public charging infrastructure is also a concern for many customers. Most have noticed public charging stations in the region, but even 37% of current EV/PHEV owners mention some difficulty locating charging stations when needed. Though we know most charging will happen at home (99% of current EV drivers reported typically charge at home), 38% of customers report using public charging at least once per month.[54] Further, many non-EV drivers do not have access to home charging because they either do not have off-street parking, they do not have panel capacity, or their landlord has not installed charging stations at their unit.	5: PGE can deploy infrastructure at places where people go or near where people live. Further PGE can develop home charging programs that reduce barriers to home charging.
Equitable access to all segments	Many customers do not have means to buy a new vehicle, rely on transit/car share/ride share or other means to get around, or otherwise do not have means to benefit from TE. Solutions must be created to allow all customers to benefit from clean electric transportation.	3: Though PGE can look for ways to find partners to accelerate change, much of this is driven by third-party efforts such as model development and product pipeline decisions.
Dealer sales process	Many dealerships have a disincentive to actively promote EVs, citing that sales processes take longer, they sell fewer service contracts, as well as the fact that most sales staff lack general education about EV technology, charging, and incentives.[55] 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." It is important that dealerships support the acceleration of EV adoption and that they have the tools necessary to talk to customers about the benefits of EVs and to close the EV sale. Further, dealers must have sufficient vehicle inventory for customers to select a vehicle that meets their needs.	4: PGE can empower dealers with the tools they need to successfully talk about electric fuel. Further PGE can create incremental value for dealers by providing incentives for EV and/or charger sales, and for participating in smart charging programs.

As illustrated above, market actions are required to support EV adoption that are beyond PGE's control, which are largely a function of auto manufacturer investments in technology to reduce cost, increase range, and increase vehicle diversity. PGE can have a meaningful impact in three main areas:

1. **Rates**: reduce TCO and to make EV fueling easier to understand;
2. **Infrastructure**: reduce concerns about charging access; and
3. **Programs**: increase awareness, engagement, and reduce TCO.

Fundamentally, EV adoption is a function of supply and demand. PGE must work with our customers to drive consumer acceptance and demand for EVs but also ensure that we have an actively-engaged sales force and supporting policies to ensure that supply exists.

[54] Id.

[55] See: http://www.nytimes.com/2015/12/01/science/electric-car-auto-dealers.html.

1.2.2 Fleet Market Barriers

Fleet managers face similar challenges to those posed to the Passenger Vehicle segment, but the Fleet segment is less mature and buying decisions for vehicle fleets can be a complicated process. Table 9 below enumerates customer considerations for adoption for MDV/HDV fleet vehicles:

Table 9 – Customer Considerations Regarding EV Adoption (MDV/HDV fleet vehicles)

Customer Considerations	Description	Utility Ability to Impact (1=low; 5=high)
First Cost	The price premium for electric buses and trucks can be several hundreds of thousands of dollars. In addition, deployment of necessary charging infrastructure requires hundreds of thousands of dollars.	2: PGE can develop programs that reduce the cost to procure and install charging infrastructure. This is a small portion of the overall first cost.
Model availability	Other markets, such as China and Europe have models either under development or available. Supply constraints currently play a role in electrification decisions. Nearly 60 auto companies have developed EV offerings and 30 are working on MDV/HDV offerings.	1: PGE alone has no impact on automotive supply chains. PGE can work with industry trade groups (e.g. EEI) to have a larger voice with OEMs.
Model functionality (e.g. vehicle range)	For some fleet operators, range matters significantly. Further, seasonality impacts the range of a vehicle, so fleet operators must account for this when developing routes, sizing their batteries, and procuring charging. Worth noting is that batteries can increase vehicle weight—this can impact the amount of freight a vehicle can haul legally.	
Awareness & knowledge	Though we've found little research on awareness of fleet managers on EV availability, in our experience, customers do not have many resources to devote to tracking market trends in new technologies such as EVs.	4: Electricity is our product—we can very much influence how customers learn and communicate about electricity and EV fueling.
Total Cost of Ownership (TCO)	Though electricity is generally cheaper than diesel and gas, the price structure differs from petrol fuels. For those on a time-variant rate, rates change throughout the day, and customers can be charged a premium for their instantaneous energy use (i.e. demand charge). Some customers may not have the flexibility in their schedules to change when they charge their EV. Demand charges can be challenging as customers try their first EVs—they may not have enough utilization to cover the cost of the demand charge, thus resulting in a high unit cost per kWh. Further, large fleets have experience and expectations of long-term fuel price hedging. It is worth noting that uncertainty around residual/salvage value can create significant uncertainty for calculating fleet TCO, as well as planning for fleet investments.[56,57,58]	5: PGE can simplify rates and make them easier to understand; PGE can develop rates and programs that allow customers to reduce charging costs by charging intelligently.
Fueling infrastructure deployment & cost	Deploying large, fast fueling infrastructure for large fleets can be costly and require significant levels of planning and (in some cases) take years to build. This can be particularly troublesome for fleet operators who test the new technology to evaluate its viability within the fleet.	5: PGE can partner with customers on infrastructure planning and make infrastructure investments to reduce customers' barriers to entry.
Business planning/ process	EVs can be logistically challenging as fleet managers must work with parties such as facilities, real estate, and their utility to deploy the right charging infrastructure at the right locations available at the right times. This is a new layer to business planning and logistics operations for customers considering an EV fleet.	3: PGE can consult with customers, sharing our expertise in rates, infrastructure, and electrification to design the right fleet solution.

[56] Residual values are uncertain because suppliers do not know the range (and thus the utility) of the vehicle in the future, nor do they know what new products will be available on the market.
[57] See: https://www.autonews.com/commentary/residual-value-ready-new-path.
[58] See: https://www.hybridcars.com/ev-residual-values-are-a-challenge/.

1.2.3 Market Barriers PGE can Address

PGE fundamentally has three primary modes to address market barriers to EV adoption:

1. **Rates**: electricity is an EV customer's fuel. Changes to PGE's pricing structure can reduce long-term operation and maintenance (O&M) costs associated with operating an EV and bring down the TCO.
2. **Infrastructure**: charging and supporting electrical infrastructure is necessary to meet the state's EV goals.
3. **Programs**: can reduce TCO, increase awareness, and help create incremental value for the grid.

Table 10 summarizes the major barriers identified in Sections 1.2.1 and 1.2.2 with a utility impact rank of 3 or higher, as well as PGE's potential interventions/desired outcomes in addressing those barriers:

Table 10 – Market Barriers that PGE can Address

Major Barrier	PGE Ability to Intervene	Desired Outcomes
Cost	• PGE can develop programs and deploy infrastructure that reduce the cost to procure and install charging equipment. However, note that this is a small portion of the overall first cost. • Changes to PGE's pricing structure can empower customers to manage long-term O&M costs associated with operating an EV and bring down the TCO. • Customer programs to reward customers for smart charging.	• Lower first cost: reduce cost for installing home charging station. • Simplify/reduce cost of fuel.
Awareness, anxiety of the unknown, and business planning	• Customer and dealer education on how to simplify the concept of electricity as a fuel. • Technical support and planning assistance for business fleet customers.	• Increased customer adoption of personal and fleet EVs in PGE territory. • Increased availability of EV on dealer showrooms/lots and/or improved sales of EVs from more dealers. • Increased number of customers considering EVs as their next personal vehicle purchase.
Access to Infrastructure	• Public charging infrastructure • Make-Ready infrastructure for public, businesses, multi-family, workplace, etc.	• Increase customer access to EV charging • Eliminate fueling anxieties
Equitable access to all segments	• Programs and infrastructure deployments that accelerate transit and school bus electrification • Rate and program offerings to empower transportation network company (TNCs, e.g. Uber or Lyft) drivers to choose EVs • Programs and infrastructure targeted in underserved areas	• More customers able to benefit from electric transportation • More electric transportation options for customers (e.g. bus, car, shared vehicles, bikes, etc.)

1.2.4 Market Barriers Beyond PGE Control

The market barriers outside of PGE's control are largely product barriers driven by the auto manufacturers:

- **Vehicle availability**: the availability of the products that customers will want to drive/buy is entirely up to the automotive industry. PGE alone has no impact on automotive supply chains. PGE can work with industry trade groups to have a larger voice with OEMs. Details regarding automotive manufacturers' investments in electric vehicles is included later in this section.
- **Vehicle functionality**: the availability of the product with the features that customers expect is entirely up to the automotive industry. PGE alone has no impact on automotive supply chains. PGE can work with industry trade groups to have a larger voice with OEMs. Manufacturers are committed to developing EVs with additional range and other features to make them more desirable for consumers.
- **Battery costs**: battery costs are one of the key variables in the price of an EV. As discussed later in this section, battery costs are expected to decline and drive decreases in the overall cost of EVs over time. If those cost reductions do not materialize, cost barriers to EV adoption may continue for longer than expected.
- **Incentives and polices** (local, federal, global, and other states): the EV market today is largely driven by government policies that mandate change or incentivize adoption. Major changes to foreign, domestic, or state EV policies could have a dramatic impact on vehicle availability in our region.

1.2.5 Emerging Challenges

The pace of change in this industry is fast—we must track emerging challenges that could create new barriers to EV adoption. Several factors we have identified to track and evaluate are: network and charging equipment reliability, workforce development and readiness, and charger queuing because these areas, if not addressed could yield poor customer experiences in the future.

1.2.5.1 *Network/Charging Equipment Reliability*

As EV adoption grows, we must ensure that charging equipment has an uptime (time the equipment is operating and useable by the customer) commensurate with what they expect from their traditional electric service. Equipment downtime stretching into days (or weeks) is unacceptable. As the industry matures, there are natural growing pains including hardware, software, and interconnection challenges. That said, PGE procurement must set very high standards for equipment suppliers regarding equipment uptime. Customers must be able to rely on electric vehicle supply equipment (EVSE) just as they do their refrigerator or gas pump today. Because reliability is core to PGE's business, we will set high expectations and standards with our electric vehicle service providers (EVSPs).

1.2.5.2 *Workforce Development*

Part of ensuring equipment reliability is making sure we have a workforce that can perform quality installations, conduct preventative maintenance, and respond to equipment malfunctions. In this nascent industry, there is a dearth of trained technicians capable of conducting this work. This issue is manageable, as the current market is small enough that PGE can make a material impact in developing this workforce. However, as vehicle adoption and charger deployments experience accelerate, we must ensure that the workforce is growing at a comparable rate. We expect EVs and charging infrastructure to continue to create opportunities for engineers, construction managers, electricians, planners, programmers, technicians, and specialized automotive technicians. We anticipate working with the state, unions, local universities, and community colleges to ensure Oregon proactively manages this challenge.

1.2.5.3 *Charger Queuing*

Charging infrastructure deployments must keep pace as EV adoption ramps up. The supply and/or speed of EVSE is insufficient for customers to be able to rely upon, customers may end up in a situation where they are not able to get a charge when or as fast as they need one. Tesla has encountered this with some of its supercharge facilities and has begun to institute mitigation strategies to support throughput at their fueling stations.[59] As EV adoption grows, it will be important for infrastructure deployments to keep pace and for charging operators to have mitigation strategies in place to ensure our customers have positive charging experiences. Figure 6 is an example of a recent day when all of the charging stations at PGE's downtown Electric Avenue were occupied, and other drivers were waiting to get a charge. Additional discussion about queueing at Electric Avenue is included in Section 1.3.2.

Figure 6 – Electric Avenue (WTC) at capacity with several cars waiting to charge

[59] See: https://electrek.co/2019/05/24/tesla-limiting-supercharger-busy/.

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1.3 Charging Station Availability and Usage Patterns

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to:… (C) Existing data on the availability and usage patterns of charging stations;*

In order to ensure our customers have adequate access to charging infrastructure, we must understand charging station availability in our service area; and in order to ensure we efficiently integrate those and future chargers into our system, we must better understand how those charging stations are utilized.

1.3.1 Availability of Charging

Customers have access to charging infrastructure today, but-as we will detail in the following sections-said charging infrastructure is insufficient to meet growing customer demand. Fewer than 1,000 public charging ports currently exist in our service area:

Table 11 – Publicly Available Charging Ports in PGE Service Area (as of Q1 2019)[60]

Port Type	No. of Ports	Additional Planned Ports	Total Ports (est.)	No. Registered Vehicles per Port
L2	810	12	822	31
DCQC	117	40	157	162

We define charging availability as: (1) charging stations deployed in optimal locations; (2) charging stations capable of serving all customers; and (3) charging stations are fully operational when customers need them. In this Section, we will discuss all three availability criteria. A discussion of charging needs is included in Section 1.5.1.

1.3.1.1 *Public Charging Stations do not Serve All Customers*

Of the charging stations deployed, not all chargers serve all vehicles. There are two primary types of EV plug that EVs and chargers can connect to: CHAdeMO and SAE Combo (Tesla vehicles may connect to CHAdeMO via an adapter from Tesla). The two plug types cannot be used interchangeably. Most of the public quick chargers in our service area today have only a CHAdeMO or Tesla connector, meaning they can only serve a limited portion of all EVs. As the EV vehicle fleet grows and more auto manufacturers adopt the CCS standard, we must consider ways to ensure all chargers can serve all customers.

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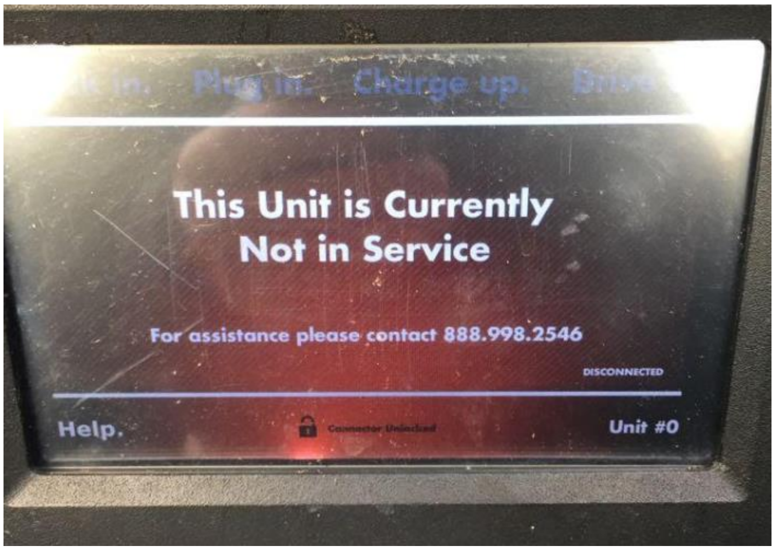
[60] USDOE Alternative Fuels Data Center. See: https://afdc.energy.gov/

1.3.1.2 *Charger Up-Time Limits Availability to Users*

Though we are not able to track charging station up-time for public charging equipment, we know this is a challenge with much of the equipment in the field today. An inoperable charging station could mean that an EV driver is unable to get home from the store or that a prospective buyer is deterred from considering an EV as their next vehicle purchase. Figure 7 is a recent example of a damaged charging station in our service area:

Figure 7 – DCQC Out of Service (at a Portland, OR site with only one DCQC)



1.3.1.3 *Public Quick Charging Sites are not Adequately Deployed*

Outside of PGE's Electric Avenue Network, Electricity America Sites, and Tesla's super charging network, few charging sites have more than two DCQCs; most have just one or two quick charging stations at each site. If those stations are in use, or if they are blocked by a non-electric vehicle or out of service for any reason, the customer cannot charge their EV as needed. Additionally, many of these sites are at capacity-they were designed for just a single charger. Because the sites were not future-proofed when they were deployed, adding additional chargers or faster chargers would require significant/costly infrastructure upgrades.

1.3.2 Charging Usage Patterns

In this section we summarize utilization patterns in home, public quick, workplace/fleet, and MHDV charging stations. Later in this Plan, we highlight how these loads impact the distribution system, charging needs, and opportunities for smart charging.

PGE has identified three important factors to consider when evaluating charging usage patterns:

1. **Overall utilization:** the ratio of A) time that a charging asset is used to supply electricity to a vehicle, to B) the total hours in the time period.
2. **Coincident and non-coincident peak:** these traditional load planning metrics will be used to understand impacts of different site configurations and their impact on the electrical grid.

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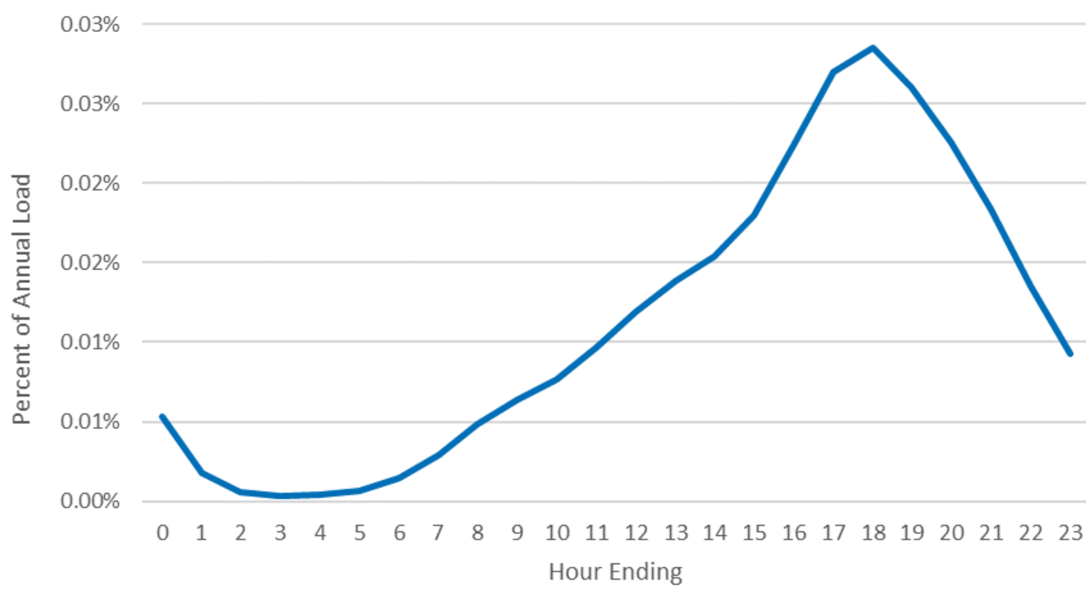
3. **Load shapes:** the variability of load profiles across charging use cases over day types (e.g. weekday versus weekend).

1.3.2.1 *Home Charging*

Most charging today occurs at home in the late afternoon-to-evening and through the night. Customers typically plug in their vehicle after work and charging stops when the battery is full. Without a current residential EV charging program, PGE does not have a clear line of sight into how customers are actually charging at home.

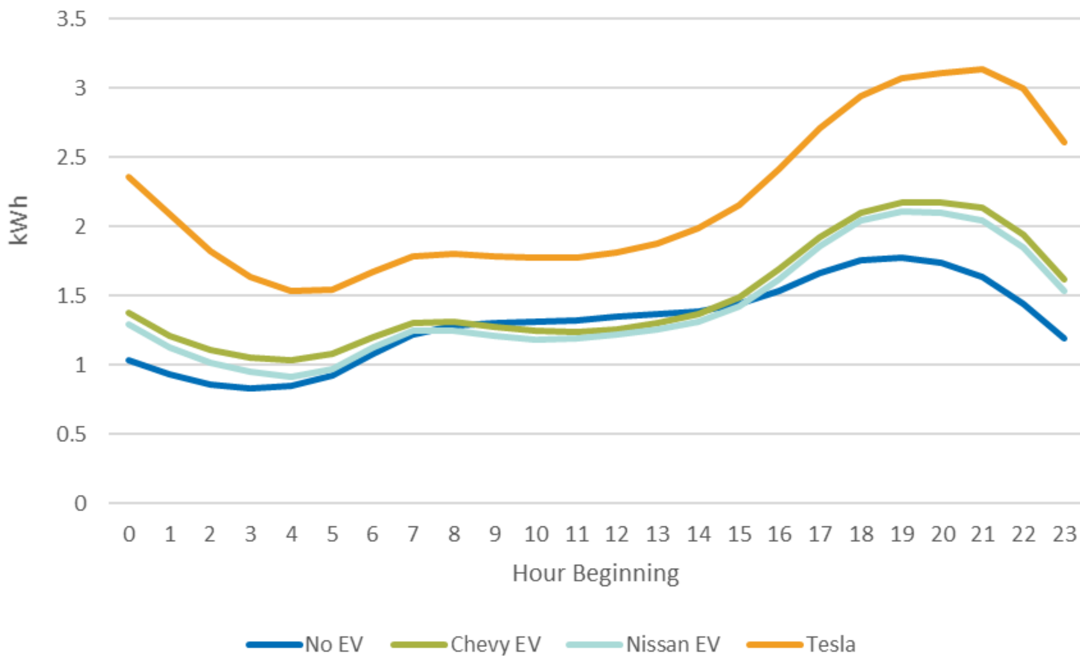
Figure 8 below shows the estimated EV LDV load profile used in PGE's 2019 IRP to estimate capacity needs from EV load growth. This reflects a system-wide load profile to estimate total vehicle energy consumption across home, workplace, and public charging.

Figure 8 – Estimated Residential EV Load Shape



In the absence of a residential EV charging program, it is difficult to determine what type of charging is occurring at home. For instance, some vehicle models are now equipped with a L2 charging unit, whereas others use only the traditional 120V outlet in the garage. Figure 9 highlights impacts of different types of EV on the average annual load profile of a home:

Figure 9 – Residential Annual Average EV Load Shape by OEM, PGE Service Area



As illustrated in Figure 9, above, Tesla owners consume more energy on average, which could be attributable to household size and income; however, they also exhibit accentuated peaks during likely charging hours. This is expected given that Teslas can accept a charge near the top end of the range for L2 chargers (up to about 20 kW compared to a typical L2 charge of 6-7 kW). This will be increasingly important to monitor as more home EVSE equipment offers higher charging speeds.

The "No EV" category was derived from a random sample of 928 residential homes. The Chevy and Nissan EV homes have a very similar profile from about 7am to 4pm, and then a noticeable pattern of increased nighttime and early morning usage.

PGE will continue to analyze this data to uncover other underlying patterns, for example whether EV owners are more likely to also own rooftop solar (which would make interpretation of the net load shape difficult without further submetering and analysis).

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1.3.2.2 *Public Quick-Charging*

PGE analyzed the usage patterns of its existing public chargers through the Electric Avenue network. Table 12 shows each public charging station in PGE's network, with summary statistics about overall utilization.

Table 12 – Utilization of PGE-owned EV Charging Infrastructure

Electric Avenue Site	No. of L2 Ports	No of DCQC Ports	MWh Sales (since opening)	Utilization	Open Date
World Trade Center	2	4	337	19%	May 2017
Milwaukie	2	4	11	3%	March 2019
Hillsboro	2	4	4	1%	April 2019
Total	**6**	**12**	**352**	**-**	**-**

Figure 10 below shows the quarterly kWh delivered to EVs through PGE's Electric Avenue network. Data collection for the World Trade Center site started when PGE began collecting fees from customers for their use of the site in 2017. The noticeable drop in 2018 Q2 was coincident with the introduction of pricing structures to the Electric Avenue 2.0 site. Prior to February 2018, charging was free to all customers. The new rates introduced in February 2018 included a flat fee ($3 or $5 for L2 and DCFC respectively) plus $0.19/kWh for on-peak charging (defined as weekday non-holidays from 3-8pm).

Figure 10 – Quarterly Energy Deliveries at Electric Avenues, by Site

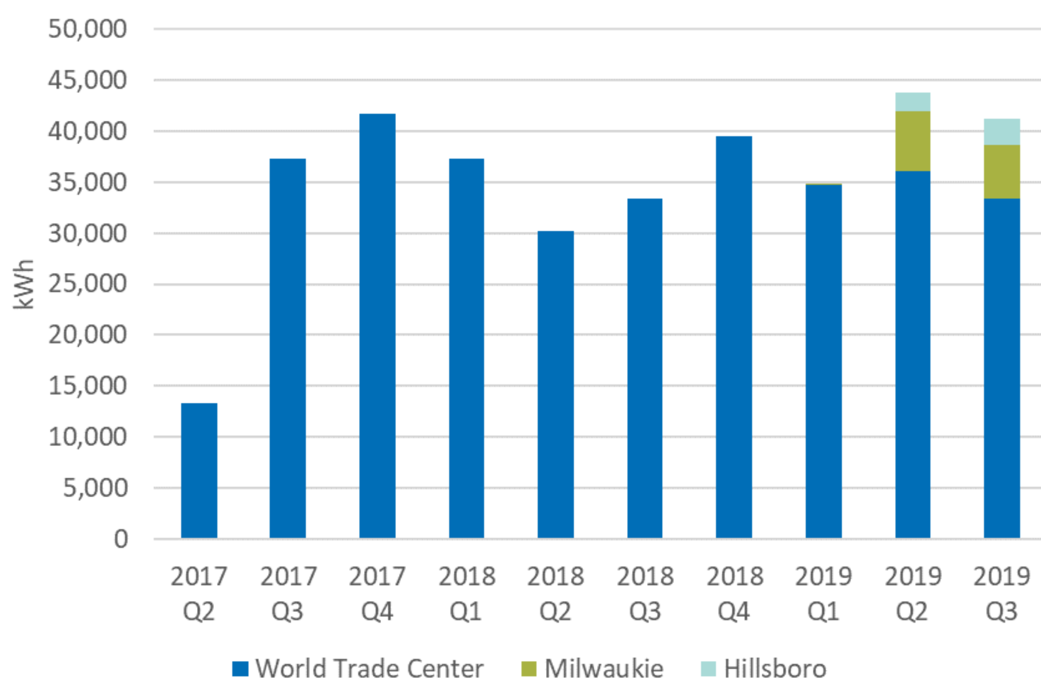

Figure 11 below shows the hourly load profile for Electric Ave 2.0 for each month of the year, as well as the average load profile that can be used for planning purposes. As discussed earlier, charger queueing will be a continuing challenge as EV adoption rates outpace charger deployments. Over the past year at our World Trade Center (WTC) Electric Avenue, all four chargers have been simultaneously in use 32 times, or approximately 0.1% of the year. This may seem insignificant, but it is material in that it indicates that EV drivers may experience periods when no public charging is available during daytime hours in areas where they expect to be able to charge. This figure also underrepresents when vehicles are occupying a charging spot but are not actively charging. It will be important to keep track of how these load profiles evolve to ensure Electric Avenue has adequate charging capacity and are creating the right tools for customers to charge (and do so at a grid-optimal time of day).

Figure 11 – Electric Avenue Average Load Profiles by Month

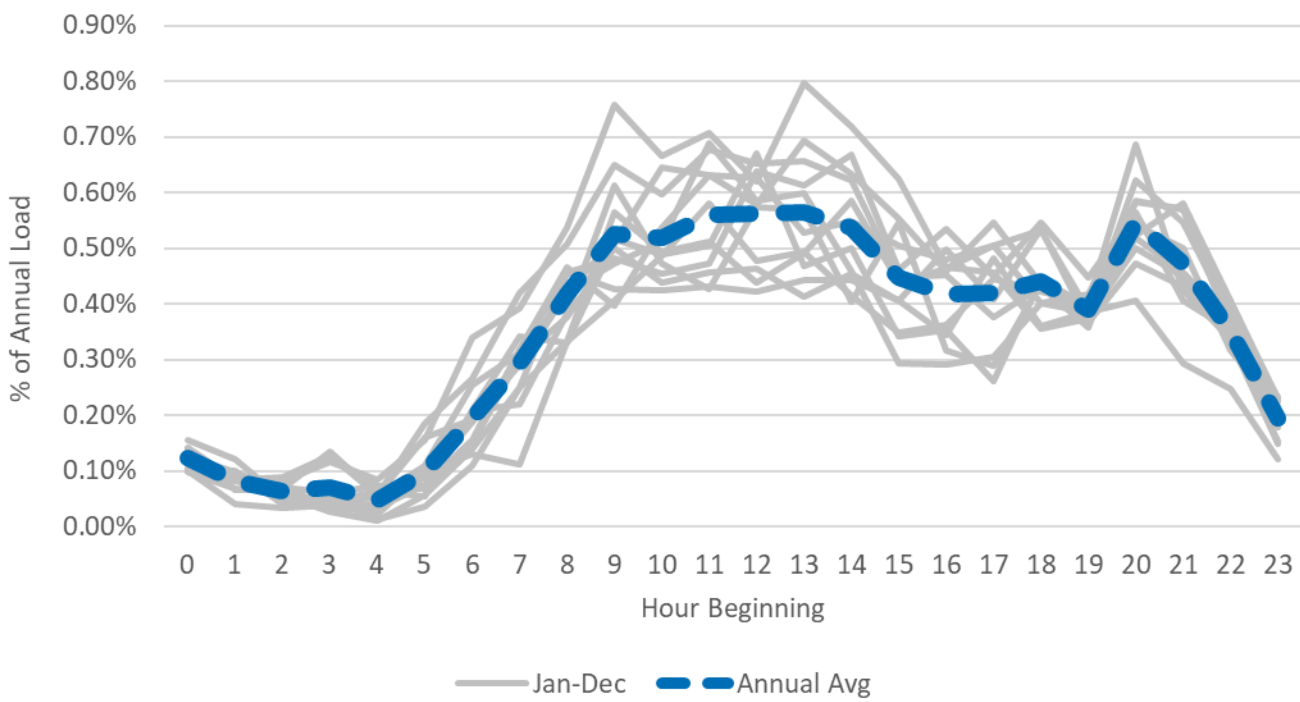

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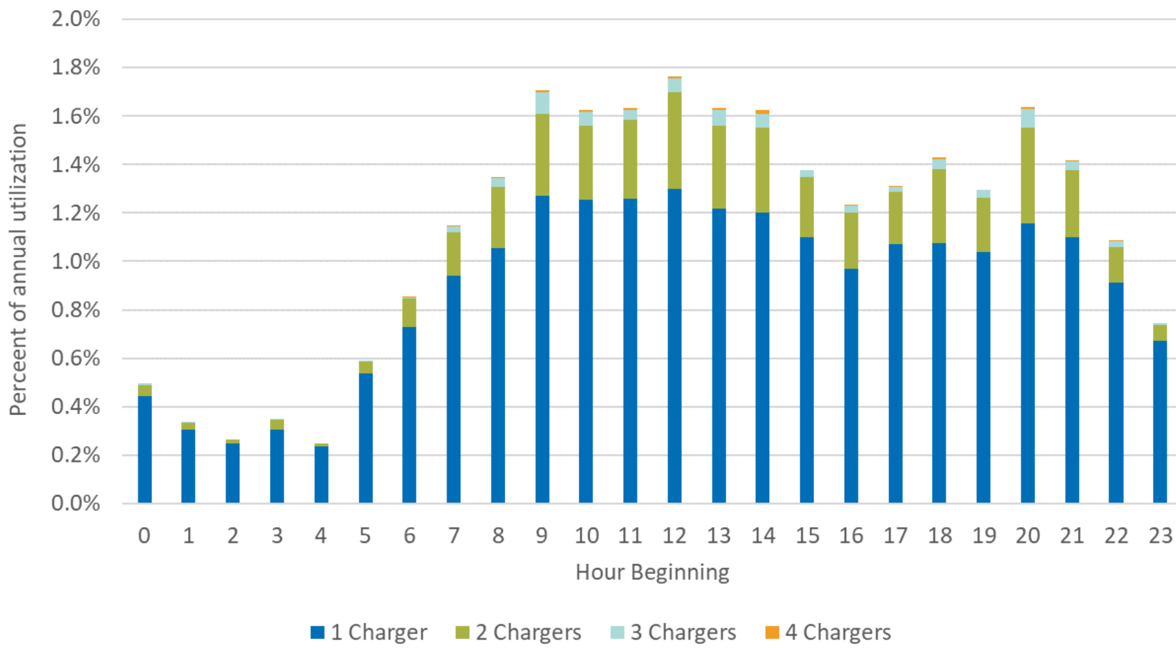
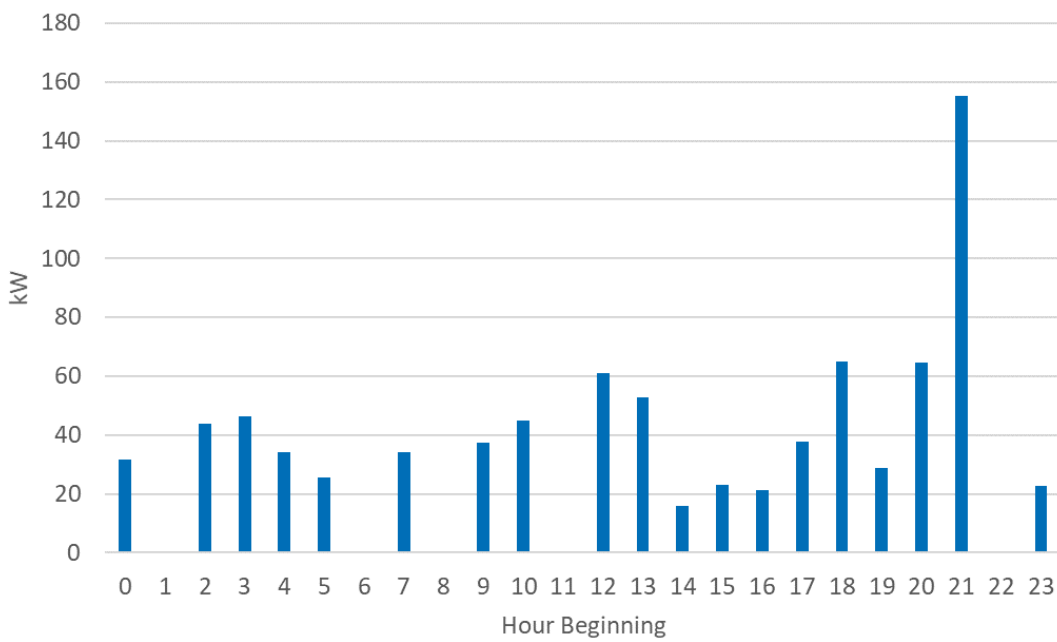
Figure 12 provides a breakdown of how often a given number of the DCQC ports were in concurrent use over the past year at the WTC Electric Avenue location.

Figure 12 – WTC Electric Avenue 2.0 Percent Charger Utilization (Sep 2018 - Sep 2019)



Understanding the maximum power consumption of clustered public fast chargers (i.e. non-coincident peak) is important for local system planning. Evaluating average demand at time of bulk electric system peak (i.e. coincident peak) helps ensure we account for EV energy and capacity needs. A typical Electric Avenue site is equipped with four DCFC stations (50 kW) and one or two L2 chargers (7.2 kW) at the site. The potential maximum power demand when all chargers are in use at these sites is therefore approximately 200-215 kW. It is noted that this is an upper bound, and actual demand will depend on the type of EV battery and the state of charge at the time of coincident charging. Figure 13 shows an indicative hourly demand profile for WTC Electric Avenue on the day with the highest single-hour demand in 2019:

Figure 13 – Hourly Demand from Electric Ave 2.0 on Peak EV Demand Day (June 15, 2019)



The average kW shown in Figure 13, above, is 35 kW and peaks at 155 kW at 9:15 PM when all four DCFC ports are in simultaneous operation. The resulting load factor (average kW / peak kW) is therefore 0.23. This is a relatively low load factor indicating that the EV charging at Electric Avenues has a high difference between average and peak charging rates. Table 13 below shows the coincident and non-coincident peak of WTC Electric Avenue over the last year:

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Table 13 – WTC Electric Avenue Coincident and Non-Coincident Peak Loads

Year	Month	Coincident Peak	Non-Coincident Peak
2018	September	110	141
2018	October	128	143
2018	November	107	128
2018	December	117	117
2019	January	93	139
2019	February	105	105
2019	March	97	121
2019	April	113	128
2019	May	131	131
2019	June	117	126
2019	July	127	134
2019	August	127	166

The following figures highlight different customer usage patterns for WTC Electric Avenue chargers under different pricing structures and time of week.

Peak pricing successfully modified customers' charging behavior at the Electric Avenue 2.0 site, as shown in Figure 14 below. In February of 2018, PGE implemented a $0.19/kWh charge from 3-8pm to try and shift consumption away from the system peak.

Figure 14 – Electric Ave 2.0 Hourly Weekday Load Profile Before/After Peak Pricing

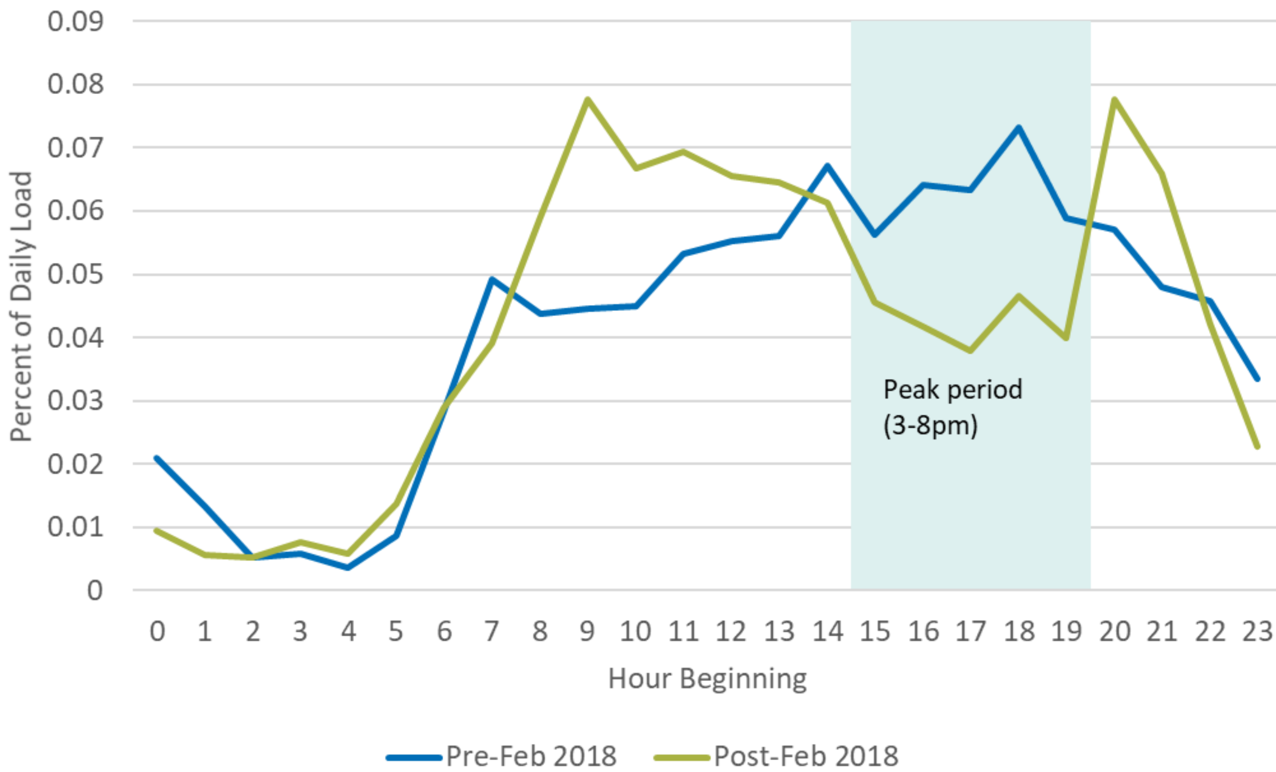

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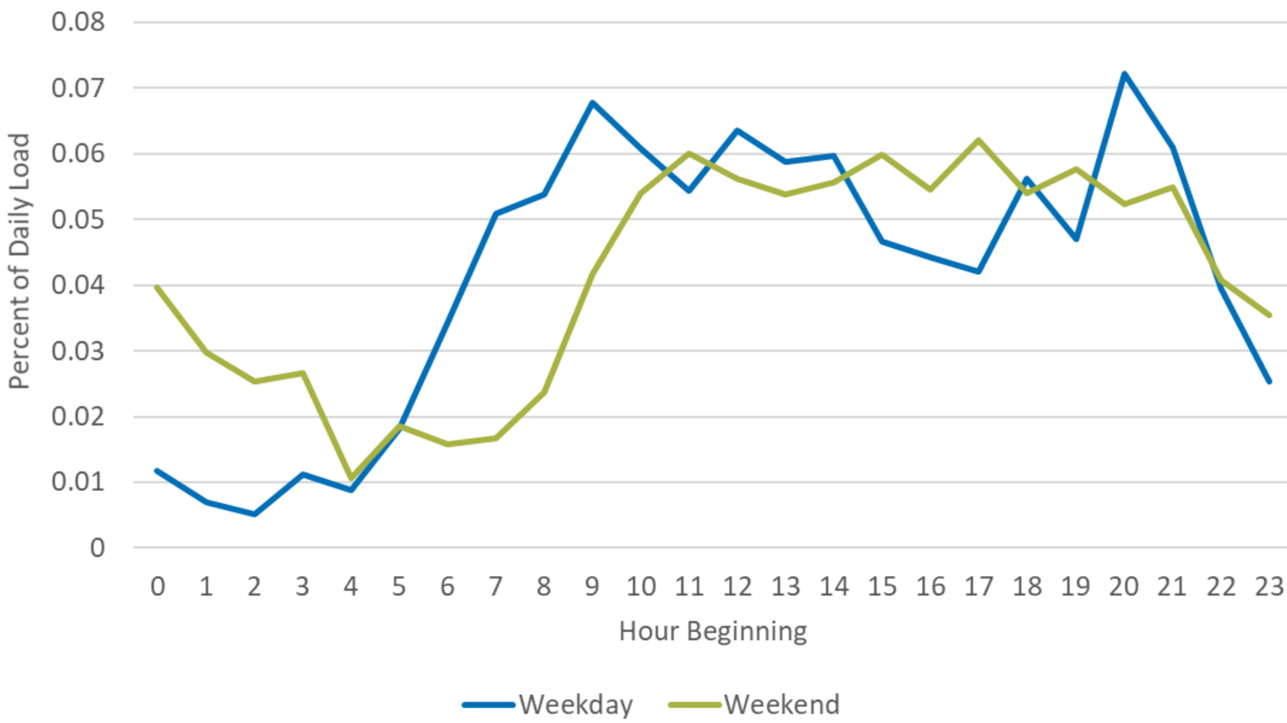
Figure 15, below, shows the differences in charging at WTC Electric Avenue 2.0 on weekdays versus weekends. On the weekends, charging begins a few hours later and does not have a noticeable decrease during the 3PM to 8PM window because weekends are defined as off-peak and therefore have no commensurate price signal.

Figure 15 – Weekday vs. Weekend Load Profile – WTC Electric Ave 2.0



1.3.2.3 *Workplace/Fleet Charging*

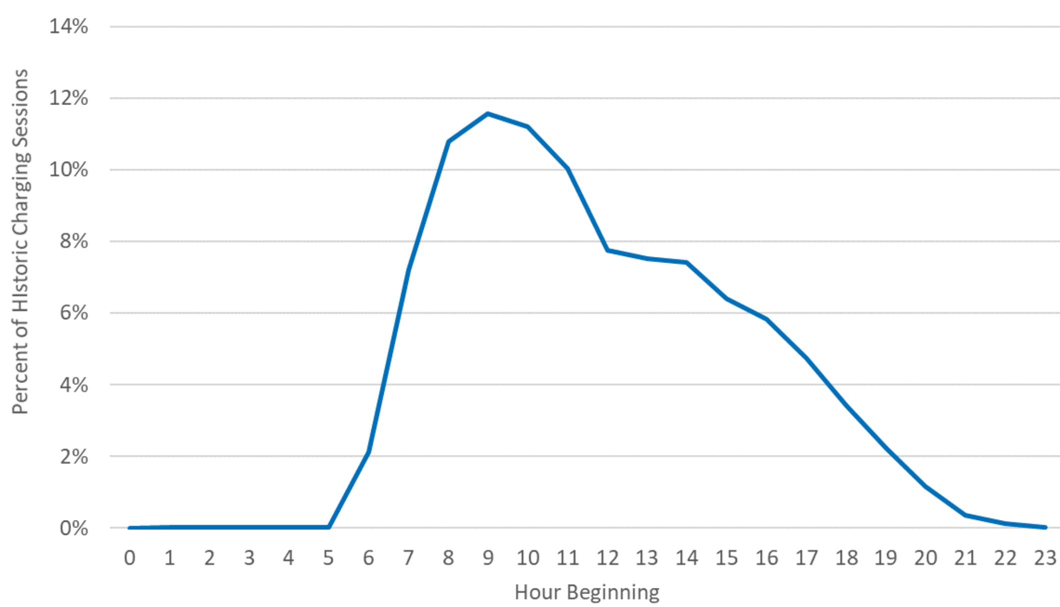
PGE has operated business workplace charging at multiple locations including the World Trade Center, various service centers, and generating facilities for both employee and fleet charging use cases. This experience has provided useful information on how chargers are utilized. Table 14 shows the number of ports by charging power along with summary statistics for commercial charging:

Table 14 – Summary of PGE-Owned EV Charging Infrastructure for Commercial and Fleet Uses

Commercial Type	No. of L2 Ports	No of DCQC Ports	Cumulative MWh Sales
PGE Workplace	57	1	199
PGE Fleet	16	0	83
Other Public / Destination	15	6	346
Total	**88**	**6**	**629**

PGE analyzed cumulative session charging data for each location to understand how employees are using the chargers. Figure 16 below shows the hourly profile of active charging sessions at the largest workplace by number of EV drivers.

Figure 16 – Charger Utilization Since Install of PGE Workplace Charging, (Tualatin Contact Center)



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PGE also analyzed other indicators of workplace charger usage to inform this Plan. Table 15 below provides details pertaining to select locations where PGE employees have access to dedicated charging:

Table 15 – Summary of PGE Workplace Charging Locations

PGE Location	No. of L2 Ports	Avg. Max Output per Port (kW)	Est. No. of EV Drivers
Tualatin Contact Center	4	3.6	14
Salem Line Crew Center	2	8.3	1
Rose City Core	4	3.1	6
Portland Service Center	4	8.3	8
Oregon City	2	6.2	0
Salem Brown House	2	4.2	0
Beaver Generating Plant	4	8.3	3

Table 16 shows the percentage of time in 2018 that a given number of ports were actively charging simultaneously. The Tualatin Contact Center had the highest utilization (37% of the year at least one port was active) and the highest number of EV drivers (14). Additionally, 4% of the year all four ports were actively charging. This figure helps us evaluate if and when more chargers are needed at a given site.

Table 16 – 2018 Analysis of PGE Workplace Port Utilization

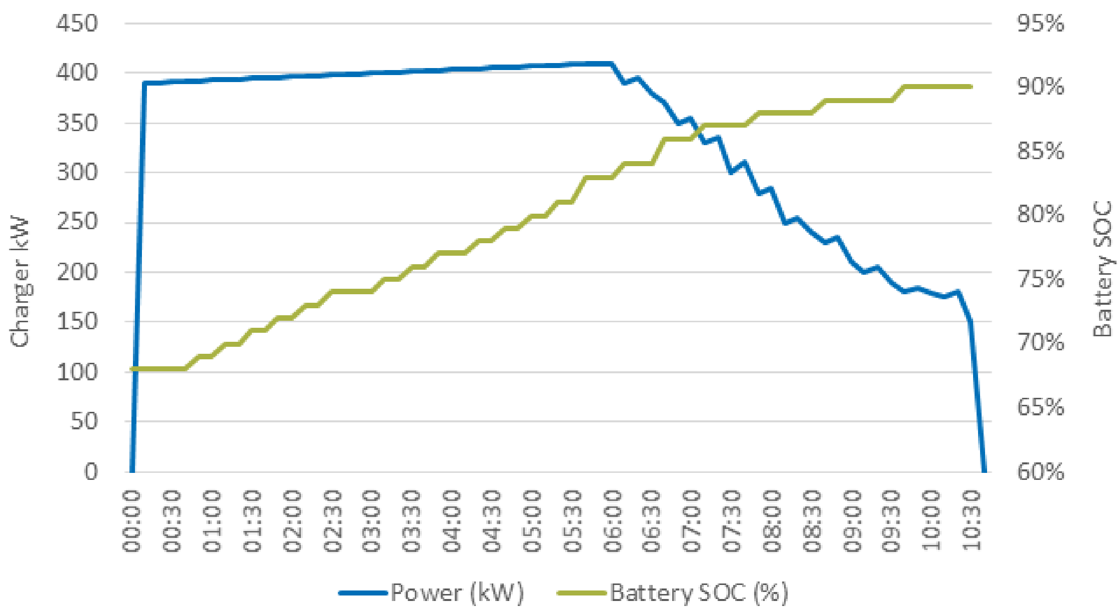
PGE Location	0 Ports Active	1 Port Active	2 Ports Active	3 Ports Active	4 Ports Active
Tualatin Contact Center	63%	12%	11%	10%	4%
Salem Line Crew Center	83%	17%	0%	-	-
Rose City Core	79%	10%	7%	3%	1%
Portland Service Center	66%	22%	8%	3%	1%
Oregon City	99%	1%	~0%	-	-
Salem Brown House	99%	1%	~0%	-	-
Beaver Generating Plant	90%	10%	~0%	~0%	~0%

1.3.2.4 *Medium and Heavy-Duty Charging*

Large fleets of heavy-duty vehicles will have unit impacts on the system. Charging patterns will be driven largely by fleet use case, vehicle type, route, charging speeds, number of vehicles in the fleet, etc. Though there are few electric MHDVs in our service area today, TriMet's first electric bus line (Line 62) has been operational since April 2019. This line is comprised of 5 battery electric buses that run between the Sunset Transit Center and Washington Square. Electricity for Line 62 is served by a combination of on-route and depot charging solutions.

Figure 17 illustrates a typical power draw pattern from the on-route charging station (nameplate of 450 kW), with power quickly ramping to almost 400 kW, from where it gradually increases until the battery reaches between 80-85% state of charge (about six minutes into the session). After that point, the charge ramps down until the battery is fully charged at 90% state of charge. The entire session lasts just over 10 minutes.

Figure 17 – TriMet 450 kW On-Route Charger Load Profile



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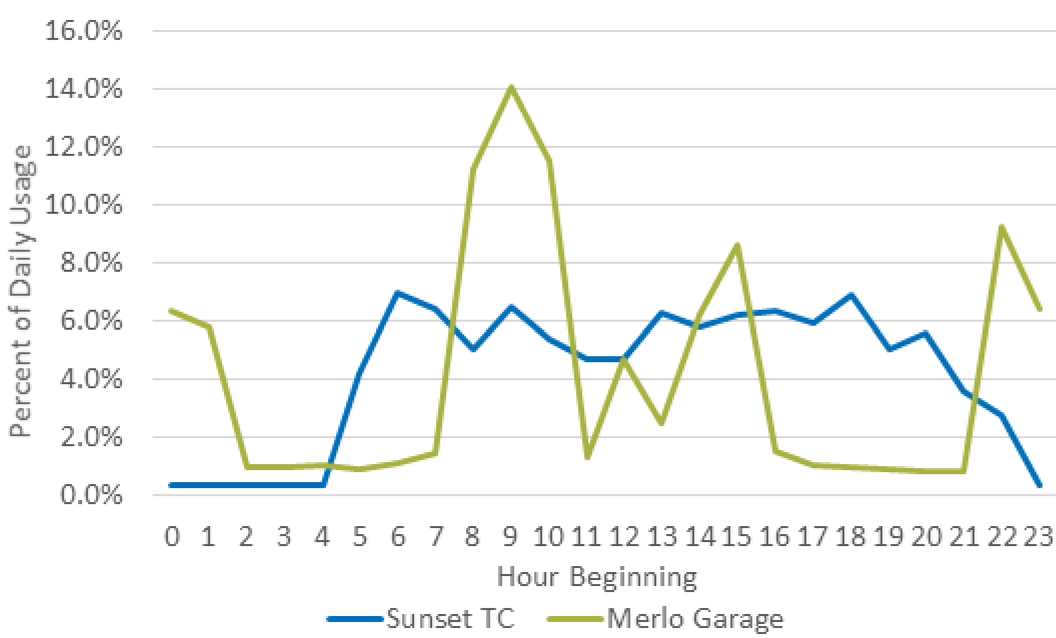
As transit agencies move to electrify their fleets, it will be important to consider how such on-route charging and depot charging impact system peak: from a utility planning perspective, as a measure to mitigate customer demand charges, and also to ensure that the full benefits of electrification are realized. Table 17, below, shows the energy usage by location for TriMet's line 62 and what percent of charging is happening during PGE's peak periods:

Table 17 – TriMet Line 62 On- and Off-Peak Energy Consumption Since (March-August 2019)

Location	On-Peak kWh (3-8pm weekdays)	Off-Peak kWh	Total kWh	% On-Peak
Merlo Garage	77	2,947	3,024	3%
Sunset Transit Center	18,989	74,678	93,667	25%
Total	**19,065**	**77,626**	**96,691**	**25%**

Figure 18 shows the current load shapes for the Electric Mass Transit Pilot. These shapes are likely to change in the future as they do not include all buses in service and include some charging equipment testing early in TriMet's deployment.

Figure 18 – Hourly Load Shape of Electric Mass Transit Pilot



Though every customer's use cases for charging will be unique, early discussions with customers suggest that customers will prefer vehicles with longer battery range and overnight depot charging due to existing operational parameters, reduced logistics challenges, and less need for on-peak charging.

1.4 Number of EVs in PGE's Service Area

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to:… (D) Number of electric vehicles of various sizes in the utility service territory and projected number of vehicles in the next five years;*

In Oregon, 3.1 million licensed drivers operate 3.2 million registered passenger vehicles.[61] As of September 2019, 25,000 of those vehicles (or less than 1%) are BEVs or PHEV.[62] Table 18, below, illustrates the cumulative numbers of EVs in Oregon and the related rate of adoption:

Table 18 – Cumulative EV Adoption in Oregon[63]

Vehicle Type	2014	2015	2016	2017	2018	2019 (Jan-Jul)
BEVs	4,098	5,607	7,647	9,861	13,189	15,635
PHEVs	2,415	3,188	4,605	6,309	8,897	9,895
Total	6,513	8,795	12,252	16,170	22,086	25,530
YOY Growth	-	**35 %**	**39%**	**32 %**	**37 %**	**16 %**

Nearly two-thirds (63%) of the state's EVs are in PGE's service territory. Table 19 shows the increase in EV registrations by PGE customers over time:

Table 19 – Cumulative EV Adoption in PGE Service Territory over time

Vehicle Type	2016	2017	2018	2019 (Jan-Jul)
BEVs	5,606	6,664	9,371	10,249
PHEVs	3,314	4,092	5,492	5,882
Total	**8,920**	**10,756**	**14,863**	**16,131**

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[61] See: https://www.oregon.gov/ODOT/DMV/Pages/News/factsstats.aspx

[62] See: https://energyinfo.oregon.gov/blog/2019/8/21/state-celebrates-halfway-mark-to-50000-electric-vehicles-on-oregon-roads

[63] ODMV through June 2019.

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During PGE's 2019 IRP process, PGE worked with Navigant to develop forecasts for many distributed energy resources (DERs) and evaluate their impacts upon the system plan. Included in that analysis was a forecast on EV adoption (LDV, MDV, and HDV). Table 20 outlines the various assumptions that went into our reference, high, and low scenarios for adoption:

Table 20 – EV Adoption Scenarios Assumptions

Assumption	Low EV Forecast	Reference Case	High EV Forecast
Technology Costs	Navigant high lithium-ion costs	Navigant reference lithium-ion costs	Navigant low lithium-ion costs
Policies	Decreased vehicle availability, production, and marketing	Navigant reference case for vehicle availability, production, and marketing	Increased vehicle availability, production, and marketing
Carbon Prices	PGE low carbon price future	PGE reference carbon price future	PGE high carbon price future
TOU Participation	0% residential TOU	10% residential TOU	Opt-out residential TOU

As illustrated in Table 21, below, EV adoption is on the rise. These vehicles will need reliable charging infrastructure to ensure they fulfill their primary function of moving people and goods. Later in this section we will discuss the load and system impacts of those vehicles.

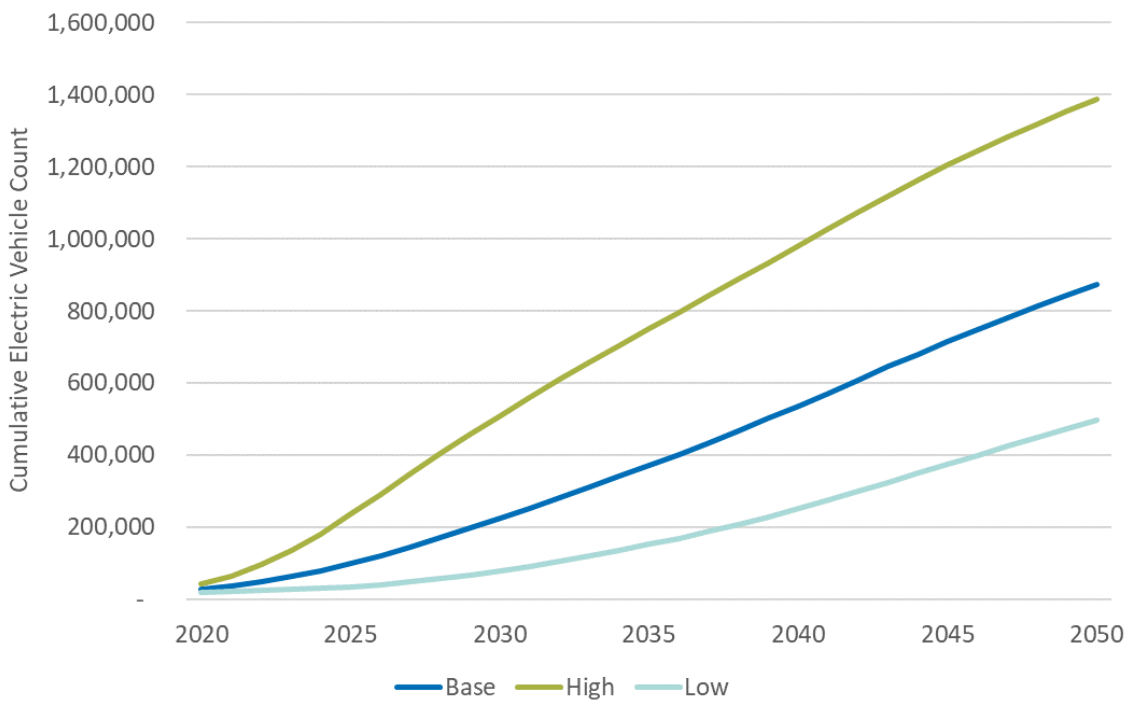
Table 21 – PGE Service Area EV Forecast through 2050 by Vehicle Type (Reference Case) [64]

Vehicle Type	2020	2025	2030	2035	2040	2045	2050
Light Duty	28,000	99,000	225,000	371,000	537,000	715,000	875,000
Medium Duty	20	500	3,300	8,000	14,000	23,000	33,000
Heavy Duty	10	200	1,500	4,000	8,000	12,000	18,000
Total	**28,030**	**99,700**	**229,800**	**383,000**	**559,000**	**750,000**	**926,000**

[64] Navigant. Distributed Resource and Flexible Load Study (from PGE's 2019 IRP, page 465*)*.

Figure 19, below, shows that there remains a high degree of uncertainty in future EV adoption. Factors contributing to this uncertainty include: vehicle/battery costs, customer acceptance, policy, manufacturers' abilities to convert supply chains, and other economic considerations.

Figure 19 – LDV Scenario Forecasts, PGE Service Area



PGE strives to work with stakeholders to drive higher EV adoption in order to enable Oregon to make more progress toward the state's decarbonization goals. Achieving those outcomes will require a mix of policy, infrastructure, rates, customers programs, and vehicles.

1.4.1 Other Trends:

We are at a pivotal point in one of the most transformative periods in transportation. Consider these trends:

- Driver's licenses are declining among younger generations.[65]
- Growing adoption of car-sharing, like ReachNow or car2go, and of ride-sharing, such as Uber and Lyft.[66]
- A recent pilot for electric scooters in Portland resulted in fewer car trips.[67]

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[65] "Disruptive trends that will transform the auto industry." McKinsey & Company, January 2016. Available at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/disruptive-trends-that-will-transform-the-auto-industry

[66] "Cracks in the ridesharing market—and how to fill them." McKinsey & Company, July 2017. Available at: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/cracks-in-the-ridesharing-market-and-how-to-fill-them

[67] "2018 E-Scooter Pilot: User Survey Results." Portland Bureau of Transportation, 2018. Available at: www.portlandoregon.gov/transportation/article/700916

- The introduction of autonomous vehicles may result in people opting to take driverless cars instead of driving themselves.[68]

As a result of the above, car ownership may have already hit its peak.[69] As trends and technologies continue to change the way we move, we are preparing for a dramatic evolution over the next decades. It is important that we closely monitor transportation sector trends to ensure that we update our forecasts as appropriate.

[68] Walker, Jonathan and Charlie Johnson. Peak Car Ownership: The Market Opportunity of Electric Automated Mobility Services. Rocky Mountain Institute, 2016. Available at: http://www.rmi.org/peak_car_ownership
[69] Ibid.

1.5 Other Transportation Electrification Infrastructure

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to:… (E) Other transportation electrification infrastructure, if applicable;*

This section details infrastructure needs, gaps, and active EV charging deployments in our service area.

1.5.1 Charging Needs Assessment

As part of the EV forecast outlined in the previous sections, PGE worked with Navigant to develop an EV charging needs assessment for 2025 and 2050. This needs assessment is a forecasting model that leverages, amongst other sources, the National Renewable Energy Laboratory's (NREL) EVI-Pro tool, PGE's base case EV forecast, local demographics and traffic patterns, existing charging stock, and characteristics of the local building stock. The primary purpose of the model is to identify locational charging needs (by zip code) for LDV charging at the home, in public, and at the workplace. PGE was primarily interested in understanding the near-term infrastructure requirements to support the base case IRP forecast for PHEV adoption in PGE's service area. The modeling exercise assumed a minimum density of one charging station per 2.5-mile radius. PGE conducted a sensitivity analysis using 1- and 5-mile scenarios and determined that 2.5-miles resulted in a reasonable number of sites while maintaining an acceptable distance an EV driver would have to travel to access a charging station.

The model identifies Level 1 (L1), Level 2 (L2), and Direct Current Quick Charge (DCQC) charging needs for the following use-cases:

- **Home**:
  - **Single-Family (SF)**: charging stations installed at a SF home for individual use.
  - **Multi-Family (MF)**: charging stations installed at MF home sites for shared use.
  - **Shared**: public charging sites that aim to serve home-charging challenged (charging stations located near homes without access to off-street parking or other constraints prohibiting home charging stations).
- **Workplace**: charging stations at workplaces available for use by employees.
- **Public**: charging stations accessible to all.
- **LDV Fleet**: private charging stations available for use only by dedicated fleets.

The needs assessment model was structured with the objective to ensure equitable access to EV charging (maximizing geographic coverage) within PGE service area. Table 22, below, identifies the future charging needs identified in our service area by charging speed and end use case:

Table 22 – EV Charging Future Needs: Port Count, by Use Case, Year, and Charger Type

	2025			2050		
Charger Type	**L1**	**L2**	**DCQC**	**L1**	**L2**	**DCQC**
Home (SF)	34,778	43,633	0	38,452	346,500	0
Home (MF)	0	856	121	0	20,525	5,085
Home (Shared)	0	220	38	0	9,020	2,217
Workplace	0	1,813	0	0	21,388	0
Public	0	3,392	221	0	11,692	654
Fleet (LDV)	0	387	415	0	160	1,767
Total	**34,788**	**50,301**	**795**	**38,452**	**409,285**	**9,723**

Figure 20 – EV Charging Future Needs: Port Density by Zip Code

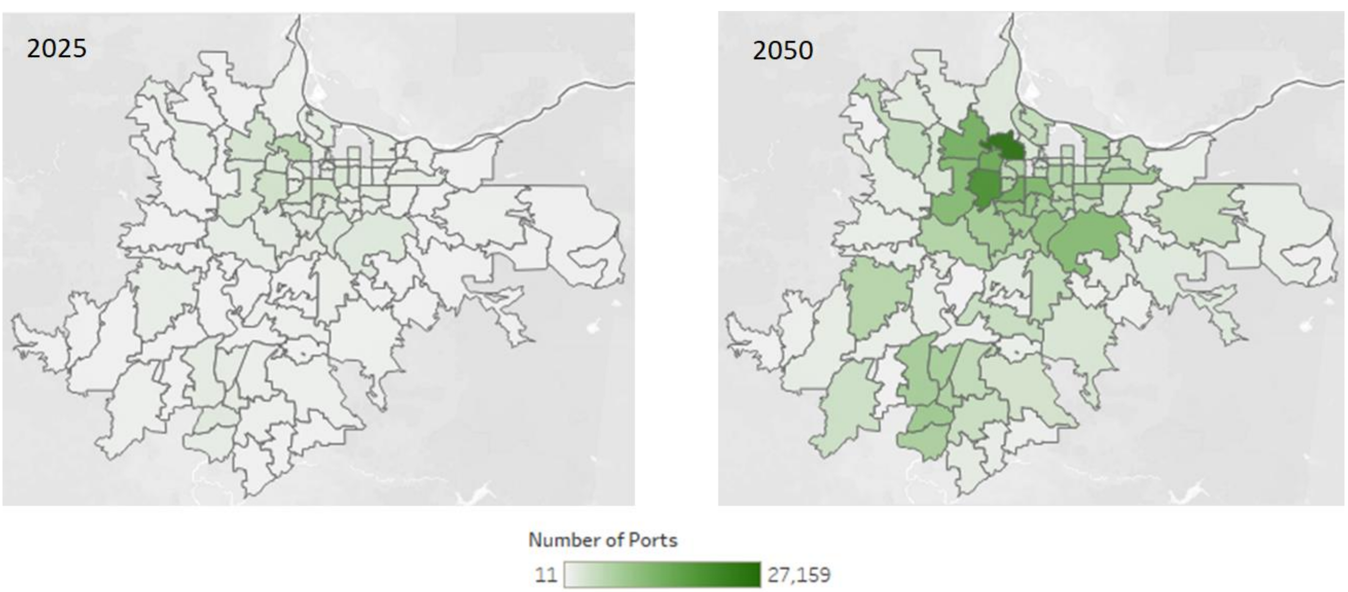
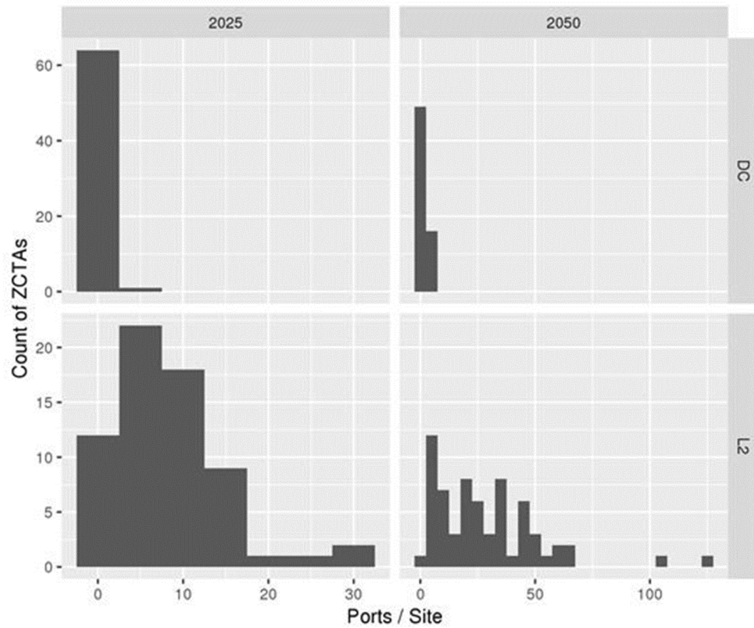


Figure 20, above, illustrates the forecasted EV charging needs for customers in the PGE service area. In 2025, most Zip Code Tabulation Areas (ZCTAs) have between 5-10 ports per site; however, there has been a growth in charger density per site over time, with some ZCTAs having more than 100 L2 charging stations. Figure 21, below, demonstrates the distribution of charging stations' port density growth over time:

Figure 21 – Charging Stations' Port Density Distributions



ZCTAs with the most ports per site are the Lents area east of Portland, West Slope east of Beaverton, and Multnomah area south of Portland. The results of the needs assessment and charging station distribution analyses will help inform our future infrastructure activities to ensure we have charging adequacy to meet our customers' needs.

1.5.2 Charging Investment in Oregon

In addition to PGE's deployment of Electric Avenue public charging infrastructure (See Section 2.1), several electric vehicle service providers (EVSPs) are deploying additional infrastructure in Oregon. We will continue to analyze these activities carefully to ensure our customers have adequate charging infrastructure to comfortably travel in their EVs. Key infrastructure investments made in Oregon to date include:

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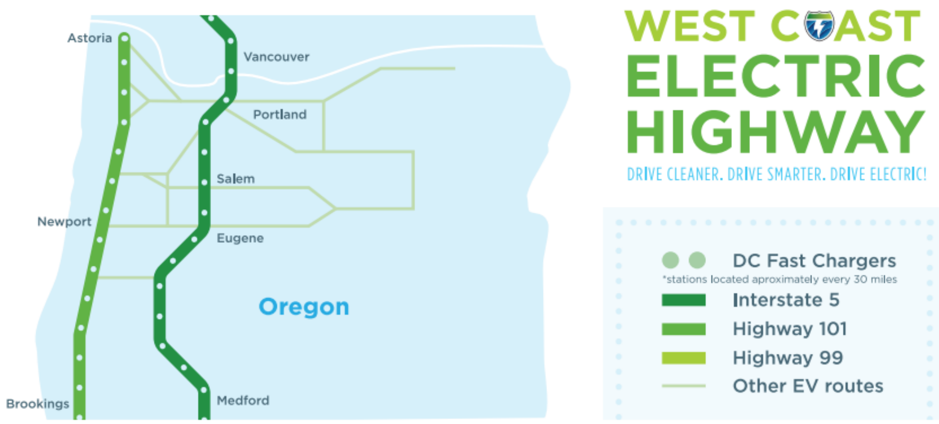
- **Oregon Electric Highway**: The West Coast Electric Highway is a network of fast-charging stations located every 25-50 miles along I-5, Highway 99, and other major roadways in the Pacific Northwest.[70] It is worth noting that many of the quick charging stations deployed in this network only offer a CHAdeMO charging connector, meaning that many vehicle makes and models are not able to use the station. An important learning from these deployments is that public charging infrastructure must be equipped with different ports so that all EVs can utilize it, regardless of make and model. Figure 22 below illustrates the deployment of charging stations along the West Coast Electric Highway:

Figure 22 – West Coast Electric Highway Charging Infrastructure Map

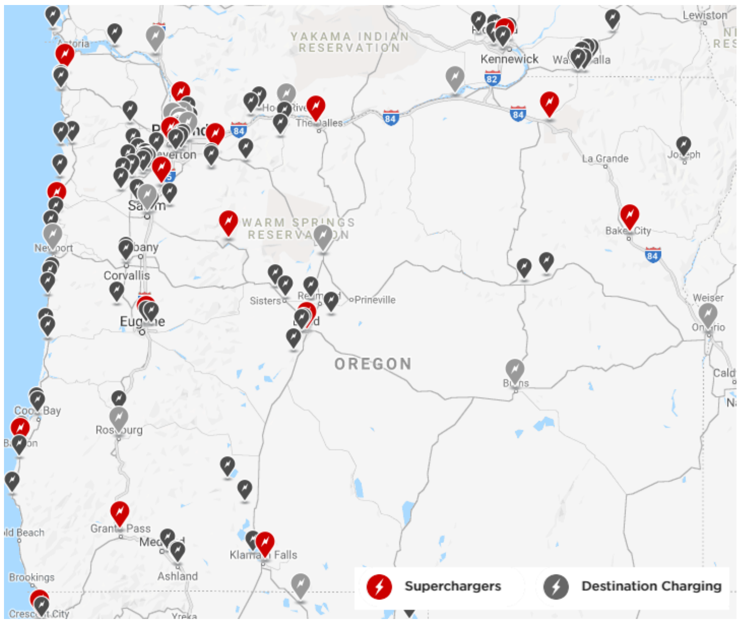


- **Pacific Power (PAC)**: PAC is developing a network of seven public DCQC sites across their service area.

[70] See: https://goelectric.oregon.gov/charge-your-ev

- **Tesla**: As detailed in Figure 23 below, Tesla has made significant investments in charging infrastructure in Oregon. To date Tesla has been identified as having 14 Tesla Supercharge (DCQC) sites, and 12 more “coming soon”. Additionally, Tesla has made investments in several “destination chargers,” defined as L2 charging ports at places where people are likely to travel to (e.g. hotels, parks, wineries). Tesla charging ports are only available for use with Tesla vehicles.[71]

Figure 23 – Tesla Public Charging Network in Oregon[72]



[71] See: https://www.tesla.com/findus/list/superchargers/United%20States
[72] Ibid.

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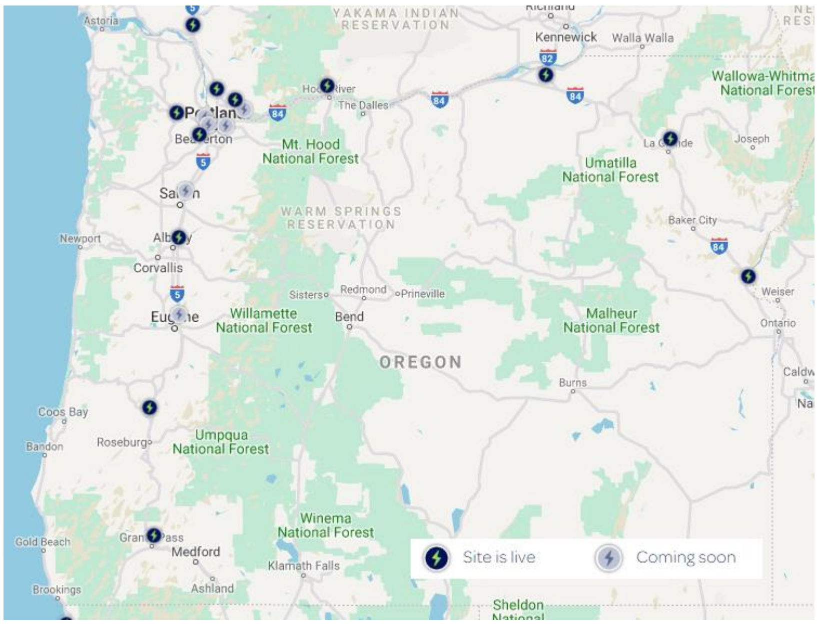
- **Electrify America**: the VW subsidiary has committed to two rounds of investment in Oregon. To date, Electrify America has activated four public quick charging sites in the Portland metro area, with plans to deploy four more soon.[73] Figure 24 below shows Electrify America's deployment of public charging throughout Oregon:

Figure 24 – Electrify America Public Charging Network in Oregon[74]



1.5.3 Medium- and Heavy-Duty Fleet Charging

MDVs and HDVs are likely to have unique needs to support their rapid electrification. Though the market is still emerging, PGE is conducting two key studies to effectively support our customers in electrifying their fleets:

Firstly, PGE is developing a long-term electrification plan for our fleet. Given that we have a mix of LDV, MDV, and HDVs and operate one of the largest fleets in the state, we should understand the challenges and opportunities of electrifying our own fleet. The study will create a replacement schedule for vehicles in our fleet with EVs, create a charging infrastructure and facilities plan to charge those vehicles. The study will also create an input to our distribution system plan to identify what distribution infrastructure upgrades might be required and when we expect to need to make them. The study is ongoing and expected to complete later in 2019.

Secondly, PGE is collaborating with eight electric utilities and two agencies (representing many municipal utilities) on the West Coast Clean Transit Corridor Initiative. This initiative represents a collaborative utility effort to better understand the long-haul trucking sector so we can establish a collective understanding of what barriers and opportunities exist for electrifying long-haul trucking along the I-5 corridor from Mexico to Canada. The fleet study

[73] See: https://www.electrifyamerica.com/locate-charger
[74] Ibid.

is looking at variables such as freight requirements and traffic volume for long-haul trucking; it will also review how much charging would be necessary and where to deploying it to support the sector. The target for completion of the study is the end of 2019.[75]

PGE is also focused on customer support for medium- and heavy-duty fleets. We are currently working with several customers that are evaluating potential investments in heavy duty electric vehicles. PGE is helping these customers identify charging requirements and system needs to support their electrification goals.

75 See: https://newsroom.edison.com/releases/west-coast-power-providers-explore-ev-charging-for-zero-emission-shipping-along-i-5-connecting-routes.

1.6 Charging and Vehicle Technology Updates

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to… (F) Charging and vehicle technology updates;*

The EV market is rapidly evolving-PGE must actively monitor industry trends and remain nimble so that we can meet our customers' needs throughout the transformation of the transportation sector. In this section we discuss technology changes related to EVs, charging, and trends in interoperability.

1.6.1 Vehicle Technology Updates

The EV market is rapidly evolving: our customers and auto manufacturers are making bold commitments to electrification; costs are continuing to rapidly decline; battery density is improving; and the evolution of shared autonomous vehicles. All of these developments are expected to implications on how and when EVs will impact our system.

1.6.1.1 *Customer and OEM Commitments*

Customer demand for EVs is rising, with Tesla's Model 3 in the top 10 of new car sales for any vehicle.[76] Table 23, below, illustrates that fleet customers are also showing their demand:

Table 23 – Public Corporate Commitments on Fleet Electrification

Company	U.S. EV Fleet commitments
FedEx	Acquired 1,000 EV delivery vehicles in 2019; committed to buy 20 e-HDVs
UPS	Committed to buy 125 e-HDVs and developing a proprietary EV delivery truck
DHL	Purchased 63 EV cargo vans; committed to zero fleet emissions by 2050
Sysco	Committed to convert 20% of fleet to alternative fuels by 2025
Albertsons	Committed to buy 10 e-HDVs
Anheuser Busch	Committed to buy 40 e-HDVs; aims to convert entire fleet to renewables by 2025
PepsiCo	Committed to buy 100 e-HDVs
Amazon	100,00 electric trucks by 2030
City of Portland	Plan to add 60 EVs to sedan fleet by the end of 2020

[76] See: https://cleantechnica.com/2019/08/07/tesla-model-3-9th-best-selling-car-in-usa-in-2nd-quarter/

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Customers are looking for new models and vehicle options, and auto manufacturers are making major investments to meet the demand. Over $200 billion of investment has been committed by major auto manufacturers with plans to deploy over 400 new vehicle models by 2025. Additionally, new entrants to the market such as Rivian (an Amazon-backed electric truck and SUV company) are likely to further accelerate the launch of more EV models. Table 24 below illustrates some of the OEM investments in EV technologies:

Table 24 – Summary of Major Auto OEM Investments in EV Technologies (September 29, 2019)

OEM	Committed EV Investments ($Billion)	Planned No. of EV Models by 2025
	$ 91	80
DAIMLER	$ 42	130
KIA	$ 20	23
Ford	$ 11	28
FCA FIAT CHRYSLER AUTOMOBILES	$ 10	32
Other OEMs	$74	114
TOTAL	**$ 248**	**407**

It is worth noting that many of these vehicle models may not be available in the U.S. or Oregon market. Products are likely to be available where there is a strong balance of policy, infrastructure, and customer demand.

1.6.1.2 *Medium and Heavy-Duty Vehicles are Coming to Market*

We anticipate several dozen plug-in MDVs/HDVs will arrive in the market over the next 10 years (the majority of these in the mid-2020s). Many factors impact the expected timing of electric truck parity with diesel powertrains. Industry leaders expect many of those factors driving to parity by the mid-to-late 2020s.[77] Photographed below is Daimler Trucks North America's CEO, Roger Nielsen, declaring, “The Future is Electric” to a group of industry peers (Figure 25) and announcing Daimler’s first delivery of 100% battery electric class 8 trucks (Figure 26):

Figure 25 – Daimler Trucks NA CEO, Roger Nielsen, Declaring the Future is Electric

Source: Trucks.com

Figure 26 – Daimler’s first deliveries of its 100% electric class 8-truck (eCascadia), August 2019

Source: Daimler Global Media (media.daimler.com)

[77] North American Council for Freight Efficiency. 2019. See: https://nacfe.org/future-technology/electric-trucks/

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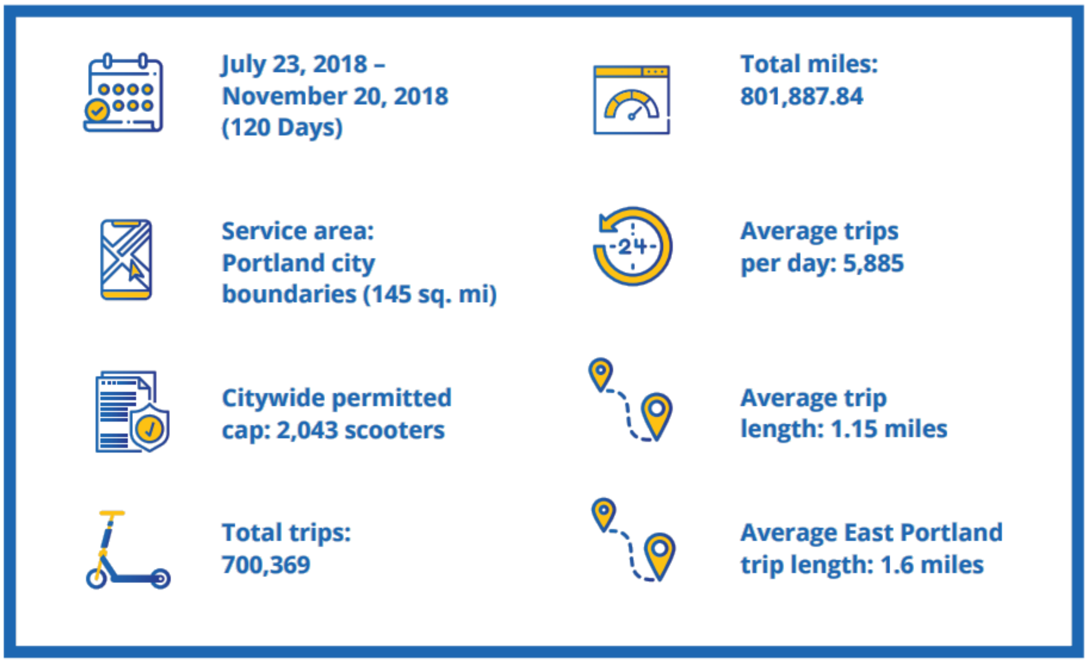
1.6.1.3 *Micromobility is on The Rise*

According to Deloitte Insights, micromobility is the future of urban transportation.[78] Micromobility is defined as small, often shareable-and electric-means of transportation. Today, micromobility is largely comprised of e-scooters and e-bikes. Though the segment is quite small today, its low up-front capital cost and ease of use is driving rapid adoption.

The City of Portland recently concluded a 120-day pilot for electric shared scooters. During that period, tens of thousands of individuals took over 700,000 electric scooter trips. Though the grid impacts of a single scooter are relatively small, if this technology grows it may have material impacts on EV adoption or car utilization, which could impact our system forecasts.[79] Figure 27 below provides further detail regarding the City of Portland's E-Scooter Pilot:

Figure 27 – City of Portland E-Scooter Pilot Overview[80,81]



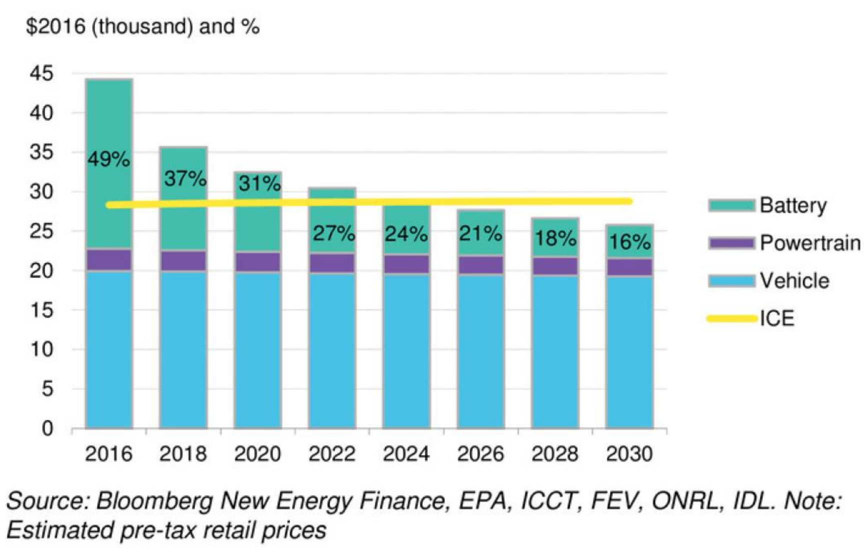
[78] See: https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/micro-mobility-is-the-future-of-urban-transportation.html
[79] See: https://www.portlandoregon.gov/transportation/article/709719
[80] Id.
[81] Id.

1.6.1.4 *Costs are Declining*

Bloomberg New Energy Finance (BNEF) anticipates that EVs will achieve price parity (without subsidy) with ICEVs in the mid-2020s. This confluence is largely driven by the declining costs of batteries. Figure 28, below, illustrates that battery costs have dropped approximately 85% since 2010. BNEF research goes on to indicate that battery costs are declining by approximately 18% each time that cumulative manufacturing doubles (and expects that rate of decline to continue).[82] This is significant, as batteries currently make up about 35% of the cost of a new EV. Figure 29, below, details the impact of forecasted reductions in battery price upon the total cost of an EV.

Figure 28 – Average Lithium Ion Pack Costs ($/kWh)[83]

Figure 29 – US Mid-sized BEV Price Breakdown[84]



[82] BNEF. When Will Electric Vehicles Be Cheaper than Conventional Vehicles? Mar 2018.
[83] BNEF. EV Outlook 2019. Available at: https://about.bnef.com/electric-vehicle-outlook/.
[84] BNEF. When Will Electric Vehicles Be Cheaper than Conventional Vehicles? Mar 2018.

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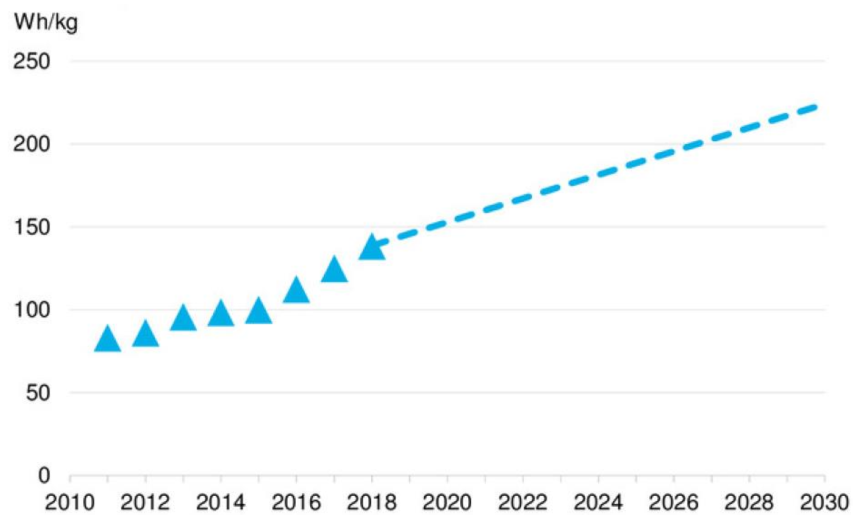
1.6.1.5 *Battery Density is Improving*

As shown in Figure 30, below, BNEF expects battery density to nearly double by 2030. Higher density batteries are likely to drive increased vehicle range to beyond 300 miles, as well as smaller battery capacity requirements, less overall battery weight, and a lower battery cost.

Figure 30 – Historical and forecast average battery energy density (Wh/kg)[85]



Source: BNEF

1.6.1.6 *Shared and Autonomous Fleets Continue to Evolve*

Many of our customers are already making the transition from car ownership to utilizing a shared vehicle. Companies like TriMet, car2go, Get Around, ReachNow, Uber, and Lyft are making it simpler and more cost effective for residents to forego car ownership, and rather subscribe to a transportation service. As battery prices continue to decline, public charging infrastructure proliferates, and electricity will likely be the most cost-effective fuel, these transportation service fleets are expected to electrify.[86] The above companies are likely only a small subset of the future transportation services. Tesla, Google, Apple, BMW, General Motors Company (GM), Ford and other industry players have announced plans to support an autonomous vehicle share program in one form or another.[87,88,89,90] Google's autonomous vehicle subsidiary, Waymo, recently declared that they have "driven more than 10 million miles in the real world, and over 10 billion miles in simulation."[91] Rocky Mountain Institute

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[85] Id.
[86] See: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/disruptive-trends-that-will-transform-the-auto-industry
[87] See: http://insideevs.com/google-reveals-electric-self-driving-car-video
[88] See: http://www.investors.com/news/technology/apple-car-moving-forward-direction-unknown/
[89] See: https://www.wired.com/2016/09/self-driving-autonomous-uberpittsburgh
[90] GTM: How to Accelerate EV Market, 2016. Available at: https://www.greentechmedia.com/articles/read/how-to-accelerate-the-electric-vehicle-market
[91] See: https://techcrunch.com/2019/07/10/waymo-has-now-driven-10-billion-autonomous-miles-in-simulation/

(RMI) projects $2.8 billion of investment in autonomous mobility in the Portland Metro area by 2025.[92] The commodity of mobility service could drop below the operating cost of a personal vehicle, down to around $0.30 per mile (less than gasoline and parking for a personal vehicle).[93] Rapid proliferation of autonomous vehicles could accelerate the demand for electric fueling infrastructure and could change the locations of where charging is needed.[94] Technological maturity and state and local policies will have a major impact on how and when autonomous vehicles enter our service area.

1.6.2 Charging Technology Updates

Charging trends are continuing to evolve as the EV market matures. Efforts exist to increase charging speeds, decrease grid integration costs, extract new value from EVs (e.g. V2G), and to improve operational logistics. Developments in any of these areas may significantly alter the impact of EVs upon PGE's system, so we must closely monitor technology updates.

1.6.2.1 *Charging Stations are Getting Faster and Drawing More Power*

Mass market adoption beyond the innovator stage, as well as the proliferation of the HDV market, are driving charging OEMs to accelerate the rates of EV charging. Just this year has seen the standard for DCQC jump from 50 kW to 150 kW; and many LDV manufacturers aspire to have their vehicles accept a 350 kW charge.[95,96] Tesla has indicated that they will develop faster charging stations and enable existing vehicles to utilize the same with over-the-air software updates.[97]

HDV electrification is further putting pressure on charging speeds, with Tesla's planned heavy-duty truck expected to be able to accept a charge sufficient to delivery 400 miles of range within 30 minutes. This equates to over 1.5 MW charging speeds, and over eight times the capacity of an entire Electric Avenue site for a single charger.[98] Other industry players have indicated the possibility of charging speeds up to 3 MW. CharIN, a global leader in vehicle charging standards, has established a High-Power Charging for Commercial Vehicles Working Group, for which many auto and charging OEMs are actively working to establish standards.[99]

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[92] Walker, Jonathan and Charlie Johnson. Peak Car Ownership: The Market Opportunity of Electric Automated Mobility Services. Rocky Mountain Institute, 2016. Available at: http://www.rmi.org/peak_car_ownership
[93] Id.
[94] In a highly autonomous future, charging may not be so widely distributed as home charging stations are today and may be concentrated in centralized charging depots.
[95] See: https://electrek.co/2019/07/17/porsche-taycan-250-kw-charging-launch-promised-350-kw/
[96] See: https://electrek.co/2018/12/06/electrify-america-first-350kw-charger-california/
[97] See: https://www.tesla.com/blog/introducing-v3-supercharging
[98] See: https://cleantechnica.com/2017/11/17/tesla-semi-8-charger-holes-800-kwh-battery-tesla-megacharger-1-6-megawatts/
[99] See: https://www.charinev.org/fileadmin/HPCCV/High_Power_Commercial_Vehicle_Charging_Requirements_v2.0.pdf

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As illustrated in Table 25, below, PGE has already started to see the deployment of high-powered charging infrastructure in our service area. We expect to see continued and increasing customer demand for these deployments in the future.

Table 25 – Cumulative Number of High-Powered Chargers Deployed in PGE Service Area (Estimated)

Charger Speed	2016	2017	2018	2019
No. of 25kW+ chargers	189	195	222	302
No. of 150kW+ chargers	0	0	8	41
No. of 350kW+ chargers	0	0	0	1
No. of sites > 250 kW	12	14	17	37

Figure 31, below, is an example of the high-powered charging infrastructure that PGE is starting to see deployed in our service area:

Figure 31 – Electrify America Charging Stations (Cornelius, OR)

(Source: Plugshare.com)

1.6.2.2 *Technology Innovations are Reducing Integration Costs*

There is growing investment in portable charging stations, which are defined as batteries with EV charging ports integrated into the unit. BP recently demonstrated their interest in the technology by investing $15M into FreeWire Technologies.[100] Other promising products include the Spark Charge's modular charging unit, which offers emergency charging to stranded drivers. These technologies have the potential to offset the need for new grid infrastructure to support new charging hardware. Such units could be charged overnight and then charge a vehicle in a parking lot during the day without the need to install additional charging infrastructure. Figure 32 is a photo of a BP FreeWire battery charging a Nissan Leaf without any connection to the grid.

Figure 32 – FreeWire Mobile Battery Charging a Nissan Leaf

[100] See: https://news.bloombergenvironment.com/environment-and-energy/bp-leads-15-million-investment-in-charging-business-freewire

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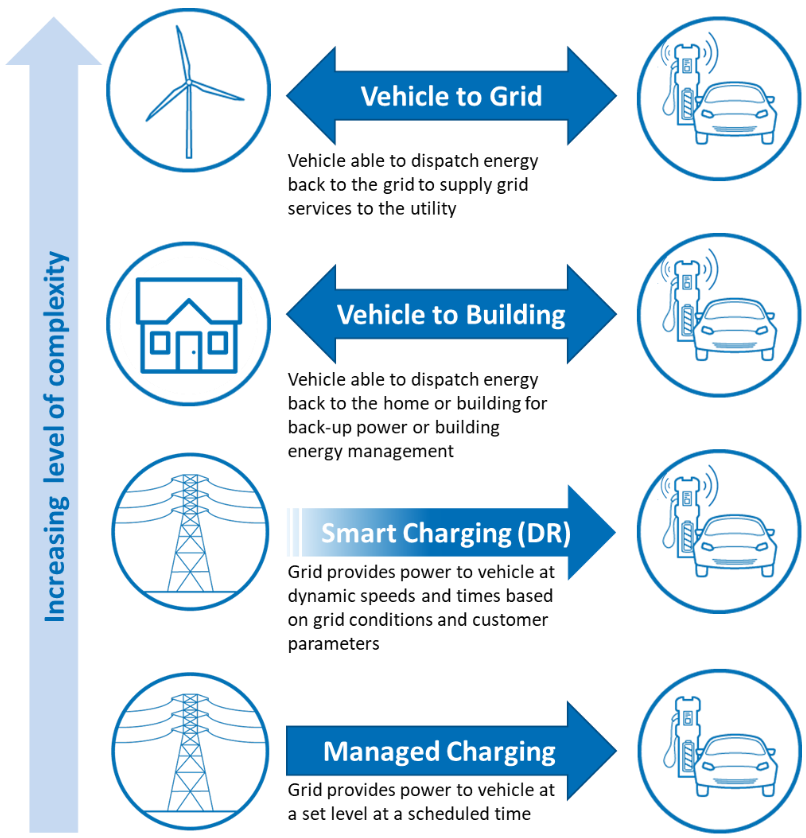
1.6.2.3 *Vehicle to Grid*

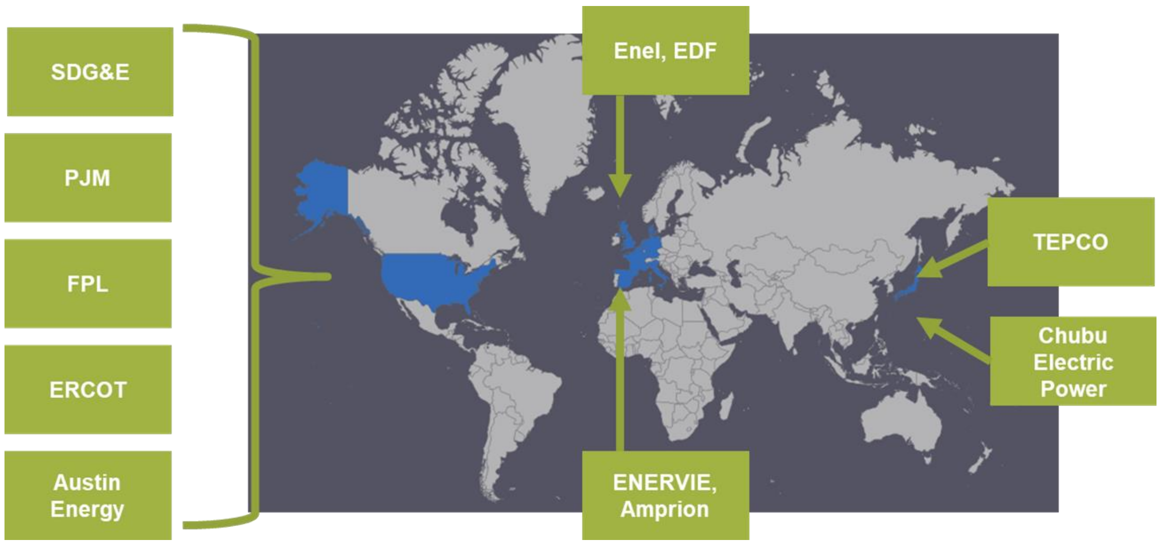
V2G technology enables electricity to flow from a car battery back onto the electrical grid or directly into a building. The key components of the V2G ecosystem include A) EVs equipped with battery and inverter hardware capable of bi-directional energy flow, B) charging equipment that safely connects EVs to the grid, and C) communication software giving grid operators control of charge and discharge. When users are not driving vehicles, their vehicle batteries can act as a form of storage capable of providing a variety of services critical to a safe, reliable, and low-carbon grid of the future. By dispatching energy back to the grid, V2G chargers can realize more benefits than traditional smart charging (i.e. incremental capacity, backup power, ancillary services). Figure 33, below, illustrates how V2G is built upon-and differs from-related charging technologies:

Figure 33 – Smart Charging/V2G Hierarchy



It should be noted that V2G is in a relatively immature state. Not all EVs are currently equipped with the hardware necessary to enable bi-directional power flows-particularly through alternating current (AC) L2 charging. Interconnection standards often only approve of the flow of electricity from UL1741-certified devices. Standards need to expand to also accept electricity from SAE J2072-certified devices. These limitations mean that only a few select vehicle models are currently capable of delivering V2G. We must see demonstrable progress on battery impacts (energy storage life and OEM warranties) and operational issues (ease of use and automation) before looking to deploy such a technology at scale with customers.[101] Despite these challenges, several pilots are being undertaken around the globe (Figure 34).[102]

Figure 34 – Map of Global V2G Demonstration Projects



PGE plans to perform V2G tests with a charger at one of our fleet facilities to test interconnection, operational impacts, and value streams.

[101] See: https://www.energy.gov/sites/prod/files/2014/02/f8/v2g_power_flow_rpt.pdf
[102] See: https://www.nrel.gov/docs/fy17osti/69017.pdf

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1.6.2.4 *Innovative Technologies may Improve Charging Logistics*

Most charging today occurs through a direct connection between a vehicle and a charging station via a plug. However, promising alternatives could have implications for grid integration. For example, wireless charging could reduce barriers to the electrification of autonomous vehicles, reduce charging operations and maintenance costs, and may prove more convenient for customers. PGE has tested a wireless charging station for our fleets but has not seen much progress from OEMs or adoption by our customers. One promising data point regarding wireless charging in PGE's service area is Kenworth Truck Company, which was funded $5 million from the U.S. Department of Energy (DOE) to deploy a megawatt-scale wireless charging station.[103]

Battery swapping is another technology that has been discussed by many auto OEMs to speed vehicle “fueling”. However, this technology has no penetration in the U.S. Tesla abandoned early plans to develop a battery swapping network in lieu of its Supercharger network, but, have continued to investigate the technology.[104,105] Chinese EV manufacturer Nio aspires to build out a network of more than 1,000 battery swapping sites by 2020 (see Figure 35 for an illustration of concept). Battery swapping could allow for innovative opportunities for grid integration/battery management, but we do not foresee much near-term opportunity locally due to lack of investment in the U.S. market.[106]

Figure 35 – Nio Battery Swapping Station

Source: InsideEVs

[103] See: https://www.energy.gov/sites/prod/files/2019/07/f65/FY19%20MD-HD%20Truck%20selections%20table_0.pdf
[104] See: https://www.teslarati.com/tesla-shuts-down-battery-swap-program-for-superchargers/
[105] See: https://electrek.co/2017/09/15/tesla-new-battery-swap-technology-to-deploy-trailer/
[106] See: https://insideevs.com/news/338117/nio-opens-first-battery-swap-station-in-shenzhen/

1.6.3 Interoperability[107]

Electric Power Research Institute (EPRI) recently commissioned a White Paper with the EEI, the Alliance for Transportation Electrification, the American Public Power Association, and the National Rural Electric Cooperative Association to identify challenges and opportunities to achieving greater interoperability and open standards in the U.S. EV charging market.[108] The paper identifies five areas of focus around interoperability:

- **Charging network-to-charging network interoperability**: Implementation of a standard protocol for business-to-business connectivity that facilitates customer roaming between charging networks. Several EVSP networks have in the past year signed bilateral agreements to implement roaming partnerships, marking vital progress towards increased access to networked public charging.[109,110,111] Example protocols include Open InterCharge Protocol (OICP) and Open Charge Point Interface (OCPI).
- **Charge station-to-network interoperability**: Implementation of open, nonproprietary protocols enabling interchangeable services and operations between charge stations and networks. The Open Charge Point Protocol (OCPP) is an open networking standard widely used in Europe and with growing in acceptance in the U.S.[112]

[107] Section paraphrased from EPRI White Paper, *Interoperability of Public Vehicle Charging Infrastructure*, August 6, 2019. See: https://www.epri.com/#/pages/product/3002017164/?lang=en-US.
[108] See: https://www.epri.com/#/press-releases/bbNEezyqGaBoXybI1vzlx?lang=en-US
[109] See: https://electrek.co/2019/06/11/chargepoint-electrify-america-partnership/
[110] See: https://insideevs.com/news/366785/evgo-electrify-america-roaming-partnership/
[111] See: https://www.chargepoint.com/about/news/chargepoint-and-greenlots-partner-increase-access-ev-charging-throughout-north-america/
[112] See: https://www.openchargealliance.org

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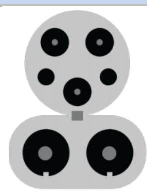
- **Physical charging interface interoperability**: The adoption by appropriate standards-setting organizations of a DC charging protocol and interface, or alternative solutions. The aim of said adoption being to facilitate electric LDV interoperability, improve charging access, and efficiently scale infrastructure. The lack of a unifying standard for DC charging for electric LDVs increases operational complexity and costs and could lead to customer confusion as public DC fast charging expands. Figure 36 summarizes common charging standards and connectors.

Figure 36 – Charging Standards and Connectors

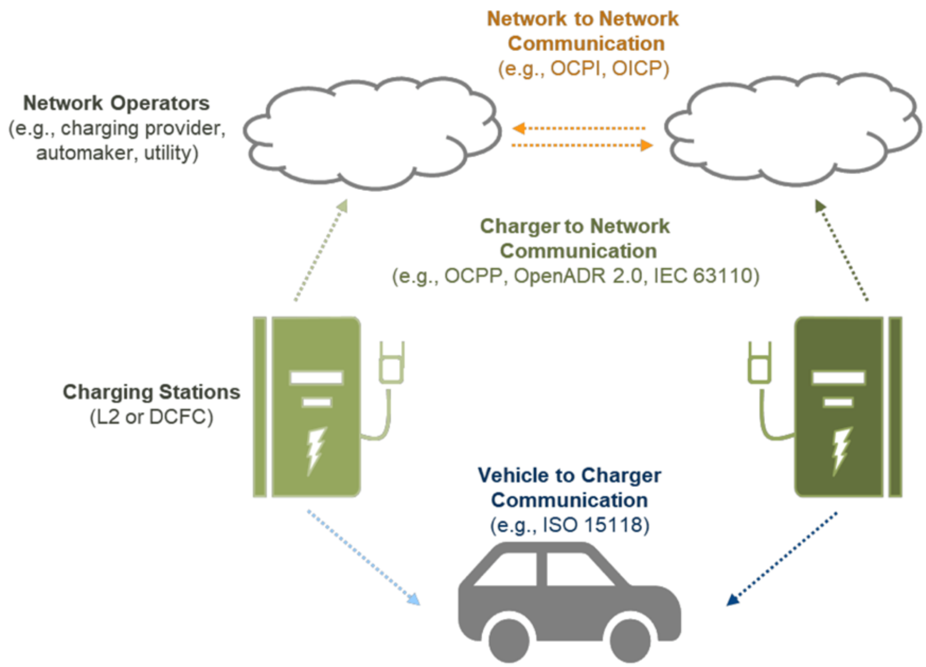
DC Standard	Connector	Used By		Chargeway Color Indicator
SAE Combined Charging System (CCS)		• GM • Ford • Honda • Kia • Hyundai	• BMW • Mercedes • Porsche • Audi • VW	GREEN
CHAdeMO		• Nissan • Mitsubishi		BLUE
Tesla Supercharger		• Tesla		RED

- **Vehicle-grid interoperability**: Development and implementation of open standards for grid-condition based charging management (e.g. OpenADR).
- **Vehicle-to-charger interoperability**: ISO 15118 development created a framework to enable electric vehicle communication with an EV charging station, with the goal of making it easier to charge by allowing a driver to plug in and charge their vehicle without the need for an app or RFID card.[113] Though the industry is still debating the right standards for vehicle-to-charger interoperability, PGE is supportive of this standardization to simplify customers' experience with EVSEs.

[113] See: https://www.chargepoint.com/about/news/chargepoint-statement-iso-15118-white-paper/

Figure 37 illustrates how these various interoperability standards interact with the vehicle, charger, and utility:

Figure 37 – Summary of EV Interoperability Communications Types



PGE supports the work of industry on interoperability and agrees with EPRI and others that we should collectively strive to offer our customers an experience that offers convenience, confidence, and security.

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1.7 Distribution system impacts and opportunities for efficient grid management

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(a) Current condition of the transportation electrification market in the electric company's Oregon service territory, including, but not limited to:… (G) Distribution system impacts and opportunities for efficient grid management;*

1.7.1 PGE's Grid is Robust and Ready to Accommodate New EVs on the System

PGE's investments in customer energy efficiency over the past several decades will enable us to make initial investments in transportation electrification without significant impacts upon our distribution system. EVs will, however, have a growing overall impact on energy and capacity needs. PGE must continue to make investments into our system to ensure that our service-level transformers, feeders, substation transformers, and substations will have enough capacity to provide EV customers access highly-reliable charging service throughout our service area.

This section introduces the expected distribution system impacts arising from EVs that PGE will need to plan for. This section is not intended to present a thorough distribution planning exercise for EVs. Instead, we provide indicative examples of how various types of EVs can impact the distribution system, and strategies to efficiently manage the grid in light of these impacts.

For example, PGE did not conduct power flow analyses to determine EV hosting capacity or estimate locational value. Such analyses will be done in concert with other new loads coming to the system through the course of the DRP (the guidelines of which are being established through Docket No. UM 2005). Through that plan, we aim to identify where system constraints may exist and what strategic deployments of DERs could mitigate those constraints.

1.7.2 System Impact will Vary Based on Charging use Case and Location of Charging Infrastructure

To effectively understand the impacts of TE on our distribution system and, ultimately, our planning of the distribution system, PGE must understand:

- Forecasted EV adoption;
- Projected charging deployments including the locations and speed of charging stations deployed; and
- Load profiles of different use cases detailing how and when customers charge.

As discussed earlier in this section, PGE conducted an EV adoption forecast for our 2019 IRP. In addition to vehicle count, we also forecasted the load growth that EVs will bring to the system:

Table 26 – Forecasted EV Load (Reference Case), PGE Service Area, MWa

Vehicle Type	2020	2025	2030	2035	2040	2045	2050
Light Duty	10	35	79	131	190	255	316
Medium Duty	~ 0	2	9	22	41	65	95
Heavy Duty	~ 0	3	20	55	104	169	247
Total	**10**	**39**	**108**	**207**	**335**	**489**	**657**

Throughout this analysis, we utilize the IRP reference case for EV load growth. It is possible that a high or low adoption case could lead to different results. Through that study, we also disaggregated system load at the zip code and feeder level using PEV propensity models (correlated to measures such as "green" awareness, education-level, occupation, and economic considerations). This disaggregated load study was the primary tool utilized to project residential passenger vehicle load impacts on the distribution system.

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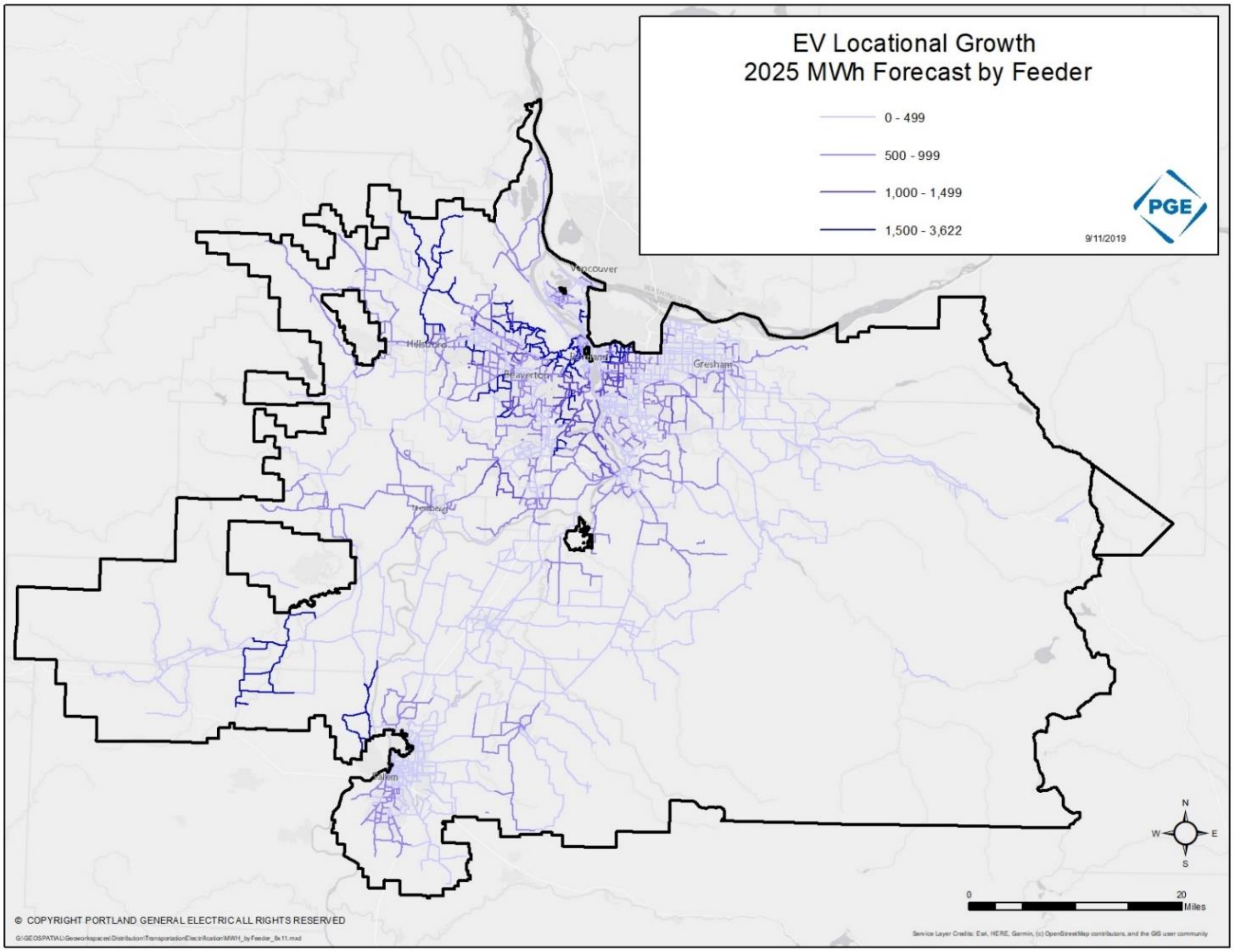
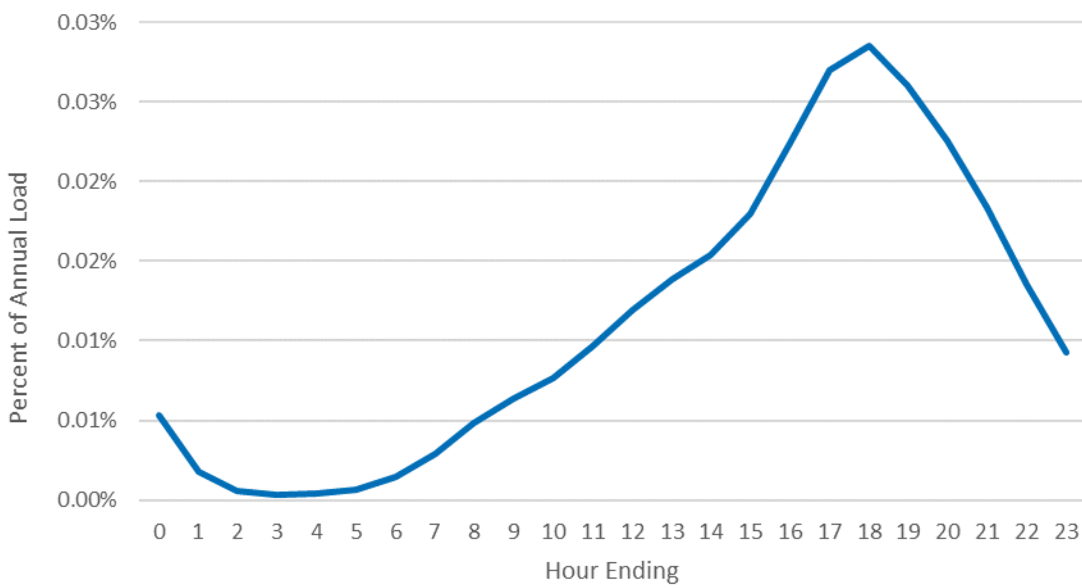
Figure 38 illustrates projected feeder loadings from light duty EVs in 2025:

Figure 38 – 2025 Forecasted MWh from LDV EV Charging Mapped to PGE Feeders



For the purposes of this study, we assumed a mix of home, public, and workplace charging for an aggregate average unmanaged load shape that peaks in the early evening (illustrated in Figure 39).

Figure 39 – Light Duty EV Average Load Shape[114]



These three elements: load forecast, locational impacts, and load shapes have been used to estimate light duty EV impacts on the distribution system in this section.

For medium and heavy-duty fleets, the market is continuing to emerge (vehicle types, charging speeds, and potential customers), and as such does not have the same system-wide locational insights. We do, however, have several indicative examples that we use to highlight potential future impacts.

1.7.3 Light Duty EVs will have Minimal System Impact

PGE applied the geocoded locations for anticipated EVSE and analyzed the average projected loading of all service-level transformers within a 1-mile radius of the EVSE location. This analysis excludes other DERs or load changes on the distribution system. Through the exercise, we identified that LDVs will initially impact only service-level transformers.

We estimate that 3% of the EV drivers will require a transformer replacement when they start charging at home.[115] Using the 2025 reference case EV forecast (n=99,000), this equates to around 3,000 transformer upgrades triggered by LDV charging. PGE estimates an average cost to upgrade a 50kVa transformer to a 75kVA transformer to be $2,500 - $5,000.

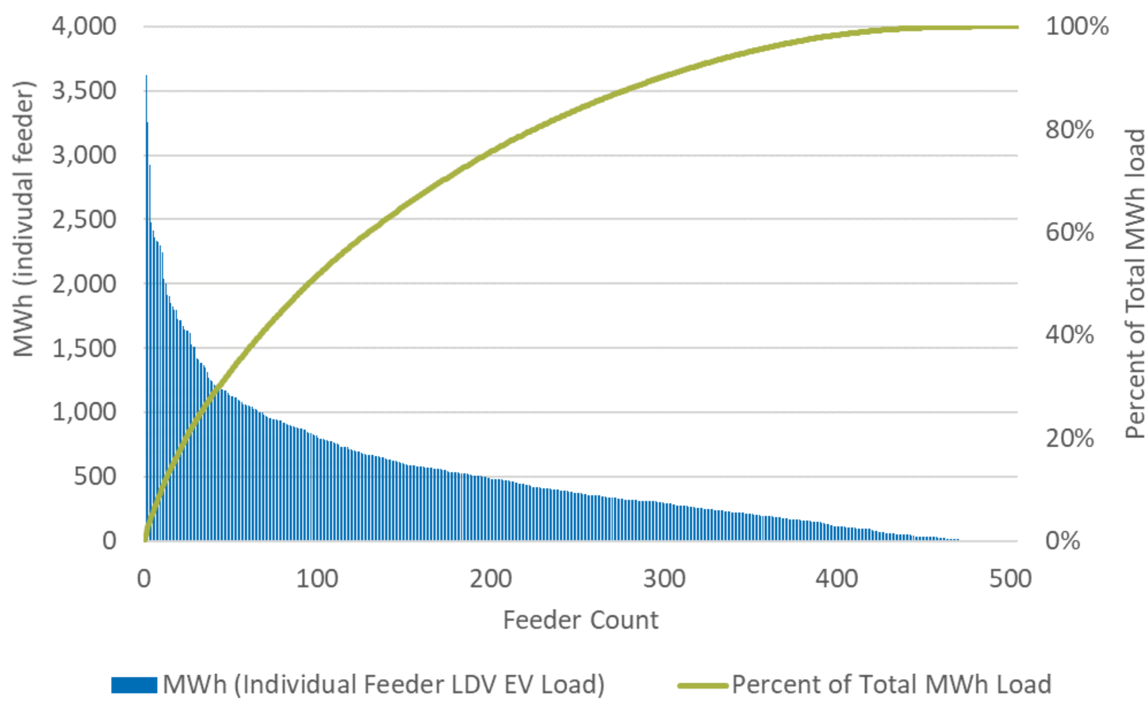
[114] PGE 2019 IRP

[115] Typical home level 2 charging units charge at rates of 7-19kW.

Our findings are consistent with other utilities, such as that in the City of Palo Alto, which has one of the highest EV penetrations in the country, and where it was found that service transformers posed the highest risk of overloading based on their hosting capacity analysis.[116]

The majority of PGE's distribution feeders can likely handle expected LDV growth without issue. By 2025, PGE expects 80% of the total MWh attributable to electric LDV charging to be concentrated in just 44% of our distribution feeders. Figure 40 illustrates the distribution of expected MWh from LDV EV charging across feeders. Five of the ten most impacted feeders are expected in the Portland-Metro area.

Figure 40 – 2025 MWh from EV LDV Charging by Feeder, PGE Service Area



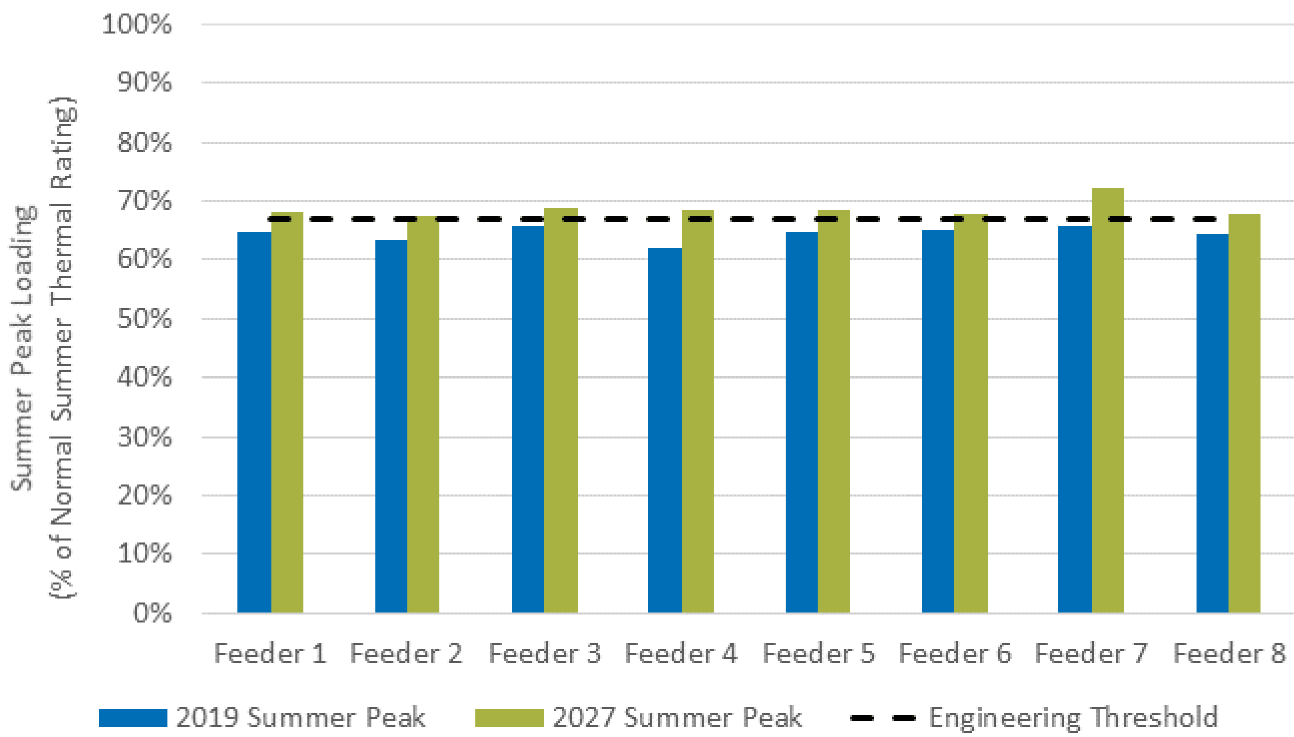
In order to assess the potential impacts from LDV penetration to feeder capacity, we combined the historical peak data for each feeder with the locational EV energy consumption forecast at the feeder-level. There are two ways that load growth can impact distribution planning decisions on where to upgrade feeders due to locational EV growth:

1. Concentrated adoption of EVs may put more strain on already heavily-loaded feeders, accelerating the timeframe for a decision as to whether to make a system upgrade to maintain adequacy; and
2. For feeders currently below the 67% planning threshold, incremental EV growth could add additional feeders to the "watch list" that triggers more in-depth planning review.

[116] City of Palo Alto Memorandum to the Utilities Advisory Commission. "Assessment of CPAU's Distribution System to Integrate Distributed Energy Resources". April 12, 2018. Available at: https://www.cityofpaloalto.org/civicax/filebank/documents/64445 (accessed 9/9/19)

PGE found after factoring in EV load growth, it currently appears that no feeders trigger a capacity upgrade, and only eight individual feeders (out of 622 across the system) crossed the planning threshold for summer peak loading.[117] In all cases, the threshold was only exceeded by 3-7%, and no feeder crossed the planning threshold for winter peak loading. Figure 41 shows the results of a comparison between 2019 and 2027 peak loading (the latter being the furthest year for which we forecast LDV feeder levels):

Figure 41 – Feeder-level Summer Peak Loading pre/post LDV EV Load Growth, through 2027 (feeders that exceed engineering threshold due to EV growth)



It is worth noting that there are 39 additional feeders already loaded beyond their engineering thresholds, and that the addition of EV load upon these feeders may accelerate their capacity upgrade timeline. Based on this analysis, we are likely to more-closely monitor these feeders through our T&D planning and DRP processes.

It is important to note that this analysis is based on system averages and does not account for site-specific infrastructure requirements to support high-powered public quick charging. Because the infrastructure is comparable to that used by MHDV fleets, understanding and planning for that infrastructure is contemplated in the MDHV section below.

[117] The Distribution Planning team uses an engineering threshold metric of 67% of the nearest lowest thermal seasonal-adjusted capacity conductor within 0.25 miles of the source substation to determine which feeders require more in-depth engineering study and analysis of potential upgrades.

1.7.4 Medium- and Heavy-Duty Fleets may Require Distribution System Upgrades on a Site-by-Site Basis

As MHDV electrification and the deployment of high-powered public quick charging infrastructure accelerate, we must carefully plan our system in conjunction with customers' needs to ensure that we have system capacity available when and where they need it. Because fleets often park in central depot locations and MHDVs are likely to require high-powered charging infrastructure, charging needs are likely to be geographically concentrated and require significant distribution system capacity. Unlike LDVs, this is likely in many cases to trigger feeder- and even substation-level system upgrades. One such recent example is from a peer utility of ours. They received a request to evaluate service options for adding over 400 electric HDV. After reviewing the power required, distribution planners realized that even if only 10% of the fleet converted, they would quickly reach the 10 MW limit on the existing substation; if the full conversion occurred, it would require the build out of a new 40 MW substation as well as new transmission service.

Because the electrification of MHDV fleets is still rapidly evolving-with new vehicle types, charging speeds, and potential customers-we do not currently have system-wide locational insights on where we expect such fleets to emerge. For this analysis, we have included several indicative examples that highlight the potential distribution system impacts of fleet electrification. These examples will inform future impact analyses of how fleets could impact the system. A more robust analysis may be contemplated in the DRP.

PGE reviewed the current inventory of HD transit fleets and explored hypothetical scenarios of fleet electrification at five depot garages across the service area. Table 27 shows the nearly 750 HDVs, the distribution feeders, and substations that these sites are located on:

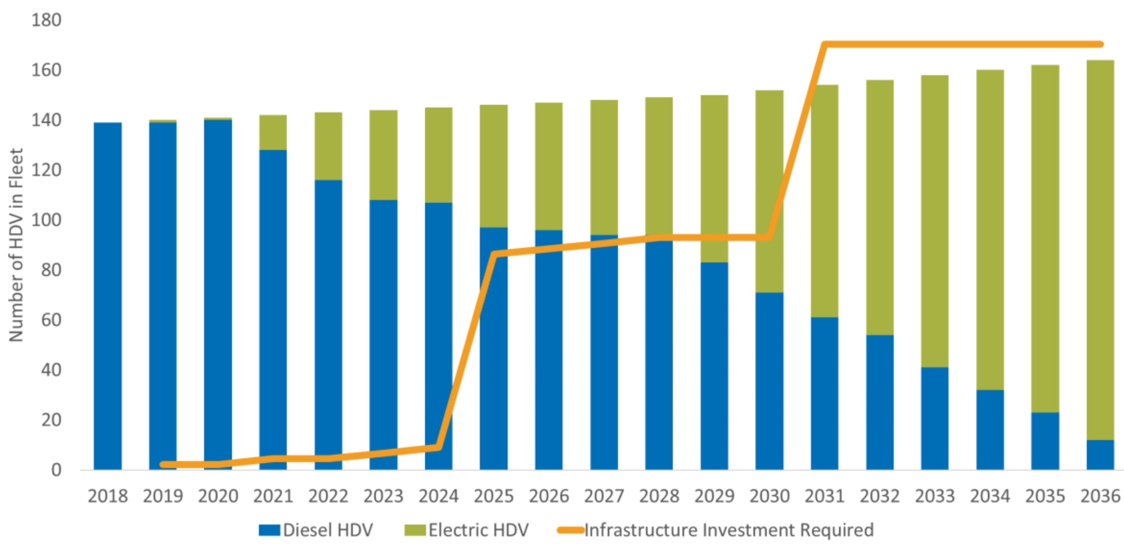
Table 27 – Example HDV Fleet Customer's Major Depot Locations by Substation and Feeder

Company Location	HDV Fleet Size (No. of Vehicles)	Feeder	Substation Transformer Winding LBNR* (MVA)	Indicative Charging Peak Load (MW)	Current Feeder Summer Rating (MVA)
Depot #1	250	St. Mary's East - Elmonica	32.2	25.0	17.8
Depot #2	250	Kelly Butte - McGrew	26.4	25.0	17.8
Depot #3	200	Holgate - Gideon	20.0	20.0	13.5
Depot #4	35	Wilsonville - Villebois	32.2	3.5	17.8
Depot #5	12	Sandy - 362	32.2	1.2	10.7

**LBNR is the Loading Beyond Nameplate Rating*

We need to be planful today to ensure we have adequate capacity to serve new vehicle loads on a schedule that meets our customers’ deployment needs. In addition to location and distribution grid upgrades, the associated costs will depend on the charger speeds and charging patterns chosen by the fleet operator. Section 1.3 discusses usage patterns observed during PGE’s first pilot mass transit program. PGE has a critical opportunity to partner with our customers to right-size and right-locate charging infrastructure to meet their business objectives and minimize system impact. Figure 42 demonstrates that as a transit fleet progresses toward electrification, grid upgrades may be triggered in a stepwise fashion (as feeder- or substation-level investments become necessary).

Figure 42 – Infrastructure Investments over Time to Support Fleet Electrification.



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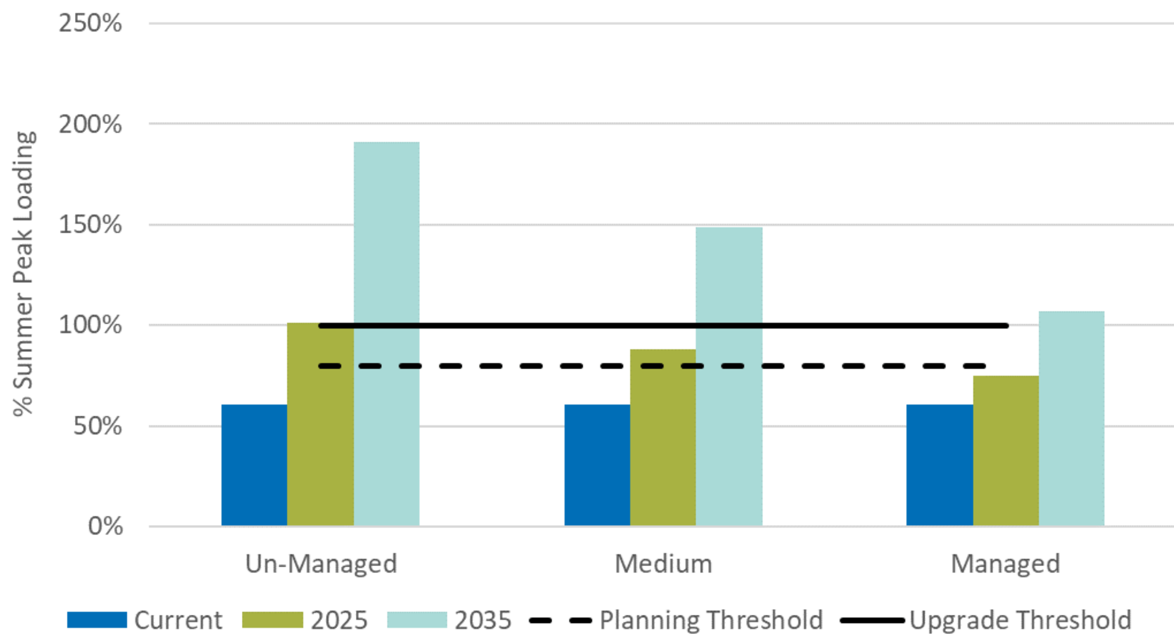
Such investments may be deferred or avoided through smart charging strategies. For example, Figure 43 shows three hypothetical scenarios ranging from "unmanaged" to "managed" fleet conversion of MDHV depots. In the unmanaged case, substantial grid upgrades are needed by 2025 and perhaps even sooner. By contrast, in the managed case, these upgrades are potentially deferred to 2035.

Figure 43 – Illustrative Substation Impacts of Managed and Un-Managed MDHV Charging



Site work for early MDHV fleet deployments can create opportunities to "future-proof" a site (e.g. adding service-level transformers, building pad-mounts, running conduit, etc.) to minimize future deployment costs to serve the new loads in the future.

1.7.5 Future Insights

As the impact of EVs on our system increases, it is critical that we take the necessary steps to ensure that we are prepared for our customers' infrastructure needs and support their transition to electricity as a transportation fuel. As such, we will expand upon these analyses to better inform a future DRP. Specifically, we aim to:

1. **Leverage activities in PGE's Smart Grid Test Bed**[118] to drive more locational insights on the impacts of EVs and EVs charging. Such tools might include leveraging Electric Avenue data, locational grid analytics, or vehicle telematics.
2. **Conduct a fleet customer assessment**: we must better understand which of our customers have vehicle fleets, where those vehicles are in our system, how many vehicles operate at those sites, and what decarbonization goals our customers have set. In addition to identifying these sites, we aim to directly

[118] Smart grid test bed is a targeted approach to deploying distributed energy resources within three concentrated areas. Within the testbeds, PGE has a number of EV customers and two Electric Avenue sites. See: https://www.portlandgeneral.com/our-company/energy-strategy/smart-grid/smart-grid-test-bed

partner with customers to create plans for electrifying their fleets (which may inform a future DRP). Additional discussion of a fleet planning program is included in Section 2.2.

3. **Perform Scenario analyses**: we anticipate conducting similar analyses to understand the impact of various assumptions on system impact (e.g. utilization of the low and high cases for vehicle forecast, assumptions on changes to charging speeds at home and public chargers, etc.).
4. **Better utilization of customer data** (e.g. AMI, market studies, etc.) to identify locations of home charging stations.

1.7.6 Opportunities for Efficient Grid Management

As we have identified in this Plan, EVs may trigger upgrades to our distribution system. We must work with our customers to identify solutions to efficiently integrate those new loads into the system, minimize the costs to serve them, as well as maximize both customer and grid value from the services they can provide.

SEPA outlined that EVs could serve as a connection point with customers to enable other utility-managed DERs in the future:

> *EVs are only one of many distributed energy resource (DER) technologies that can be leveraged to develop a smarter, more reliable grid. As consumers evolve to become prosumers, utilities must keep pace with their demands and expectations through experimentation and continual self-assessment of the traditional utility business model. Despite some initial growing pains, managed charging could prove to be a gateway for consumer adoption of other utility-managed DERs. It could also provide an innovative, highly replicable solution as our nation's fleet transitions from conventional fuels to electricity.*[119]

Other DERs may be an integral component to effectively integrating EV loads in the future. For example, the potential to manage water heater or heat pump loads on a distribution feeder to accommodate for unusually high charging loads at a given time (or vice versa).

Electric vehicles can support efficient grid management by creating system benefits such as: [120]

- Improved charging infrastructure/grid economics by achieving a higher utilization rate, and therefore load factor, of grid and charging assets;
- Reduced emissions by aligning charging with surplus renewable generation; and
- Empowering customers to intelligently manage their energy use.

Furthermore, electric vehicles can support efficient grid management by reducing the cost of system integrations as follows: [121]

- Reduced grid stress and maintain power quality by managing charging ramp rates and reducing the strain on distribution assets (deferring capital spend);

---

[119] SEPA, 2017. Utilities and EVs: A Case for Managed Charging https://sepapower.org/resource/ev-managed-charging/.
[120] Id.
[121] Id.

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- Reduced need for new peak generation and distribution capacity that would otherwise result from EV charging during peak hours, particularly as more drivers choose EVs in the coming years; and
- Avoiding high energy supply costs.

Effective grid management can be achieved through:

- **Integrated customer planning**: working proactively with fleet customers to create a timeline for a rollout of EVs and associated fueling infrastructure. One example where this occurred recently, was a customer was considering electrifying about 100 HDV in their fleet. Their planned charging strategy would have triggered a substation upgrade within five years. PGE worked with the customer to identify a charging strategy that reduced the up-front infrastructure costs and no longer triggered an upgrade to the substation.
- **Innovative rate design**: pricing signals, such as TOU or real-time locational pricing could influence when and where a customer chooses to charge or discharge their vehicle's battery.
- **Smart/managed charging**: a utility-customer partnership that enables load shifting, load curtailment, or load flexing (e.g. reducing a 7 kW charge to 3 kW for a period of time). This managed charging plan could be leveraged by our load balancing authority, power operations, or distribution system operations teams to provide grid services (such as capacity, emergency load reduction, reserves, or regulation, or to absorb excess generation from renewable energy resources, like solar and wind). The National Resources Defense Council (NRDC) has identified specific grid services that can be captured through EVs, including the use of 2nd-life batteries for grid resources. Those grid services are reflected in Table 28:

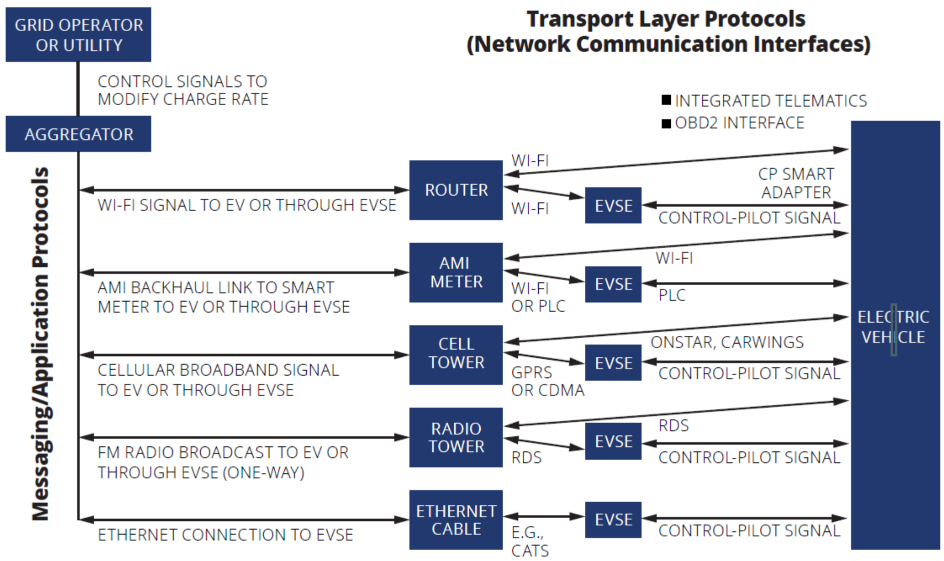
Table 28 – Grid Services that EVs Could Potentially Provide, By Grid Segment (modified from NRDC) [122]

EV 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

[122] Driving Out Pollution: How Utilities Can Accelerate the Market for Electric Vehicles. Baumhefner, Hwang. NRDC. (2016). See: https://www.nrdc.org/resources/driving-out-pollution-how-utilities-can-accelerate-market-electric-vehicles (Accessed 9/9/19)

Managed charging will require PGE to communicate with the EVSE and/or the EV via an aggregator, a home Wi-Fi router, advanced meter infrastructure (AMI), cellular network, or another networked service. Figure 44 illustrates how signals may be communicated from PGE's grid to customers' EVSEs.

Figure 44 – Managed Charging Network Communication Interface Options[123]



Con Edison of New York found that it was relatively difficult to modify the load factor of vehicle charging through customer program design. Nevertheless, petitioners to the docket on the ZEV mandate in NY have argued that increased EVs on the road will increase existing asset utilization and create net benefits for customers through increased MWh sales.[124] We agree and will continue to pursue tools that drive efficient grid integration of electric vehicles. Additional detail on efficient grid and renewables integrations are included in Section 50.

[123] Myers 2017. SEPA Utilities and Electric Vehicles: The Case for Managed Charging (edits to original graphic by Dr. David P. Tuttle. See: https://sepapower.org/resource/ev-managed-charging/

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Section 2 PGE's Transportation Electrification Activities

PGE will make planful investments in infrastructure, create new customer programs, and explore innovative approaches to rate design to create value for all customers and to reduce the cost to serve EV load.

PGE has taken many steps to learn from early pilots and demonstrations. We are prepared to take aggressive steps to ensure all of our customers can enjoy the benefits of clean, affordable, and reliable transportation fuel. In this section, we provide an update on existing EV activities and outline a roadmap for our future engagement in support of TE. PGE's TE activities:

1. **Are in support of the public interest (linked to city, county, state goals);**
2. **Aim to make EVs accessible to all;**
3. **Prioritize equitable access for underserved communities;**
4. **Prioritize interoperability to enable a variety of business models; and**
5. **Enable broader economic and health benefits.**

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(b) A summary of the electric company's transportation electrification program(s) and future transportation electrification concepts and actions in its Oregon service territory. The TE Plan must incorporate project learnings and any other relevant information gathered from other transportation electrification infrastructure investments, programs, and actions to ensure that lessons learned are carried forward;*
>
> *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities;*

By accelerating EV adoption, we can generate more revenues to spread over existing fixed costs and more efficiently integrate these new loads into our system. Both of these benefits create value for all our customers by putting downward pressure on customer rates. Put another way, if not for PGE's interventions in electric transportation, we are likely to accrue fewer benefits for customers and our cost to serve is likely to be higher. Figure 45 shows how benefits or costs savings may accrue:

Figure 45 – Goals for PGE's TE Activities (Benefit and Cost Reduction Streams)

↑ Increase Benefits	↓ Decrease Costs
Accelerate EV Adoption: • Incremental revenues associated with EVs (more EVs on the Road and more Vehicle Miles Travelled per vehicle) • Incremental value of environmental benefits (e.g. Clean Fuels Credits) Leverage EVs for Grid Services/Renewables Integration • Avoided costs from utilizing EVs for grid services Non-quantified societal benefits: • Greenhouse gas emission impacts • Air and water quality • Social justice and equity • Jobs and workforce • Customer cost savings	Efficiently integrate vehicles/chargers into the grid • Energy to serve EV loads • Capacity to serve EV loads • New infrastructure investments required to support EV loads

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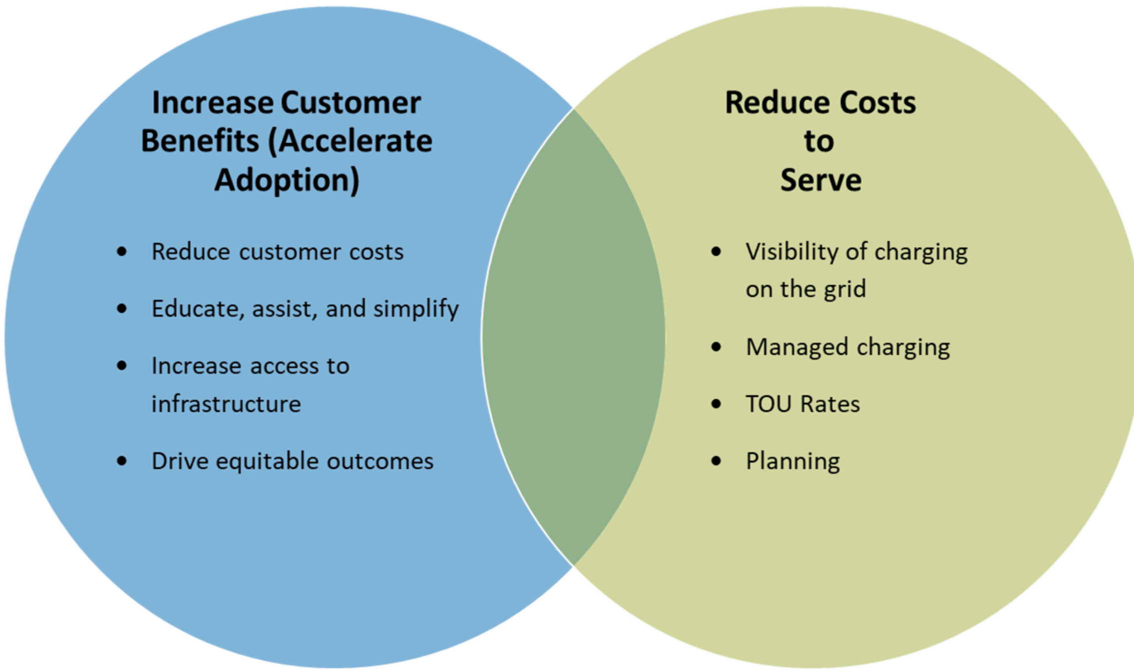
In this section, we outline current and future programs that drive towards these two desired outcomes. Figure 46 outlines which TE actions may achieve those outcomes. As the figure illustrates, some initiatives serve to both create benefits and reduce costs.

Figure 46 – Means to Achieve TE's Desired Outcomes



2.1 Summary of Existing TE Programs

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(b) A summary of the electric company's transportation electrification program(s);* and…
> *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities;*

To date, PGE has been authorized to support EV activities through two primary avenues: OPUC Docket No. UM 1811, with pilots explored pursuant to SB 1547; and OPUC Docket No. UM 1826, the OPUC's evaluation of Oregon's Clean Fuels Program.

2.1.1 UM 1811 – Transportation Electrification Pilots

On February 16, 2018, the OPUC approved three TE pilots in response to SB 1547, aiming to accelerate TE and encourage efficient integration into the grid:

1. **Electric Mass Transit 2.0**: a pilot with TriMet whereby PGE owns, operates, and maintains high-powered charging infrastructure to power TriMet's first all-electric bus line.
2. **Outreach, Education, and Technical Assistance**: a pilot whereby PGE aims to increase awareness and consideration of EVs, including technical support for business customers' installation of charging equipment or procurement of EVs.
3. **Electric Avenue Network**: a pilot deployment of public quick charging stations across PGE's service area to increase access to charging and increase awareness of electricity as a transportation fuel.

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Additionally, PGE filed two new pilots on February 15, 2019: a residential smart charging pilot and a business charging pilot. At the time of this filing, these pilots are still under consideration but have a target launch in early 2020. Table 29 summarizes the challenges that each pilot aims to address. A detailed update on each pilot follows below the table.

Table 29 – Summary of Challenges that PGE Offerings Address (UM 1811)

Challenges Addressed	Electric Mass Transit 2.0 (TriMet pilot)	Outreach, Education, and Technical Assistance	Electric Avenue Network	Residential Charging Pilot [Approval Pending]	Business Charging Pilot [Approval Pending]
Market Factors (increase adoption)					
Customer Cost	●			●	●
Point of Sale		●			
Accessible Charging		●	●	●	●
Awareness		●		●	●
Ease of Use/ Usability		●	●		
System Impacts (decrease cost)					
Uncertain Coincidence of Load			●	●	●
Grid Integration	●			●	●

2.1.1.1 *Electric Mass Transit 2.0*

Transit is a critical component of the transportation sector-it is critical that we work with our transit agencies to ensure that those customers relying on transit can realize the benefits of emission-free transportation services.

Throughout 2018, PGE worked closely with TriMet to design, install, commission, and operate the proposed electric bus charging infrastructure. PGE provided guidance on the most flexible and cost-effective methods to connect the charging infrastructure at Sunset Transit Center and Merlo Garage to PGE's distribution grid, provided insight into site layout and construction, and held regular meetings with TriMet and other construction contractors.

2.1.1.1.1 *Constructability and Future-Proofing Assistance*

PGE assisted TriMet in the design and layout of the charging infrastructure installations at Merlo Garage and Sunset Transit Center. At Merlo Garage, PGE proposed the installation of an additional underground vault, oversized transformer pad, and extra runs of secondary-side conduit to more easily accommodate the addition of subsequent charging infrastructure. TriMet chose to install oversized switchgear and additional underground electrical infrastructure to allow for the installation of up to six additional 150 kW-capable charging ports.

PGE also collaborated with TriMet's contractors on the design and layout of the overhead fast charger installed at Sunset Transit Center. As at the Merlo project, PGE installed an oversized transformer pad and extra secondary-side conduit runs to allow for the installation of a second overhead fast charger and TriMet installed oversized switchgear and additional underground electrical infrastructure. Figure 47, below, shows an overhead fast charger that PGE and TriMet deployed at the Sunset Transit Center:

Figure 47 – TriMet's First 100% Electric Bus and PGE's 450-kW Charging Station

2.1.1.1.2 Operations and Maintenance Plan Development

PGE created an Electric Bus Charging Infrastructure operations and maintenance program in collaboration with TriMet and the infrastructure supplier. PGE worked with suppliers to identify the correct spare parts to stock at PGE facilities and train local electricians and PGE staff on equipment diagnostics and repair. TriMet and PGE also established a communications and response plan that provided a clear process for bus drivers to quickly identify issues for diagnosis and repair by PGE and the charger supplier.

As TriMet began placing buses in revenue service, PGE activated remote monitoring and emergency repair programs. PGE has been available 24 hours per day / seven days per week to respond to charging infrastructure issues. Table 30 shows energy consumption for the TriMet electric bus to date:

Table 30 – Electric Mass Transit Pilot Energy Consumption Data (2019)

	March	April	May	June	July	August	2019 YTD
No. of Buses in Service	1	1	1	1	1	2	2
Total Energy (kWh)	11,326	9,952	8,383	15,460	14,099	33,230	92,451
Peak Demand (kW)	410	420	355	365	396	421	421
Load Factor	**4%**	**4%**	**5%**	**7%**	**6%**	**12%**	**n/a**

2.1.1.1.3 Challenges

Electric bus charging infrastructure is still an emerging technology and offered many challenges, including:

- Challenging integration between vehicle manufacturer and charging equipment supplier as this was one of their first integrations to each other. The bus supplier and the charging infrastructure provider were in the early stages of deploying this infrastructure. Extra time and effort were needed to ensure the bus and charging infrastructure could reliably communicate.
- There were reliability issues associated with the state-of-the-art equipment. This was not surprising given that electric buses are still an emerging technology, not yet widely deployed. Commissioning activities uncovered a variety of reliability issues that vendors had to remedy. Reliability is expected to improve as deployments grow.[125]
- Challenges emerged with the infrastructure footprint. Space at transit centers and bus depots is at a premium, which constrains the types of charging infrastructure deployments possible. PGE and TriMet carefully designed the infrastructure installation such that existing bus storage and parking stalls were not disturbed. It should be noted that large scale infrastructure deployments may be more challenging to site at existing bus depots.

[125] The buses and charging equipment used for this project were some of the manufacturers' first deployments of these products, and to our knowledge, the first time they had been used together. As such we had to work with the manufacturers and TriMet to ensure the equipment was properly communicating so that the bus was able to receive a full charge from the charging equipment.

Table 31 identifies how the Electric Mass Transit pilot addresses OAR 860-087-0020:

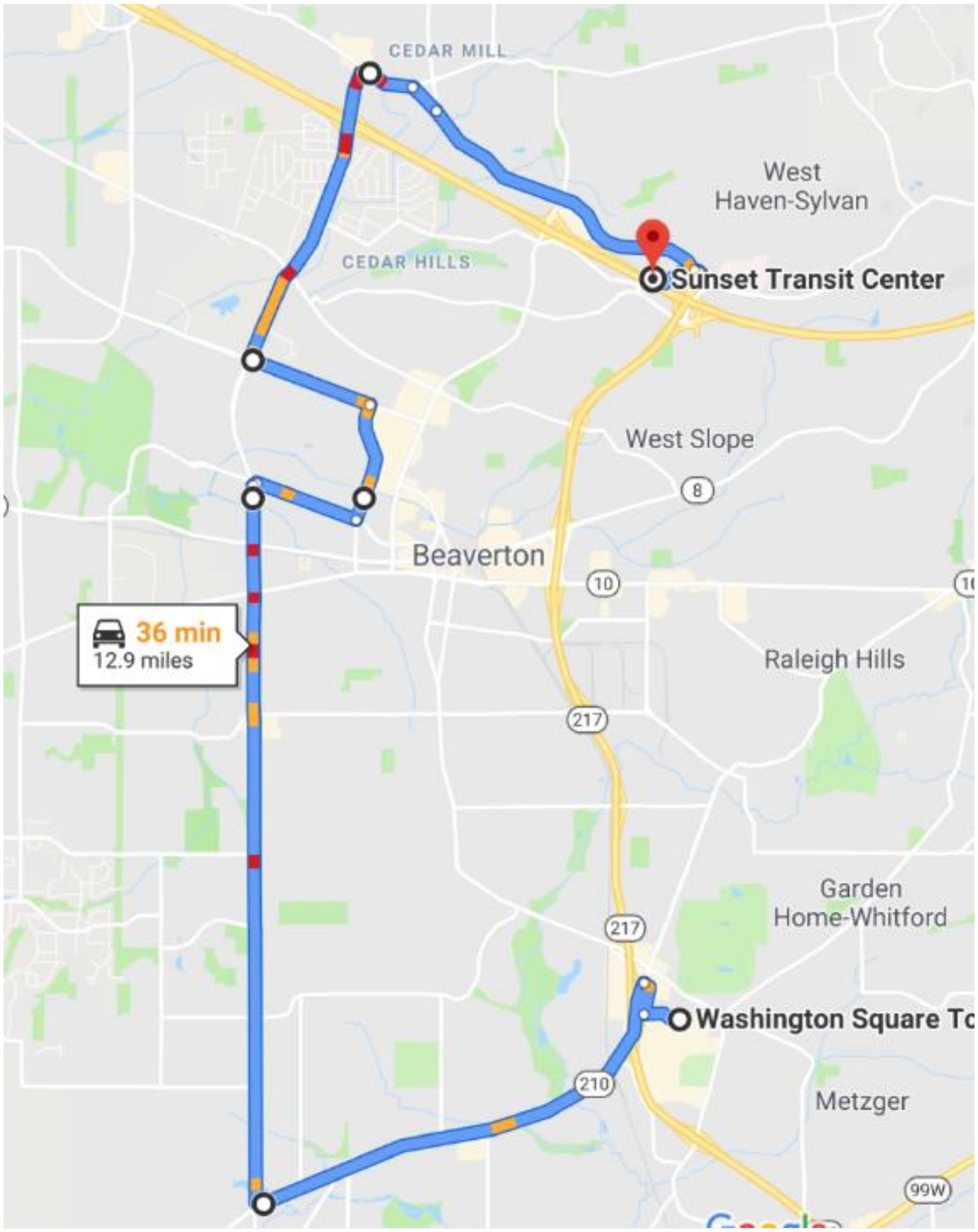
(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities:

Table 31 – Electric Mass Transit Pilot Impact Summary

Activity's impact on	Description
Accelerating TE	Any funds that TriMet is not able to spend on charging infrastructure goes directly to faster procurement of e-buses. This project enabled TriMet to purchase a fifth electric bus.
Addressing barriers to adoption	PGE's involvement solved customer concerns around cost and infrastructure.
Extending access to underserved communities	TriMet serves many underserved communities. By supporting their transition to an electric fleet, we are extending access of electric fuel to those who rely on transit.
Supporting efficient grid integration	Learnings regarding siting and best practices for integration will inform future design standards and planning processes for high-powered EV charging infrastructure.

Figure 48 shows the map of TriMet's first electric bus route. TriMet's Line 62 fully-electrified bus route is enabled by the EV charging equipment deployed at Sunset Transit Center and Merlo Garage, where the buses respectively charge during the day and overnight.

Figure 48 – TriMet Line 62 Electric Bus Route



2.1.1.2 *Customer Outreach & Education*

2.1.1.2.1 Ride & Drive Events

Since fall of 2018, PGE has hosted five EV Ride and Drive events for a variety of customer segments that are considering an EV purchase. Ride and drives allow prospective car buyers to try an EV for the first time or to test a variety of different EVs in a single location. PGE is planning at least six additional ride and drive events over the next year. Table 32 below provides additional detail on the EV Ride and Drive events held to date:

Table 32 – Summary of Key Ride and Drive Events

Event Location	No. Attendees	No. Test Drives	Event Details
Wilsonville	400	136	Partnership with local dealerships and Oregon EVs Association, Plug-in America, Sierra Club, Electric Auto Association, and Nissan. The event targeted the public.
Portland	40	40	Targeted to Lyft drivers whose vehicles were nearing a vintage that would no longer allow for them to drive on the Lyft platform
Milwaukie	150	30	Aligned with the opening of Electric Avenue in Milwaukie to generate awareness for the new site.
Hillsboro	120	30	Aligned with the opening of Electric Avenue in Hillsboro to generate awareness for the new site.
Wilsonville	330	400	A celebration of National Driven Electric week, in partnership with Oregon EVs Association and 14 local dealerships.
Total	**1,040**	**636**	

Figure 49 shows PGE's Milwaukie Ride and Drive event.

Figure 49 – Ride and Drive Event in Milwaukie, OR

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Table 33 identifies how the ride and drive events address OAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities*.

Table 33 – Ride and Drive Events Impact Summary

Activity's impact on	Description
Accelerating TE	Give customers an opportunity to see and try EVs in a low-pressure environment; increases awareness and consideration of EVs.
Addressing barriers to adoption	Ride and drive events help remove customers' unknowns about EVs and increase their awareness.
Extending access to underserved communities	Ride and drive events can be targeted at specific communities. The Portland event targeted drivers who needed a new vehicle to continue driving for Lyft.
Supporting efficient grid integration	Ride and drives are primarily focused on customer acceptance and do not have any impact on grid integrations.

2.1.1.2.2 Market Transformation/Dealer Engagement

Dealerships are an increasingly important channel for supporting vehicle adoption. Dealers are ultimately responsible for talking to our customers about electricity as a fuel and helping customers ultimately adopt an EV. As EV sales grow over the long term, dealerships are likely to be critical partners in managing charging load on site and encouraging customers to enroll in smart-charging programs.

PGE is partnering with Chargeway to deploy touchscreen kiosks (aka beacons) at several auto dealerships in our service area. The initiative aims to:

- Give auto sales staff a simple language and tools to communicate with their customers about electricity as a transportation fuel.
- Give customers a tool and visual representation of what charging infrastructure works for their new EV and where it is relative to where the customer travels.

Chargeway defines charging infrastructure in a manner that is easy for dealers to understand and communicate with their customers. Instead of communicating in technical jargon terms (e.g. CHAdeMO, CCS, J1772, etc.), Chargeway simplifies the conversation to focusing on an easy-to-understand system with colors and numbers. We have also used this nomenclature on our Electric Avenue charging stations.

Participating dealers are being trained on how to talk to customers about charging and how to use the beacon:

- **Chevrolet (Wilsonville, OR)**: As part of our initial placement (see Figure 50, below) we were able to negotiate a special discount for new EV purchases during the month of February of an additional $500 off an EV or a free L2 charger. Over the first three months in service (March- May 2019), this dealership has been selling about four times more EVs per week compared to other dealers with similar inventory over the observation period.[126] We hope to further validate this data with additional deployments and comparisons with comparable dealerships.

Figure 50 – Chargeway Beacon at Wilsonville Chevrolet

- **Platt Auto (Gladstone, OR)**: Platt is exclusively a used EV dealership and had been identified as a partner for beacon placement based on their commitment to used EVs, an underserved but growing market. We believe this site will support customers who are in the market for a used EV (such as TNC drivers or those unable to afford a new EV) as well as those looking for an inexpensive second vehicle option.
- **Kuni BMW (Beaverton, OR)**: We recently deployed a Beacon at this location based on the dealer's commitment to drive EV sales and to train sales staff.

[126] Based on sales at non-participating Chevy Dealers in the Portland Metro Area Average plug in sales per week (latest 90-day period at dealership with 30 or more plug-ins in inventory). Specifically, other dealerships are selling an average of 0.63 vehicles/week, compared to Wilsonville which is selling 2.6 vehicles/week.

Table 34 identifies how the market transformation and dealership engagement activities address OAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities*.

Table 34 – Market Transformation/Dealer Engagement Impact Summary

Activity's impact on	Description
Accelerating TE	The pilot requires dealer training and dealers to maintain minimum levels of EVs on their show floor. It also empowers dealers to have more confidence talking about electric fuel, and therefore drives to more EV sales.
Addressing barriers to adoption	This activity aims to address customers' anxiety of the unknown and dealers' challenges selling EVs by making electric fuel easier to talk about and to understand.
Extending access to underserved communities	As a market transformation exercise, we hope this activity supports all customers' access to EVs. A simplified, standard language around electric fuel will make our product more approachable for all customers and dealers' sales staff.
Supporting efficient grid integration	Long term, we anticipate dealers having many vehicles on their lots. Building strong relationships with those dealers today will enable us to: 1. Engage dealers in smart charging on the lots in the future 2. Empower dealers to encourage their customers to purchase a grid-tied home charging station and/or participate in a TOU rate.

2.1.1.2.3 Technical Assistance: Business Customers

In 2018, PGE launched technical assistance for our business customers that are considering EVs for their fleets or are considering deploying charging infrastructure at their facilities. Technical assistance includes customer classes, webinars, and one-on-one customer consultations. To date over 200 customers have participated in nine EV-themed workshops:

Table 35 – PGE's TE Trainings, Workshops, and Webinars

Class	Date
Fleet of the Future	May 22, 2018
Electrifying School Transportation, Oregon Pupil Transportation Association Conference	June 22, 2018
Making the Case for Workplace Charging	September 18, 2018
EV Ready by 2022	October 18, 2018
Making the Case for Workplace Charging	March 14, 2019
Smart Home Technologies (Earth Advantage's Sustainable Home Professionals 6-week course)	April 5, 2019
Smart Technologies for Home Builders, Home Builders Association, BuildRight Conference	April 24, 2019
Workplace Charging for EVs, NW Facilities Expo	May 8, 2019
Applying to the Drive Change Fund	June 13, 2019

PGE expects to continue to engage and support commercial customers and developers in their efforts to implement commercial and residential charging. In 2020, we expect to offer educational sessions to business customers on workplace charging, fleet electrification, as well as an EV Ready class for home builders.

To date, we have supported 47 customers with one-on-one consultations regarding EVs/charging infrastructure and conducted 49 site assessments. This high-touch consultation is extremely valuable, helping customers identify vehicles that will meet their needs and their optimal charging deployment charging strategies.

PGE now offers EV Service Providers a single point of contact to support the identification of locations for infrastructure that will meet their needs and minimizes system integration costs. Within this function, we are working with some of our customers to develop near-term electrification and infrastructure plans.

Figure 51 below is an example of the type of supporting material that PGE has developed to provide technical assistance to EV charging customers.

Figure 51 – Technical Assistance Customer Supporting Material

EV charging is as easy as 1,2,3

1. Planning

Identify key stakeholders
Contact PGE, an electrical contractor and the property manager.

Evaluate charging needs
Establish how many chargers and what types of chargers to install.

Check the electrical service
A licensed electrician can assess the building's electrical capacity.

Choose a site
To keep cost low, locate chargers as close to existing infrastructure as possible.

2. Installation

Select chargers
Consider a networked charger for smart charging capabilities.

Estimate Costs
Get multiple bids from trusted vendors.

Future proof
Plan to include extra conduit and upsize equipment to account for future EV chargers.

Build
Use contractors with EV experience.

Cost Example

Installing Level 2 chargers connected to existing building power

Potential infrastructure	Cost range
Charger (per unit)	$500–$3,000
Charger installation (per unit)	$500–$2,000
Trenching, conduit and wiring	$1,000–$20,000
Permitting	$500–$2,000
Estimated Total Cost	**$2,500–$27,000**

3. Follow-up

Promote
We can suggest creative campaigns to drive interest to the chargers.

Maintain
Contract with an equipment provider or use an internal crew.

Check-in
Re-evaluate in a few years to keep up with EV growth and technology.

Table 36 identifies how PGE's technical assistance for business customers addresses OAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities*.

Table 36 – Technical Assistance Impact Summary (Business Customers)

Activity's impact on	Description
Accelerating TE	This activity directly accelerates the adoption of EVs for fleets by giving them the necessary tools needed to make investments. It also indirectly supports mass market adoption by encouraging business customers to deploy charging infrastructure.
Addressing barriers to adoption	Our technical assistance offering is making it easier for business customers to figure out how to invest in electric fleets and empowering them to deploy charging infrastructure.
Extending access to underserved communities	The technical assistance offering supports multi-family property owners, transit agencies, and schools in evaluating options for charging and electric vehicles.
Supporting efficient grid integration	By partnering with our customers at the onset of a charging deployment, we can work together with the customer to right-size and right-locate charging infrastructure to minimize grid-integration costs.

2.1.1.2.4 Technical Assistance: Builders and Communities

In addition to providing support for business customers, PGE has worked in collaboration with our local community partners to support the development of standards that include EV-ready design elements in new construction. We will continue to work with the state and municipalities on the development of those standards.

For new construction, we support our customers adoption of best-practices for locating charging infrastructure, sizing service panels, installing dedicated EV circuits, selecting the proper cable length, etc.

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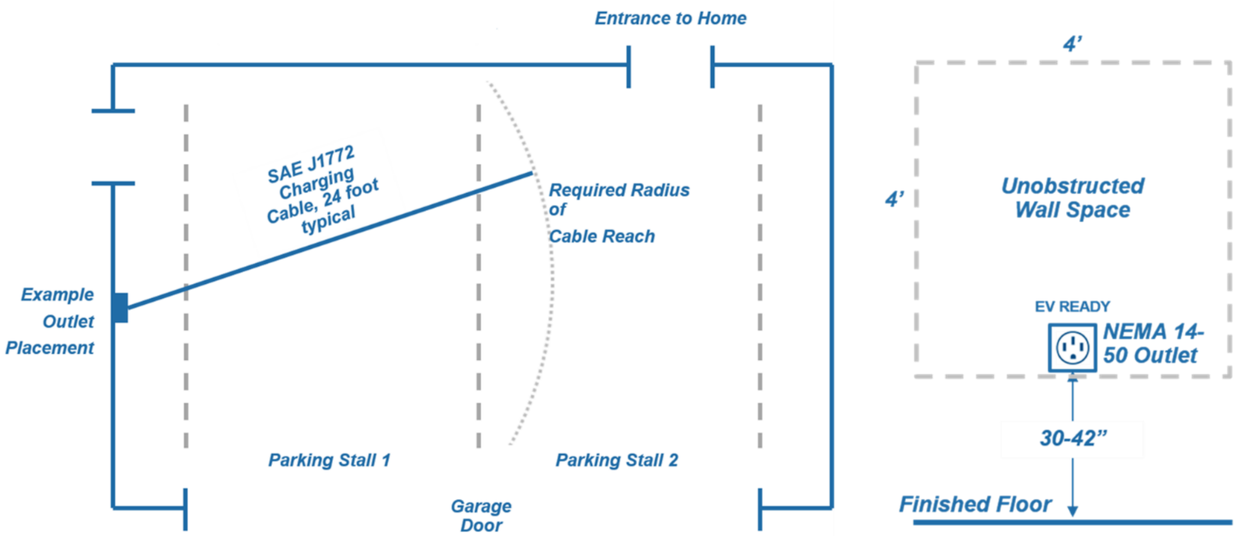
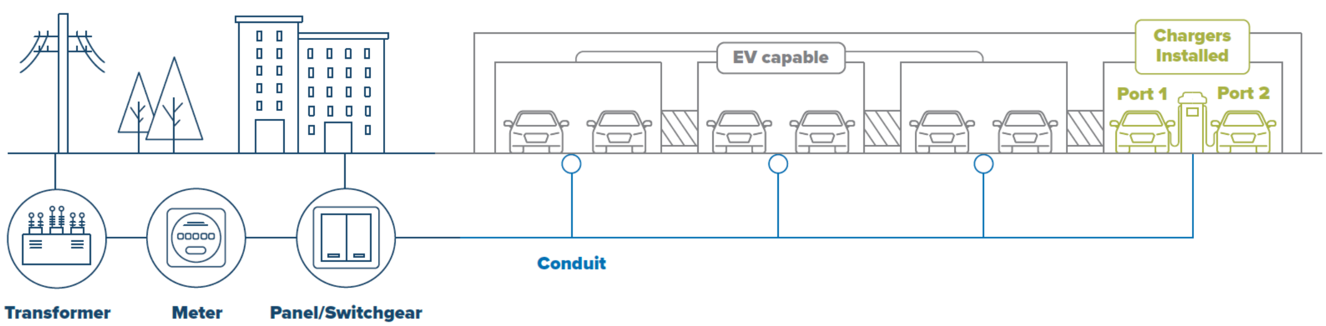
Figure 52 and Figure 53 are samples of EV-ready design elements for new construction.

Figure 52 – New SF Homes EV-Ready Example Garage Layout and Example Outlet Placement



Additionally, for multifamily (MF) properties, PGE also supports considerations around electrical capacity reserved for future EV loads, conduit installations, and the timing of charging station installations. Figure 53 illustrates an example of a MF make-ready standard we worked to develop with one of our community partners.

Figure 53 – New MF Homes EV-Ready Example Parking Layout Concept



Additionally, PGE supports the Governor's goals outlined in Executive Order 17-21 to establish EV-ready building codes by 2022. PGE looks forward to working with the State and local communities to define standards that are both reasonable and help us realize our state's long-term EV goals.

Table 37 identifies how technical assistance for builders and communities addresses OAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities*.

Table 37 – Technical Assistance Impact Summary (Builders and Communities)

Activity's impact on	Description
Accelerating TE	This will accelerate TE in the long-term by ensuring buildings constructed today make smart, low-cost investments that reduce customer friction when buying an EV in the future.
Addressing barriers to adoption	This will address a customer's first cost by reducing the cost for them to install charging infrastructure at their home, it will ensure access to charging at MF properties, and will increase access to charging at workplaces.
Extending access to underserved communities	This will drive increased access to EV charging in new MF properties.
Supporting efficient grid integration	Make-Ready policies do not directly impact efficient grid integration, however, planful investments will reduce customers' future EV infrastructure costs.

2.1.1.3 *Electric Avenue Network*

PGE's approved pilots included the establishment of the Electric Avenue Network (Community Charging Pilot). This pilot includes a network of six new charging stations with high-powered fast chargers and L2 stations that increase the visibility, availability, and accessibility of charging infrastructure throughout PGE's service area.

Shortly after receiving approval to proceed with the pilot, PGE acquired new locations for infrastructure deployment, procured charging infrastructure hardware and software, designed and engineered each new location, installed new charging infrastructure, tested and commissioned sites, and opened new locations to the public.

PGE first engaged our Geospatial Information Services (GIS) department to determine the distribution of EVs in the service area and to model the expected growth in EV ownership in the coming years. Data sources included existing Direct Current Quick Chargers (DCQC), Oregon Census Blocks, zip code block vehicle registration data, marketing data from PGE's Customer Insights department, and projected traffic volumes in the year 2025. Through data processing and analysis, PGE created visualizations and heatmaps of expected areas of high demand.

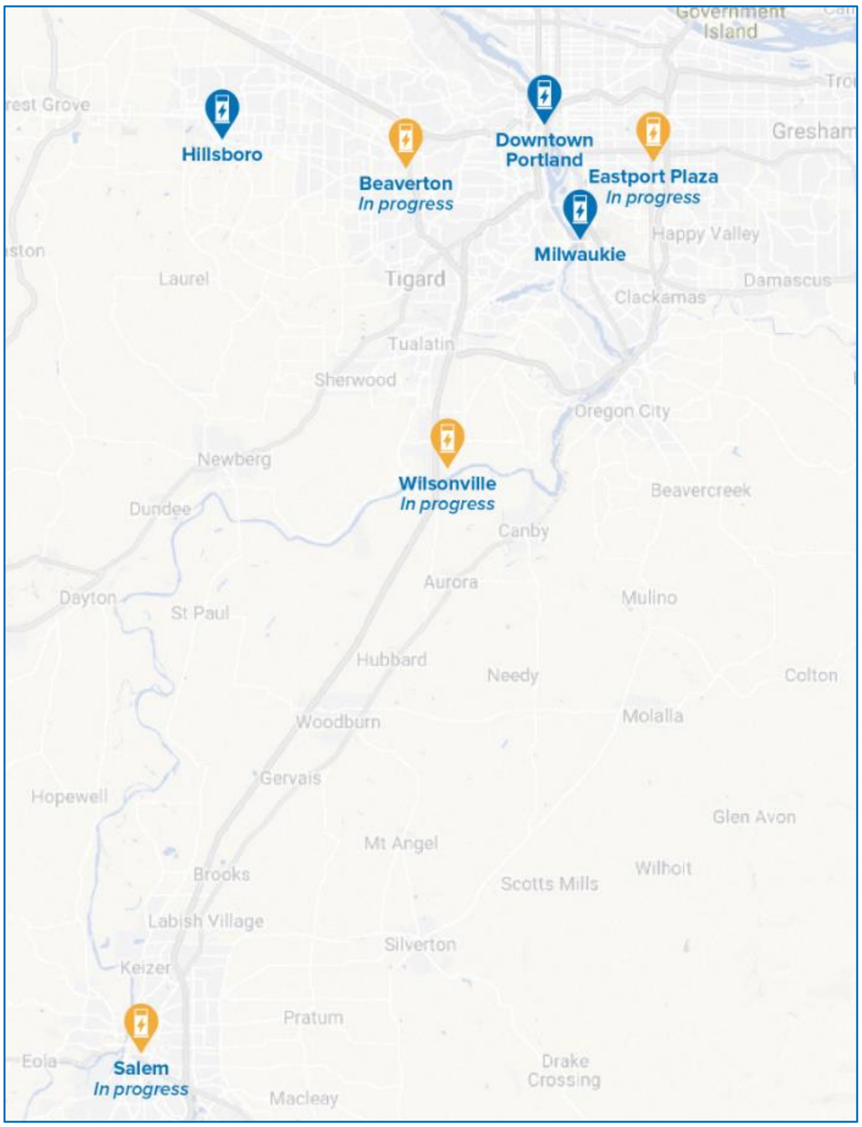
PGE used this data to identify areas of interest and to engage potential site hosts. In parallel with site host engagement, PGE made field visits to sites of interest to analyze how each site met criteria for visibility, accessibility, amenities, proximity to the distribution grid, and proximity to underserved communities. These field visits allowed the team to identify prime locations for development and pursue the execution of site host agreements therefor.

Through this process, PGE acquired six locations:

1. Milwaukie (10834 SE McLoughlin Blvd, Milwaukie, OR 97222);
2. Hillsboro (2295 SE Tualatin Valley Highway, Hillsboro, OR 97123);
3. East Portland (next to 4124 SE 82nd Ave, Portland, OR 97266);
4. Wilsonville (8200 SW Wilsonville Rd, Wilsonville, OR 97070);
5. Beaverton (corner of SW Canyon Rd. and SW Broadway, Beaverton, OR 97005); and
6. Salem (900 Court St. NE Salem, OR 97301)

To date, PGE has deployed charging sites at Milwaukie and Hillsboro locations. Figure 54 shows PGE's deployed and planned Electric Avenue charging sites:

Figure 54 – Map of Electric Avenue Sites



PGE's locations in Milwaukie and Hillsboro currently host a combined utilization of approximately nine sessions per day. Preliminary data by location is shown in Table 38 below. Utilization is expected to increase as additional Electric Avenue locations are deployed and awareness increases.

Table 38 – Electric Avenue Monthly Sessions and Energy Use from April 6 to June 27, 2019.

	Milwaukie		Hillsboro	
Month	**Sessions**	**Energy Use (kWh)**	**Sessions**	**Energy Use (kWh)**
April	178	715	n/a	n/a
May	209	1,045	52	459
June	212	1,272	110	746

2.1.1.3.1 Challenges and Learnings

DCFC infrastructure is still an emerging technology and offered many challenges, including:

- **Rapidly changing technology:** PGE's pilot locations are intended to be operational for ten years, requiring equipment that can be modified to accommodate changing vehicle and charging technology in that timeframe. When the pilot was originally proposed, public DCFC infrastructure typically offered 50 kW charging speeds (120 kW for Tesla vehicles). By 2018, the first 150 kW equipment was being deployed with vehicles in development that could receive up to 350 kW of charge (Porsche Taycan). To ensure that sites were useful and attractive to customers over the ten-year pilot life, PGE selected modular equipment that can be upgraded to provide up to 350 kW of power.
- **Lengthy site acquisition process:** Site host negotiations took longer than expected due to siting requirements and a ten-year contract length. Some contracts took over one year to negotiate.
- **High construction costs:** PGE began collecting bids for construction in a historically tight construction market. Multiple vendors declined to bid on work, while others submitted proposals that were two to three times expected construction budget estimates.
- **Vendors unfamiliar with emerging technology:** PGE encountered many civil and electrical engineering and construction firms that were unfamiliar with high powered DCFC infrastructure. PGE had to educate vendors on equipment design and function and facilitate conversations between equipment manufacturers, engineers, and construction firms throughout the design and engineering process, adding cost and time to deployments.
- **Reliability of state-of-the-art equipment:** PGE selected state-of-the-art equipment that had not been widely deployed. Commissioning activities uncovered a variety of reliability issues that vendors had to remedy. Reliability is expected to improve as deployments grow. PGE continuously monitors equipment and social media platforms for signs of poor performance.

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Table 39 identifies how the Electric Avenue Pilot addresses OAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities:*

Table 39 – Electric Avenue Pilot Impact Summary

Activity's impact on	Description
Accelerating TE	Drives adoption by reducing customers' anxieties of electric vehicle fueling; increases access to customers who may not otherwise have access to charging in these areas
Addressing barriers to adoption	Directly addresses the barrier of access to charging infrastructure; increases awareness by being in visible, well-trafficked areas
Extending access to underserved communities	We targeted locations that have been traditionally underserved with public charging infrastructure
Supporting efficient grid integration	By developing these sites, we are learning important best practices on how to effectively manage grid integrations for future high-powered charging sites.

2.1.2 Clean Fuels Program

In April 2017, the OPUC opened an investigation into utilities' roles regarding the LCFS (also known as the Clean Fuels Program, or CFP).[127] The OPUC found that electric company participation in the CFP as a credit generator is in the public interest.[128] The OPUC also adopted Credit Monetization Principles and Program Design Principles, which give direction on how the program should be administered. However, it should be noted that as these programs are not funded through ratepayer dollars, they will not be held to a traditional cost effectiveness or prudence review process.[129,130]

PGE is a registered credit aggregator for the credits generated by our residential customers. We also generate credits through the charging stations we own, operate, and/or maintain. This section discusses current activities related to residential credits.

2.1.2.1 *Drive Change Fund*

PGE is currently offering grant funding to non-residential customers to:

- Purchase EVs such as school buses, transit vehicles, or shared community service vehicles (i.e., not to include business fleet vehicles or personal vehicles);
- Launch brand-neutral education and outreach campaigns to advance TE;

[127] UM 1826, Available at: https://apps.puc.state.or.us/edockets/docket.asp?DocketID=20725. (Accessed 9/9/19)
[128] Order No. 17-250, Available at: https://apps.puc.state.or.us/orders/2017ords/17-250.pdf. (Accessed 9/9/19)
[129] Order No. 17-512, Available at: https://apps.puc.state.or.us/orders/2017ords/17-512.pdf. (Accessed 9/9/19)
[130] Order No. 18-376, Available at: https://apps.puc.state.or.us/orders/2018ords/18-376.pdf. (Accessed 9/9/19)

- Install EV charging infrastructure in limited circumstances, such as to support any of the projects above, or for installations that do not meet the requirements of programs funded under Docket No. UM 1811; or
- Launch other projects that advance TE, including but not limited to technical assistance and capacity-building around TE within underserved communities, or micromobility, electric car- or ride-share, or autonomous EV demonstration projects.

The fund will prioritize projects proposed or supported by non-profits or public agencies and will place additional weight on projects that address the needs of underserved communities. Per-application and per-applicant caps will be established. A third-party evaluator will be hired to help establish eligibility, develop a scoring rubric, interview applicants, and evaluate applications, and provide recommendations to PGE.

Given that projects that meet the needs of underserved communities are a priority for this fund, yet many community-based organizations that work with such communities are resource-limited, PGE is including a technical assistance budget in its plan. These funds are designed to support community-based organizations in preparing applications, including hiring a technical assistance vendor and supporting another capacity-building work.

CFP credits from any charging infrastructure installed with grant funds will be claimed by PGE, and the resulting funds will be directed back to support additional programs under Docket No. UM 1826.

Table 40 identifies how the Drive Change Fund addresses OAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities*:

Table 40 – Potential impacts, Drive Change Fund

Activity's impact on	Description
Accelerating TE	• PGE offers grants to customers for all types of TE activity. It is PGE's goal that the fund support electrification in diverse ways, in diverse sectors, and at different points along the value chain. • PGE also intends to use learnings from funded projects to inform future program design and selection.
Addressing barriers to adoption	• The grant fund reduces first cost of EV-related projects
Extending access to underserved communities	• The fund will provide benefits to traditionally underserved communities directly through technical assistance and capacity-building in the fund application process; and indirectly through funded projects. Addressing the needs of underserved communities will carry weight in the application evaluation process. The grant program inherently allows underserved communities to communicate their needs and build a solution that works within their community.
Supporting efficient grid integration	• These grants will give PGE early insight into where new EV charging deployments may occur. This will enable us to work with customers to reduce deployment costs up-front and look for long-term solutions for smart charging or specialized rates.

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2.1.2.2 *School Bus Pilot*

Today, there are no electric school buses on Oregon roads. Despite some interest from school districts, the upfront costs and long-term uncertainties of electric school buses remain barriers to adoption. Further, research from electric school bus projects around the nation suggests that school districts -for which pupil transportation is a secondary, not primary, mission-require a significant amount of technical assistance, in addition to financial support, to overcome these barriers. Lastly, public policy barriers exist. Current Oregon Department of Education administrative rules exclude electric school buses, which cannot meet the state's student safety specifications.[131] Despite these barriers, it should be noted that school buses are neighborhood vehicles, and their air quality impacts affect communities directly, particularly school children. PGE is working to help school districts overcome barriers to adoption of electric school buses.

PGE is working to assist two-to-five school districts and/or school bus fleet operators in its service territory with the acquisition of approximately four electric buses and the installation of demand response-enabled charging infrastructure.[132] The school districts will be selected through a competitive process that prioritizes a variety of factors including, but not limited to, income levels, geography, cost-sharing ability and demographics. PGE will provide technical assistance to the schools, which may include site assessments, cost-benefit analysis, vehicle and charger selection support, assistance participating in demand response programs and events, and utility rate optimization. PGE will also support schools through the bus procurement process, including necessary discussions with the Department of Education to ensure that the electric school buses meet all Oregon specifications for pupil transportation.

Where feasible, PGE will explore with participants and technology vendors the prospect of managed charging, demand response program participation, or V2X (vehicle-to-building or vehicle-to-grid) applications; however, the primary purpose of this pilot is to deploy electric school buses on Oregon roads.

PGE aims to cover the incremental cost of electric school buses as compared to diesel models. PGE will work with school districts to understand their unique financing needs and will leverage other financial assistance mechanisms as applicable (for example, Volkswagen mitigation funds[133] or Oregon Department of Education's pupil transportation reimbursement program[134]). The budget for this program is conservatively structured to accommodate significant up-front costs with reimbursement over time; however, other financing models will be considered and may be used to meet customer needs. Regardless of how financing is structured, any reimbursement from bus financing will be directed back to support additional programs under Docket No. UM 1826.

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[131] OAR 581-053-0240, Minimum Standards for School Buses: https://secure.sos.state.or.us/oard/view.action?ruleNumber=581-053-0240

[132] Actual number of districts and school buses may vary based on customer willingness and customer-specific project costs.

[133] Oregon Department of Environmental Quality. *Volkswagen Diesel Settlement.* Retrieved from: https://www.oregon.gov/deq/aq/programs/pages/vw-diesel-settlement.aspx

[134] Oregon Department of Education. *Transportation Reimbursement.* Retrieved from: https://www.oregon.gov/ode/schools-and-districts/ptf/Pages/Pupil-Transportation.aspx

Table 41 identifies how the School Bus Pilot addresses OAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities:*

Table 41 – Potential impacts, School Bus Pilot

Activity's impact on	Description
Accelerating TE	• Help several school districts overcome the technical and financial barriers to adopting an electric school bus. • Indirectly through the development of a strategy paper that will help other school districts, inform future program design under SB 1547, and potentially influence public policymakers.
Addressing barriers to adoption	• Reduce the first cost associated with electric buses • Increase awareness of e-buses to school districts • Provide technical support to simplify/remove complexity from the deployment of charging infrastructure
Extending access to underserved communities	• This program will strive to provide benefits to traditionally underserved communities by considering the percentage of students at each school receiving free or reduced-price meals in assessing with which school districts to partner.
Supporting efficient grid integration	• PGE will support the customer in right-sizing and right-locating the charging infrastructure and will explore strategies for smart charging and potential future integrations with V2G technologies.

2.1.2.3 *Outreach*

PGE is working on the following public outreach activities:

- **Total Cost of Ownership Tool**: 2,000 people visit PGE's website each month, and the website currently contains static information about the benefits of EVs. PGE is developing an interactive web tool which will allow residential customers to enter their driving habits and vehicle feature needs, compare EV models to gasoline vehicles, and estimate cost and emissions savings using PGE-specific carbon intensity and electric rate figures. The web tool will be updated as appropriate with information about PGE programs, rebates, and incentives related to EVs. The goal for this activity is 10,000 visits to the web tool in its first year.
- **EV Promotional Display**: PGE's community investments program sponsors dozens of community events throughout the year, many with an opportunity to set up a display booth. However, these opportunities are underutilized. PGE is developing a standalone booth and collateral materials that focus on TE and will train employees to staff it. The booth will include interactive elements and educational information, and will encourage learning and dialogue in a casual, one-on-one manner. The booth will also allow PGE to leverage existing opportunities (no CFP funds will be used for event sponsorships) and engage in community events with a consistent, cohesive TE message. The goal for this activity is 20,000 impressions in the first year of deployment.

- **Dealer Engagement**: PGE has added enhanced functionality to the touch screen kiosks we are deploying at dealerships. We are also going to deploy two more kiosks, with at least one sited at a used EV dealership. The kiosk enhancements will integrate information about used EVs in addition to new EVs and will capture customer information for follow-up and targeted communications about future programs, rebates, and incentives. This will expand accessibility of the kiosks to those in the used car market and will leverage SB 1547 investments to enable targeted marketing to EV Intenders and those who have recently made purchases. The goal for this activity is to have 750 customers submit their information; and 500 used EVs sold at dealerships with a kiosk by March 31, 2020.
- **Electric Car Guest Drive**: PGE used CFP funds to add an incremental ride-and-drive to the 2019 schedule, executed by a national EV ride and drive vendor, to learn about different approaches to customer engagement. The Electric Car Guest Drive featured a range of vehicle types, including several Teslas (which are not typically available for ride-and-drives). The event was targeted, with drivers required to pre-register to drive. At the event 141 drivers conducted 349 test drives. Two customers purchased EVs immediately after the event. We intend to follow-up with attendees over the next 12 months to track additional vehicle sales attributable to the event. Figure 55 is a picture from the event:

Figure 55 – Electric Car Guest Ride & Drive Event (Milwaukie, OR)

- **Electric Avenue Landmark Displays**: As previously discussed, PGE is in the process of building six new Electric Avenue sites throughout its service territory. PGE will use CFP funds to design, construct, and install display panels at each of these locations, which are in visible public areas with high car, bus, foot, and bike traffic. Displays will educate the public on the features and benefits of TE and will leverage infrastructure investments under SB 1547 to create an educational opportunity for members of the public regardless of their mode of transportation. The goal for this activity is 500,000 impressions among all the Electric Avenues.

Table 42 identifies how the outreach activities address OAROAROAROAR 860-087-0020: *(3)(c) A discussion of how the electric company's investments, programs, and actions are expected to accelerate transportation electrification, address barriers to adoption, and extend access to traditionally underserved communities:*

Table 42 – Potential impacts, Clean Fuels Outreach Activities

Activity's impact on	Description
Accelerating TE	• Increasing customers' familiarity and awareness of EVs • Supporting dealer engagement with EV sales • Making it easier for customers to quantify the financial benefits of EVs
Addressing barriers to adoption	• Addressing the knowledge/awareness gap • Reducing dealership friction • Allowing customers to test EVs and remove misconceptions
Extending access to underserved communities	• These activities will provide benefits to traditionally underserved communities first and foremost through community engagement research, which will have wide-ranging impact across the Portfolio of TE activities. • Other activities such as adding used EV information to Chargeway kiosks also provide benefits to traditionally underserved communities, members of whom may not be in the market for a new vehicle.
Supporting efficient grid integration	• This activity has little impact on grid integrations, however, as we grow our engagement with dealerships, we aim to leverage that channel to help promote smart charging incentives.

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2.2 Future TE Actions

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(b) A summary of the electric company's transportation electrification program(s); and future transportation electrification concepts and actions in its Oregon service territory….*

PGE's long-term vision is that EVs represent a flexible resource that creates system-wide and locational value for our customers. EVs will put downward pressure on rates, so our future program actions should continue to accelerate our customers' adoption of EVs. Further, our actions should aspire to reduce the costs to serve those new loads and to create new grid services value. By increasing benefits and decreasing costs, our interventions aim to increase the net benefit that EVs bring to our system. Figure 56 illustrates how we expect our intervention in the market to impact the benefits accruing to our customers:

Figure 56 – Illustrative Example of Customer Impact of PGE's TE Activity

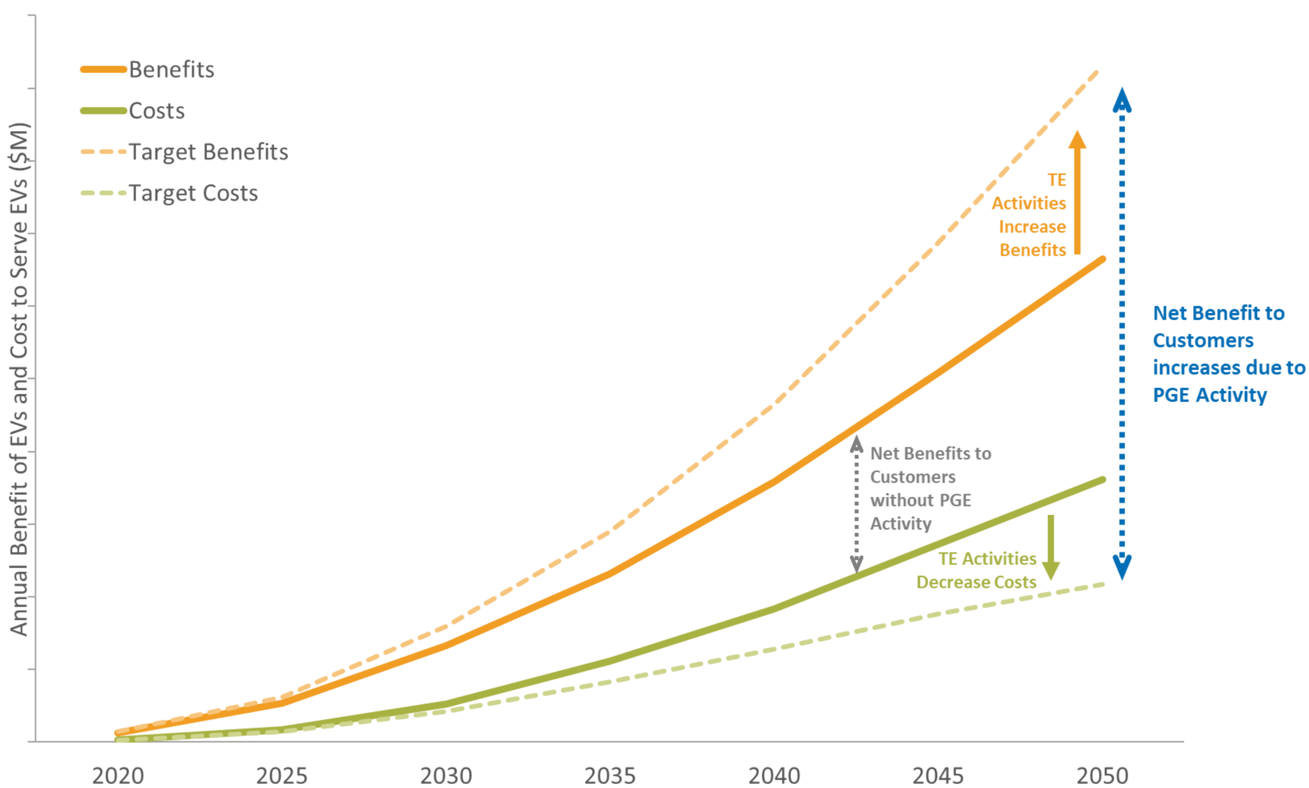


Figure 57 and Figure 58 further illustrate how those benefit streams and cost reductions may accrue.

Figure 57 – Illustrative Benefits Realized from TE Activities

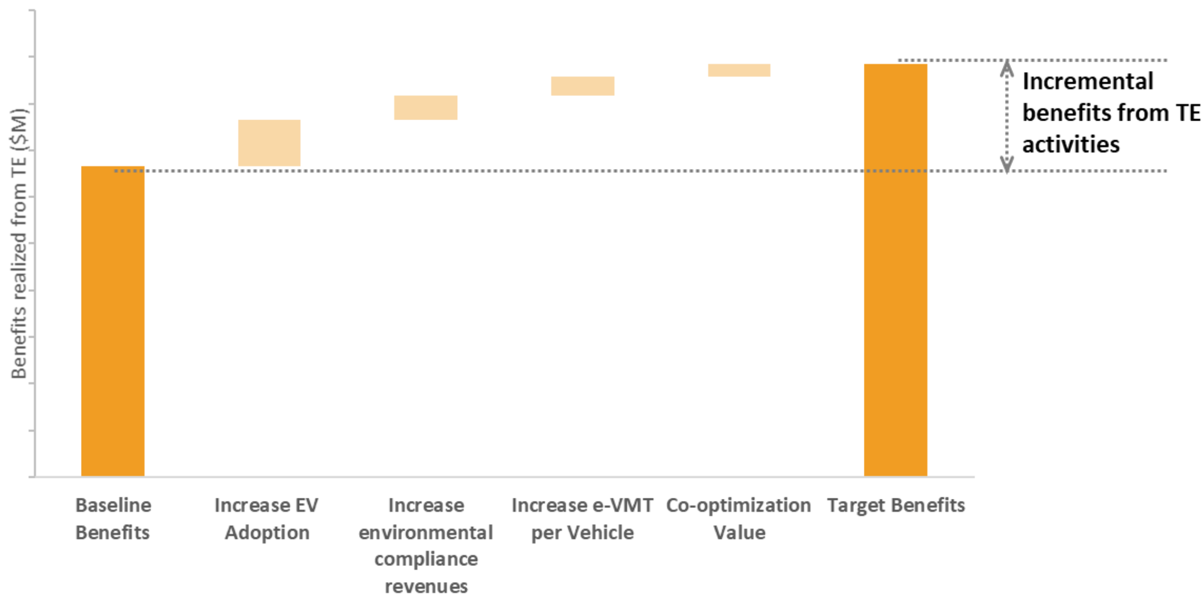
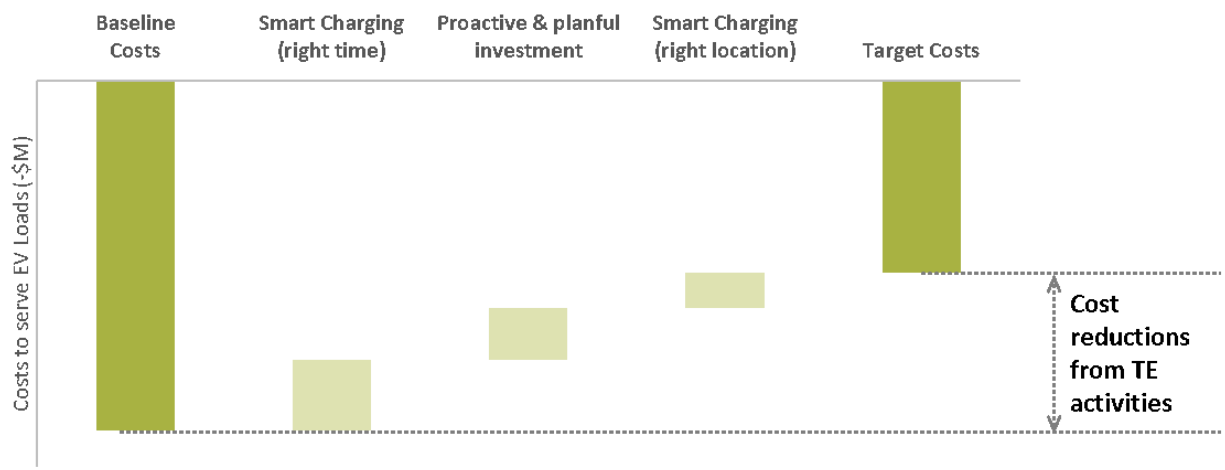


Figure 58 – Illustrative Cost Reductions Realized from TE Activities



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To create this value, our activities must address market barriers and grid impacts outlined in Section 1. These future activities in electric transportation can best be classified in three primary functions: rates, infrastructure, and programs. Table 43 identifies high-level value streams associated with each function.

Table 43 – TE Activities and Customer Value Streams

Customer Value	Rates	Infrastructure	Programs
Increase Benefits	Support increased adoption by ensuring that **electric fuel is affordable and competitive** with petrol fuels. Further, rates should be structured to ensure customers are paying their fair share.	**Ensure charging resource adequacy**: support increased adoption and positive customers experiences by ensuring customers have access to reliable charging infrastructure where and when they need it.	Support increased adoption by **enhancing the customer value proposition** (more ways to monetize their vehicle, simplified user processes) and by creating new value streams (e.g. V2G and supporting renewables integration).
Decrease Costs	Price signals can **discourage charging at unfavorable times** (i.e. when energy or capacity prices are high).	Planful investments can ensure that infrastructure is **right-sized, future-proofed, and optimally located** to minimize integration costs.	Support customer planning and charging optimization to **ensure efficient grid integration** and reduced costs to serve EV loads. **Foster a competitive environment** for EV charging OEMs and service providers.

Within this section we will address each of those functions as they pertain to the future of passenger electrical vehicle adoption (our residential customers adopting EVs) and fleet electrification (our business customers adopting EVs). It is important to note that some activities targeted at our business customers (e.g. workplace charging) are really in service to our residential customers' EV adoption.

As we explore future TE activities, we note that this industry is quickly changing, and we must remain flexible as we develop and launch new customer offerings. In this section, we highlight activities that we are planning or considering. Due to the nature of the market, these plans may change over time. Table 44 outlines the future activities we will discuss in this section.

Table 44 – Summary of TE Activities in flight or Under Consideration

Segment	Rates	Infrastructure	Programs
Passenger EV Adoption	• EV-only TOU • MF billing • Demand charge relief	• Make-Ready • Owner-Operator of charging infrastructure • Charging as a service • Mobility hubs	• Residential Smart Charging • Business Charging Rebates • Outreach and Channel Management
Fleet Electrification	• Demand charge relief • Hedged pricing/long-term fueling contracts	• Make-Ready • Charging as a service	• Fleet/Charging Planning • Business Charging Rebates • Fleet Smart Charging

2.2.1 Future Behind-the-Meter Investment

We must continue to evolve our system to ensure that our customers can affordably, reliably, and equitably connect to our system to power their lives and business operations in light of customers' growing expectations for electricity as a transportation fuel. Traditionally, we have considered our point of delivery to be the customer's home or business. However, EVs may take service from multiple points of delivery, so we must reconsider that definition. We will take new approaches to how we view the distribution system as our customers change how and where they connect with our system and as our state and local governments have aggressive policy goals to decarbonize transportation.

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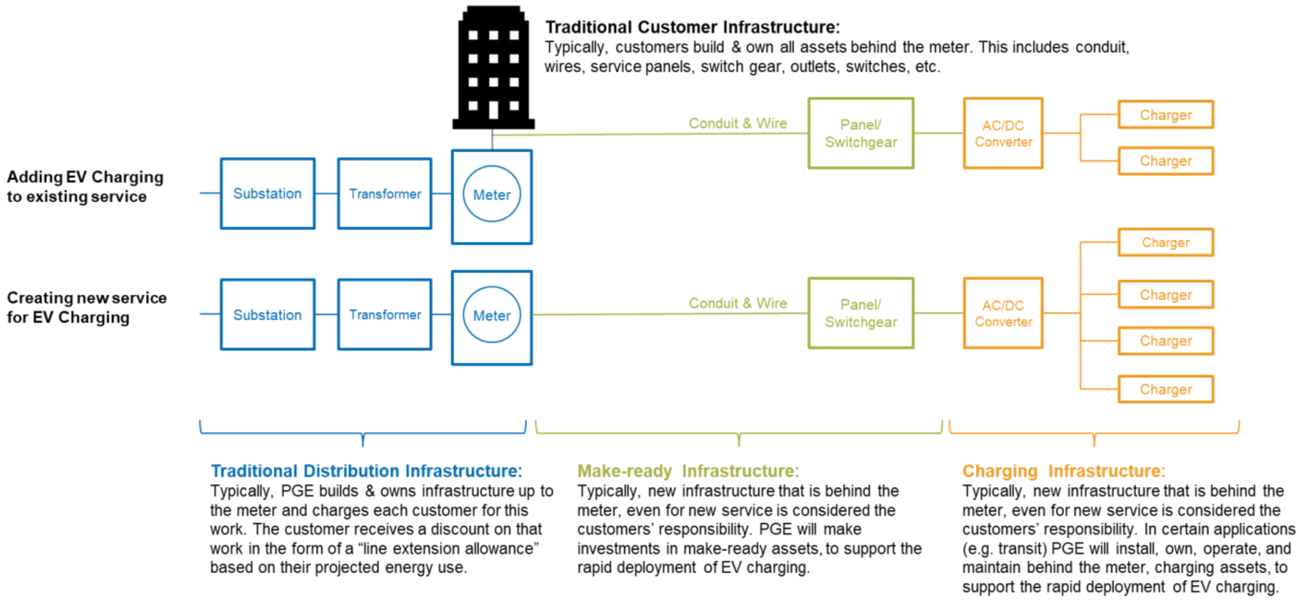
Figure 59 illustrates how make-ready (the electrical infrastructure between a customer's meter and their charging station) and charging infrastructure are extensions of our distribution system:

Figure 59 – Concept Diagram: Distribution System Segmentation



Extending our infrastructure beyond the traditional boundary of the customer meter is necessary to facilitate widescale deployment of the charging infrastructure required to fuel the future EVs on our roads. Reducing our customers' cost to deploying infrastructure is a critical mitigation of a barrier to deployment, and ultimately, EV adoption. In the near-term, we intend to make such behind the meter infrastructure investments. We will continue to remain nimble and ensure we are making the right investments at the right time.

Table 45 summarizes PGE's TE activity outlook by vehicle class (passenger vehicle and fleet), by offering type (rates, infrastructure, and customer programs), and by time frame (in flight, on the horizon, and long-term considerations). This is consistent with how the remainder of the section is outlined.

Table 45 – Summary of TE Activity Outlook

Activity	In Flight	On the Horizon	Long-term Considerations
Passenger Vehicle Adoption (Residential Customers)			
Rates	Schedule 38 (no demand charge); Residential TOU (and separately metered EV option)	Residential TOU as an option for EV drivers with home charging	On-bill payments/subscriptions; Integrated/bundled pricing; Multi-family billing; Sub-meter charging billing
Infrastructure (Public Charging)	Electric Avenue Pilot (six new sites)	Make-Ready for DCQC; DCQC where market gaps exist; Distribution Pole Charging; Mobility Hubs	Network expansion (charge rate, number of chargers per site, additional sites)
Infrastructure (Home Charging)	n/a	Residential smart charging; Make-Ready for MF	Charging as a Service
Infrastructure (Business Charging)	n/a	Make-Ready for destination and workplace charging	Charging as a Service
Customer Programs	Technical Assistance	Home smart charging rebates Business charging Rebates	Business charging integration into Energy Partner Program Charging co-optimization (with locational value)
Fleet Electrification (Business Customers)			
Rates	Schedule 38 (no demand charge)	n/a	Hedged pricing / long-term fueling contracts
Infrastructure	Electric Mass Transit Pilot; I5 Fleet Electrification Study	Make-Ready; Charging as a Service (school & transit); E-truck demonstration sandbox	Charging as a Service
Customer Programs	Technical Assistance	Business charging rebates; Electric fleet planning	Fleet charging integration into Energy Partner Program; Charging co-optimization (with locational value)

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2.2.2 Passenger Vehicle Adoption

In this section, we discuss future rates, infrastructure offerings, and customer programs that support passenger vehicle adoption. Today there are over 3.2 million registered passenger vehicles in Oregon. As discussed in Section 1, the market barriers we can address include total cost, customer and dealer awareness, and fueling infrastructure availability; our offerings must strive to address each of these barriers. Furthermore, programs must aim to reduce grid integration costs and create new value streams that support renewables integration and otherwise create customer value. It is important to note that some offerings in service to accelerating passenger EV adoption may be targeted at our business customers (e.g. a workplace charging make-ready offering would require work with our business customers to support the development of a charging network that benefits our residential customers in driving a passenger electric vehicle).

2.2.2.1 *Rates*

To support passenger EV adoption, we must:

- Ensure rates are designed such that electric fuel is affordable and competitive with petrol fuels;
- Ensure rates are designed equitably so that customers-regardless of their living situation-benefit from the relative low costs of electricity;
- Structure rates such that they ensure customers are paying their fair share; and
- Design rates to discourage charging at unfavorable times (i.e. when energy prices are high or at times of peak load).

As discussed in Section 3, PGE has several current rate schedules that support passenger EV adoption:

- **Schedule 7**: includes a TOU option for Whole Home or separately metered EVs[135], which allows customers to benefit from lower cost electric fuel;
- **Schedule 38:** allows EV charging suppliers to install public charging without the burden of a demand charge (encouraging more EV charging, which in turn accelerates EV adoption)[136]; and
- **Schedule 50:** includes an easy to understand, affordable subscription for public charging stations, which increases equitable access and adds to the customer EV value proposition when considering a new vehicle[137].

More work, however, can be done. Over the next few years, we anticipate developing EV-only TOU, Multi-family billing, and Demand charge relief rate structures. The following sections provide additional detail on these rate structures.

2.2.2.1.1 EV-only TOU:

Though Schedule 7 allows customers to sub-meter an EV for TOU, we must work to refine this rate to create value for residential customers. The current rate requires a customer to install a separate meter at their premises (and incur the cost of installing that meter) as well as pay a second monthly basic charge. As both of these requirements

135 See: https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_007.pdf
136 See: https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_038.pdf
137 See: https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_050.pdf

undermine the economics of the offer, we may explore an EV-only TOU that does not incur additional charges for separate metering equipment. We will explore a variety of options, including but not limited to:

- Utilizing on-board EVSE telemetry of home charging equipment to serve as a secondary meter for subtractive billing;[138]
- Developing an offering that utilizes a second AMI meter (or other measurement device), but does not require the customer to pay for either installation or an incremental service charge; and
- Bundling subscription offerings with other products (e.g. Electric Avenue subscription), which could allow a customer to bundle all EV charging (including home charging) into an easy-to-understand, predictable monthly charge. Such a subscription could have a low, or even no, volumetric cost for charging during off-peak hours.

Table 46 below summarizes future TOU efforts to support home charging:

Table 46 – Future TOU Product Development

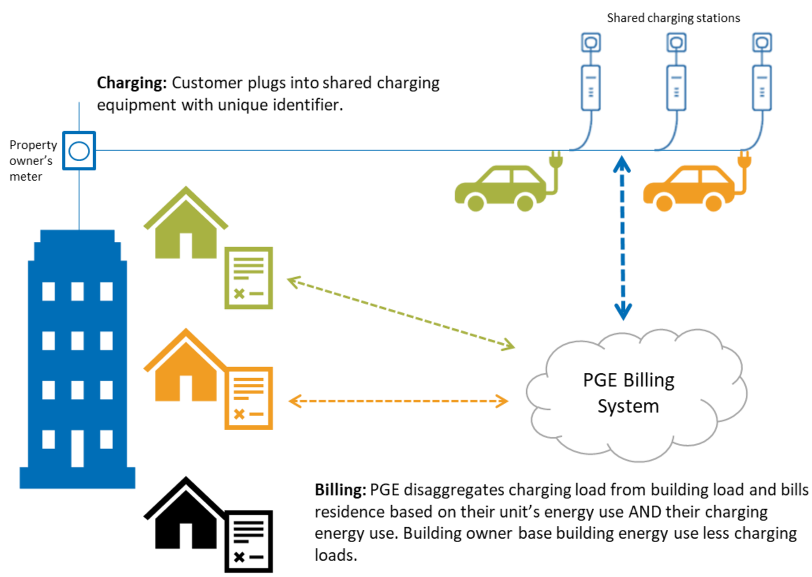
Metric		Detail
Anticipated development timeline (subject to change)		2020
Potential launch date (subject to change)		2021
Potential impact on	Accelerating TE by:	Reducing customers' TCO; Simplifying customer experience
	Addressing barriers to adoption	Reducing customers' TCO; Decreasing pricing complexity for EV drivers
	Extending access to underserved Communities	n/a
	Supporting efficient grid integration	Discourage charging at unfavorable times

[138] Subtractive billing is intended to maintain that the primary AMI meter serving the premises remains the total determinant for a customer's monthly energy usage (kWh). A secondary submeter (in this case via an EVSE) will generate a monthly energy usage that is subtracted from the customer's base bill and added back with alternative rate schedule applied for just that load.

2.2.2.1.2 Multi-family Billing

Certain MF complexes have individually metered residential units, but shared parking facilities and charging infrastructure. Today, PGE does not have a billing solution to allow a MF property manager to track a customer's utilization of a shared charging station and allocate that usage to their bills. In 2020-2021 PGE will explore disaggregating the charger load and working with EVSPs to apply a customer's individual usage to their existing PGE bill, as demonstrated below:

Figure 60 – Illustrative Example of MF EV Charging Billing



In this situation, a customer's rate is tied to the individual (the passenger vehicle customer), not their premise. This concept could be scaled to allow any EV driver to benefit from the low cost of their residential energy charge wherever they charge (home, destination, public, etc.).

Table 47 below summarizes future TOU efforts to support home charging:

Table 47 – Future MF Rate Development

Metric		Detail
Anticipated development timeline (subject to change)		2020-2021
Potential launch date (subject to change)		2021-2022
Potential impact on	Accelerating TE by:	Expanding access to MF customers; Reducing TCO
	Addressing barriers to adoption	Enabling MF property owners to invest in charging infrastructure and recover costs; Enabling MF dwellers' access to home charging
	Extending access to underserved communities	Empowers customers who dwell in MF housing to procure an EV and reliably charge at their homes
	Supporting efficient grid integration	Alone, this concept does not support efficient grid integration, but it could be coupled with TOU rates or other pricing signals in the future.

2.2.2.1.3 Demand Charge Relief

As we will discuss in Section 3, our Schedule 38 cap has enabled early deployments of public quick charging infrastructure. As EV adoption grows, the current 200 kW cap in Schedule 38 could limit new charging deployments. As individual charging stations can use as much as 350 kW, we must contemplate rate designs that encourage investment, but do not punish businesses for making early investments in infrastructure before utilization is sufficient to cover a demand charge.[139]

[139] See: https://electrek.co/2018/12/06/electrify-america-first-350kw-charger-california/

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Over the next several years, PGE aims to evaluate several different options currently being explored by other utilities around the country, including but not limited to the following:

- Removing or increasing the capacity ceiling on Schedule 38;
- Allowing customers to subscribe to a capacity level and pay a predictable, flat monthly fee for capacity; and
- Developing a rate that has no demand charge today, but phases one in over time (see Figure 61).

Figure 61 – Illustrative example of Phased in Demand Charge over Time

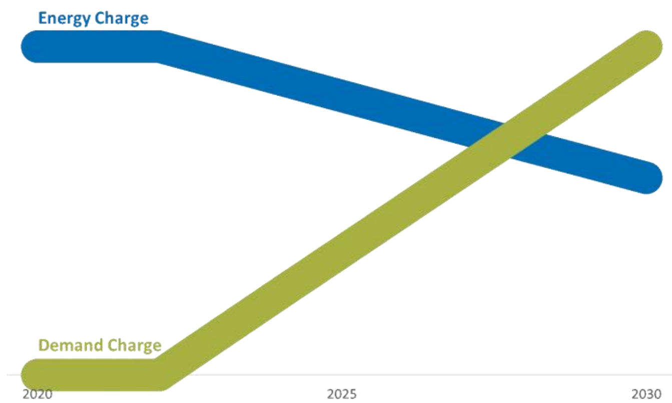

Table 48 below summarizes potential demand charge relief tariff developments:

Table 48 – Demand Charge Relief Rate Development

Metric		Detail
Anticipated development timeline (subject to change)		2020-2021
Potential launch date (subject to change)		2021-2022
Potential impact on	Accelerating TE by:	Increasing deployment of public quick charging infrastructure
	Addressing barriers to adoption	Decrease cost barriers for EVSPs and their customers to deploy high-powered quick charging stations
	Extending access to underserved communities	Offering will result in more public charging infrastructure, which will support customers without access to home charging
	Supporting efficient grid integration	n/a

2.2.2.2 *Infrastructure*

As discussed in Section 1.5.1, the projected growth of EV adoption is driving the need for substantial investment in charging infrastructure. To support passenger EV adoption, we must:

- Ensure our customers have access to charging infrastructure when and where they need it by catalyzing the deployment of reliable charging infrastructure in the service area; and
- Make planful investments to ensure that infrastructure is right-sized, future-proofed, and optimally located to minimize integration costs.

PGE's involvement in charging infrastructure has largely been limited to our Electric Avenue pilot and workplace charging for our employees. More work is needed to ensure our region's fueling infrastructure does not fall behind our customers' needs as they adopt EVs. It is critical that we work with our business customers and EVSPs to accelerate the rollout of charging infrastructure. Over the next few years, we anticipate developing several infrastructure offerings to support EV adoption. In this section we will discuss:

- Make-Ready offerings;
- Owner-operator of charging infrastructure;
- Charging as a Service; and
- Mobility hubs.

2.2.2.2.1 Make-Ready

To accelerate passenger EV adoption, we must ensure our residential customers have access to an ecosystem of charging stations, located where they need them. As such, we need to work with our business customers to accelerate the deployment of charging infrastructure at workplaces, multi-family dwellings, and other public destination locations. For those business customers, making investments in charging infrastructure can be expensive and complicated. Lack of access to charging is a barrier to passenger vehicle adoption, and cost of infrastructure is a barrier for fleet adoption.

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Typically, our view of distribution system stops at the meter, which is the point of delivery tied to a premise. However, as customers' energy use moves beyond the building, our distribution system must evolve. Delivering power to the point of delivery is necessary to ensure reliable supply of electricity to our customers' vehicles. Figure 62, below, illustrates how make-ready extends our traditional distribution system up to the charging infrastructure.

Starting in 2020, we plan to make such infrastructure investments in behind-the-meter infrastructure at our customers' premises to ensure our service area has adequate charging infrastructure to meet the state's EV goals.

Figure 62 – Make-Ready One Line Diagram

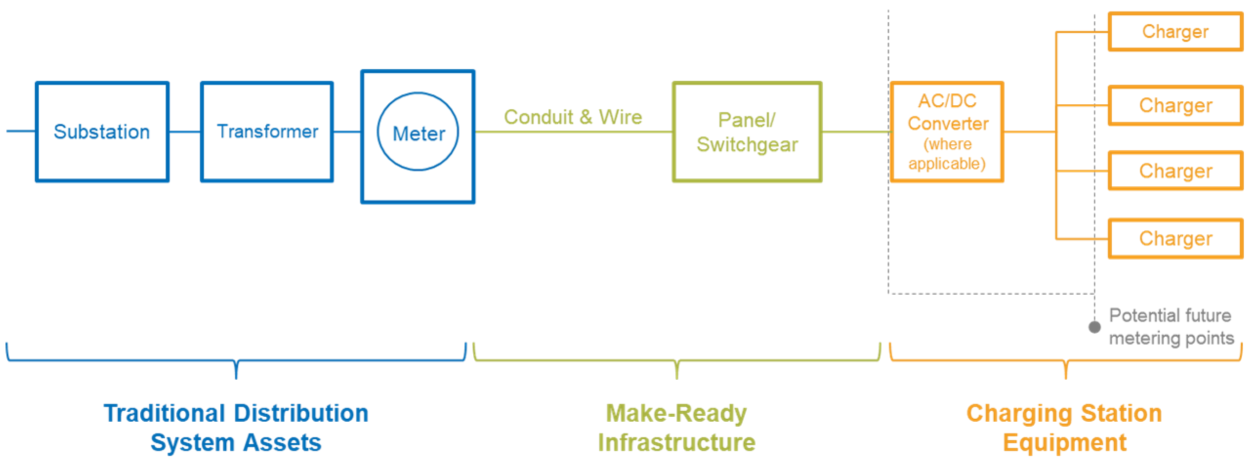

Table 49 below provides an overview of PGE's plans for make-ready infrastructure to support EV charging:

Table 49 – Make-Ready Infrastructure Development

Metric		Detail
Anticipated development timeline (subject to change)		2019
Potential launch date (subject to change)		Q1-Q2 2020
Potential impact on	Accelerating TE by:	Increasing deployment of public and private charging infrastructure
	Addressing barriers to adoption	Increase fueling infrastructure availability
	Extending access to underserved communities	Offering will result in more deployments of public and MF charging infrastructure, giving all customers more access
	Supporting efficient grid integration	By leading the deployment of make ready infrastructure, PGE will be able to work with customers to deploy charging in locations which minimize integration costs

2.2.2.2.2 Owner-Operator of Charging Infrastructure

PGE currently offers charging as a service through the Electric Avenue pilot. We are committed to regularly reevaluate the market to determine if the market needs additional infrastructure. We are committed to working with our communities and EVSPs to identify optimal locations for public quick charging infrastructure. PGE plans to support such projects with make-ready infrastructure.

In addition to our network of public quick charging stations, we are exploring additional solutions for our customers who are 'home charging challenged' (either have no off-street parking or have a garage with limited electrical capacity, which precludes their ability to install a home charging station). One such solution we are exploring is to leverage our existing distribution poles to host pole-mounted charging stations in neighborhoods.

Targeting pole charging stations strategically in neighborhoods with little access to off-street parking (or other impediments to home charging) could allow residents to benefit from low-cost, convenient, overnight charging without having to rely on quick charging infrastructure for their typical EV fueling.

We are exploring a proof-of-concept in 2020 and will evaluate its impact on customers' willingness to procure an EV. Table 50 below summarizes key program dates and deliverables:

Table 50 – Owner-Operator of Charging Infrastructure Development

Metric		Detail
Anticipated development timeline (subject to change)		Exploratory at this stage
Potential launch date (subject to change)		Proof of concept targeted for June, 2020
Potential impact on	Accelerating TE by:	Increasing accessibility of charging near the home
	Addressing barriers to adoption	Increased availability, accessibility, and convenience of charging infrastructure
	Extending access to underserved communities	Pole charging could greatly increase accessibility and convenience of charging in older, underserved neighborhoods; and could create a solution for municipalities
	Supporting efficient grid integration	Pole charging would encourage customers to park and charge their vehicle overnight at times when energy prices are typically low and renewable wind resources are abundant

2.2.2.2.3 Charging-as-a-Service

In the future, PGE may offer business customers a charging-as-a-service option, whereby we own the charging station and lease it to the customer for a monthly fee. Included in the cost of a subscription could be installation, maintenance, upgrades/replacements, driver customer service, etc. Such a model will be explored for several segments in order to benefit passenger EV adoption:

- Residential charger lease offering (e.g. customer pays flat monthly fee 3, 5, or 10 years to get a charging station installed at their home); and
- Business charger lease offering (for MF homes, destination charging, workplace).

Similarly, PGE may also explore charging asset management services to allow charging site hosts to focus on their primary business needs. Such asset management services may include but are not limited to:

- Charging optimization;
- Energy management/bill management; and
- Charger maintenance (preventative and responsive).

Table 51 below summarizes key program dates and deliverables:

Table 51 – Charging-as-a-Service Infrastructure Development

<table>
<tr><th colspan="2">Metric</th><th>Detail</th></tr>
<tr><td colspan="2">Anticipated development timeline
(subject to change)</td><td>Exploratory at this stage</td></tr>
<tr><td colspan="2">Potential launch date
(subject to change)</td><td>Not yet planned</td></tr>
<tr><td rowspan="4">Potential impact on</td><td>Accelerating TE by:</td><td>Decreasing first cost associated with charger installation;
Increasing deployment of public and private charging infrastructure</td></tr>
<tr><td>Addressing barriers to adoption</td><td>Reducing friction in deploying charging infrastructure;
Increase fueling infrastructure availability</td></tr>
<tr><td>Extending access to underserved communities</td><td>Offering will result in more deployments of public and MF charging infrastructure, giving all customers more access</td></tr>
<tr><td>Supporting efficient grid integration</td><td>By leading the deployment of make ready infrastructure, PGE will be able to work with customers to deploy charging in locations which minimize integration costs</td></tr>
</table>

2.2.2.2.4 Mobility Hubs

As discussed in Section 1, our customers' mobility needs are rapidly changing. McKinsey estimates that micromobility could be a \$200-\$300 billion market by 2030.[140] Declining battery costs are driving a rapid deployment of private and shared electric transportation technologies (e.g. e-scooters, e-bikes, etc.). Though the market is quite small today, and though each individual vehicle has a limited grid impact, it is critical that we continue to evolve our solutions in a manner that is meaningful with our customers' transportation needs.

[140] See: https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/micromobilitys-15000-mile-checkup.

PGE is currently leading the design of a mobility hub in inner southeast Portland. This hub will include active modes of new transportation (e.g. scooters, e-bikes, electric car share, etc.). We are working closely with the City, County, TriMet, and local businesses to identify transportation priorities in the future. Such a project can help us better understand the long-term system impacts of micromobility, facilitate adoption of electricity as a transportation fuel for customers who do not or cannot drive, and support our communities in transitioning to multi-modal and active transportation options. This first deployment is exploratory and will inform how we engage micromobility in the future.

Table 52 below summarizes key program dates and deliverables:

Table 52 – Mobility Hubs Infrastructure Development

Metric		Detail
Anticipated development timeline (subject to change)		Through Q2, 2020
Potential launch date (subject to change)		June, 2020
Potential impact on	Accelerating TE by:	Launching electric car and micromobility share options for customers without a car or as a secondary mode of transportation for those who primarily rely on transit
	Addressing barriers to adoption	Expanding EV options for customers who do not have a car; Giving transit customers electric mobility tools to run errands during the day without having to drive a car to work
	Extending access to underserved communities	The mobility hub will allow alternative transportation options for customers who do not have a drivers' license and for those who rely on transit. If successful, the demonstration could potentially be replicated in underserved neighborhoods.
	Supporting efficient grid integration	The project will better inform PGE of the impact of micromobility loads on our system and what-if any-charging management strategies could be employed in the future.

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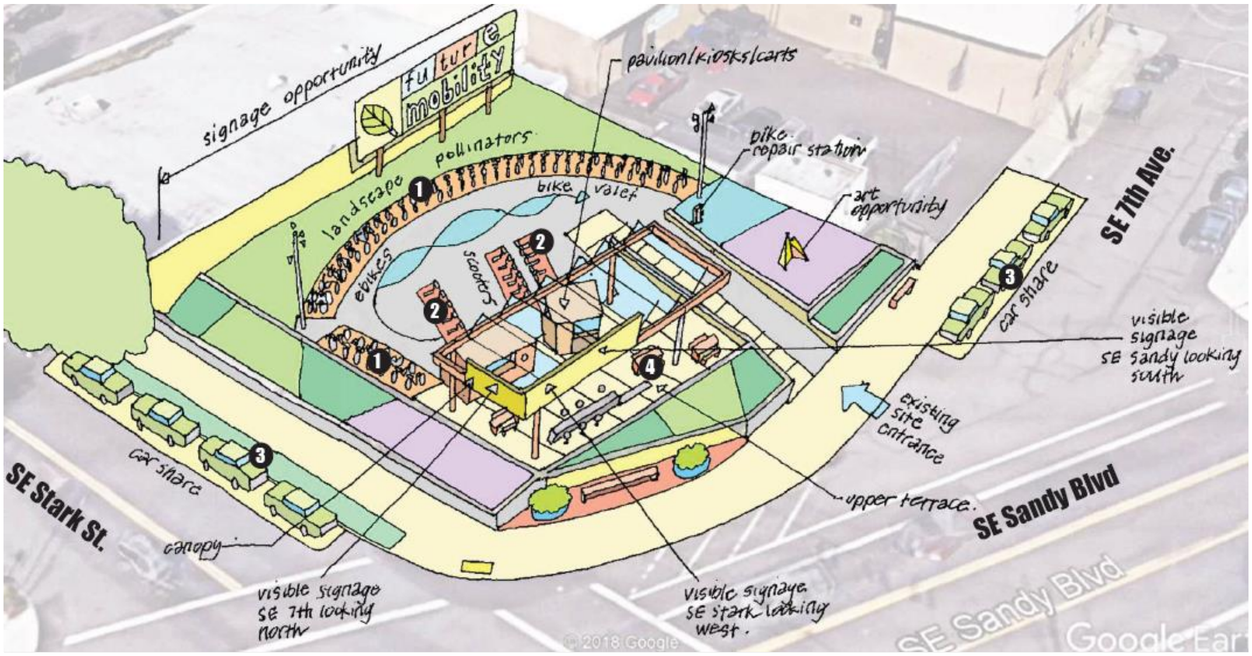
Figure 63 below illustrates a Mobility Hub concept:

Figure 63 – Mobility Hub Conceptualization



2.2.2.3 *Customer Programs*

In addition to smart rate design and planful investments in infrastructure, we must craft programs that support increased adoption by enhancing the customer value proposition (increased ways to monetize their vehicle, simplified user processes) and by creating new value streams (e.g. V2G and supporting renewables integration). In this section we will discuss:

- Residential Smart Charging;
- Business Charging Rebates; and
- Outreach and Channel Management.

2.2.2.3.1 Residential Smart Charging

Earlier this year, PGE proposed a pilot program to support the deployment of residential smart charging stations.[141] The pilot targets SF homes and aims to provide rebates for approximately 3,600 home chargers over a three-year period. Participants will receive a rebate ranging from $500-1,000 per charger, and EV dealers will receive a $100 mid-stream rebate for referring a qualified and successful EV charger installation. Further, the pilot program will test the effectiveness of providing grid services, specifically demand response (DR) using home chargers, offering customers a $50 annual incentive for participating in grid services events.

[141] See: https://edocs.puc.state.or.us/efdocs/HAD/um1811had151943.pdf

The pilot aims to:

- Decrease customers' first cost of adopting an EV;
- Engage dealers in selling EVs and connecting customers to simple charging solutions;
- Lower customers' fueling costs;
- Give PGE insight into where customers are adopting EVs, and which customers have home charging stations; and
- Manage home charging loads to minimize system impact (and, in the long-term, to manage localized system impacts).

Though this has been proposed as a pilot, if approved, PGE anticipates this growing into a full-scale program very quickly. It is critically important that as EV adoption scales, PGE is able to monitor and manage home charging stations. We are also exploring the possibility of demonstration project in PGE's Smart Grid Test Bed neighborhoods to test a vehicle-based smart charging offering to track and influence customers' charging at home, work, and in public. Table 53 below summarizes key program dates and deliverables:

Table 53 – Residential Smart Charging Program Development

Metric		Detail
Anticipated development timeline (subject to change)		Through Q1, 2020
Potential launch date (subject to change)		Q1/Q2, 2020
Potential impact on	Accelerating TE by:	Reducing customers' first cost and operating cost of an EV; Engaging dealerships in the sales process
	Addressing barriers to adoption	Reducing first cost and TCO; Empowering dealerships to sell EVs and electric fuel
	Extending access to underserved communities	The pilot offers a 2x incentive (up to $1,000) for income-qualified families
	Supporting efficient grid integration	Better insight into home EV charging and the ability to manage home charging loads will enable PGE to minimize the cost to serve EV loads

2.2.2.3.2 Business Charging Rebates

Earlier this year, PGE proposed a pilot program to support the deployment of business charging stations. The pilot targets nonresidential customers who are installing workplace, destination, MF, or fleet charging stations. Through the pilot, PGE will offer $500 for each L2 charging port installed (up to $2,300 per port at low-income MF properties).

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Unlike the residential pilot, this offering does not include a smart charging element at the onset. Business charging is a far more complicated proposition for charger control, in that the end user (in many cases) is not the customer who owns the charging station. We need to better understand the dynamic between site host and EV driver before offering a business smart charging solution. Ultimately, we plan to enroll these business charging customers into the existing Energy Partner Demand Response Program, where we can create custom DR solutions to meet each customer's unique needs. Rebates will only be provided to DR-enabled charging stations to minimize future costs to integrate into the Energy Partner Program.

Table 54, below, summarizes key program dates and deliverables:

Table 54 – Business Charging Rebates Program Development

Metric		Detail
Anticipated development timeline (subject to change)		Through Q1, 2020
Potential launch date (subject to change)		Q1/Q2, 2020
Potential impact on	Accelerating TE by:	Increasing deployment of public and private charging infrastructure
	Addressing barriers to adoption	Increase fueling infrastructure availability
	Extending access to underserved communities	The pilot offers a 4x incentive (up to $2,300) for income-qualified properties
	Supporting efficient grid integration	In exchange for receiving a rebate, customers will agree to sharing data on charger utilization. Such data will inform our smart-charging engagement strategy for enrolling business customers' charging stations into the Energy Partner Program in the future.

2.2.2.3.3 Outreach & Channel Management

We know that customer and dealer awareness remain critical barriers to EV adoption. PGE expects to continue to grow and evolve our outreach efforts and establish necessary channel management functions to ensure we're supporting a robust EV marketplace. A specific area of focus under evaluation is dealer channel management, which we expect to expand to all major dealers in our service area. Our goals here are to:

- Ensure sales staff are well-trained and versed to speak to customers about electricity as a transportation fuel;
- Empower dealer sales staff to add value to the customers' purchase by generating leads for PGE's home charging programs; and
- Ensure that as dealers' EV sales grow (and number of EVs on their lots grow), we have dealers engaged with smart charging strategies and programs at their lots.

In the future, we may pursue:

- Mid-stream incentive payments to dealers to encourage them to sell more EVs;
- Charging infrastructure services to encourage smart charging at dealerships;
- A certified dealer network to direct customers to sales staff who are well versed in EVs;
- Marketing tools to help dealers sell electric fuel; and
- TNC/Car Share engagement, where we will continue to work with new mobility customers to ensure that they are empowered to choose electric for their fleets. We will explore offering training and education, co-branding programs, specialized rates or incentives, and driver "champions" programs (that reward EV drivers for being advocates of the technology).

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Table 55 below summarizes key program dates and deliverables:

Table 55 – Outreach and Channel Management Program Development

Metric		Detail
Anticipated development timeline (subject to change)		Ongoing
Potential launch date (subject to change)		Expect continued evolution of existing efforts
Potential impact on	Accelerating TE by:	Increasing awareness (customers and dealers); Increasing value for dealers in selling EVs (alternative value streams)
	Addressing barriers to adoption	Awareness; Purchase process; Electrification of shared fleets
	Extending access to underserved communities	The program will increase the awareness and accessibility of electric fuel for all customers
	Supporting efficient grid integration	By understanding our customers' electrification schedules, we can effectively do bottom-up resource planning for our distribution system. This will ensure that we are making right-size, right-time, and right-location investments in our system

2.2.2.3.4 Clean Fuels Program:

As discussed in Section 1.1.7, PGE is a registered credit aggregator for the credits generated by our residential customers. We anticipate that this program will generate several millions of dollars annually for the foreseeable future. OPUC Order No. 18-376[142] outlines design principles for how PGE may use the revenues derived from the sale of those credits:

1. Support the goal of electrifying Oregon's transportation sectors;
2. Provide most of benefits to residential customers;
3. Provide benefits to traditionally underserved communities;
4. Programs are designed to be independent from ratepayer support;
5. Programs are developed collaboratively and transparently; and
6. Maximize use of funds for implementation of programs.

For the 2020 program year, we anticipate working with stakeholders through the process outlined in Order No. 18-376 to select next year's programs. PGE filed preliminary program concepts on September 13, 2019. Concepts included an expansion of the Drive Change Fund, expanded public outreach, smart charging, and upgrading legacy DC charging infrastructure that does not support all vehicle types. PGE held a workshop on September 25, 2019

[142] Order No. 18-376, Available at: https://apps.puc.state.or.us/orders/2018ords/18-376.pdf (Accessed 9/9/19)

and will hold an additional workshop in October. PGE will then prepare a final plan, to be followed by a Staff-prepared public meeting memo in December.

In the near term we do see the CFP as distinct from our utility programs as determined through guideline number 4.[143] PGE includes CFP in this Plan in acknowledgement of the interactions with PGE's planned activities and the programs and activities supported by CFP. As such, we believe the CFP allows us to test innovative/emerging concepts and stimulate nascent markets/segments. That said, as our portfolio of EV offerings grows and as the EV market matures, our administration of programs will evolve. Though we do not anticipate any changes in the near term, it is possible that our utility programs and Clean Fuels Programs may begin to converge at some point in the future, if such convergence supports a more efficient or effective path towards realizing the State's decarbonization and electrification goals.

2.2.3 Fleet Electrification (Business Customers)

In this section, we discuss future rates, infrastructure offerings, and customer programs that support our business customers' fleet electrification. As discussed in Section 1.2, cost, awareness (customer & dealer), fueling infrastructure deployment/cost, and business planning are major impediments to e-fleet adoption. In addition to addressing these barriers, programs must aim to reduce grid integration costs and create new value streams that support renewables integration and otherwise create customer value.

2.2.3.1 *Rates:*

To support passenger EV adoption, we must:

- Ensure rates are designed such that electric fuel is affordable, predictable, and competitive with petrol fuels;
- Structure rates to ensure customers are paying their fair share; and
- Design rates to reward customers for charging at favorable times.

As is discussed in Section 3, PGE has several rate schedules today that support passenger EV adoption:

- Schedule 38 provides fleets the ability to install up to 200 kW of charging infrastructure without the burden of a demand charge[144]; and
- All our business customer rates have TOU mechanisms to encourage smart energy use.

There is more work to be done , so over the next few years, we anticipate working on rate structure developments addressing demand charge relief and hedge/long-term pricing, detailed in the following sections.

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[143] Ibid.

[144] See: https://www.portlandgeneral.com/-/media/public/documents/rate-schedules/sched_038.pdf

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2.2.3.1.1 *Demand Charge Relief*

See Section 2.2.2.1.3, page 122 for details on demand charge relief pricing strategies.

Demand charge relief is also relevant to fleet customers as they are particularly burdensome as these customers start the transition to EVs (when they have few vehicles and utilization is relatively low). For example, if a customer buys a single electric HDV to test, they must also install a charging station. Though that charging station may eventually serve four vehicles, initial utilization of the charger will be very low, and thus the demand charge will comprise a proportionately large share of the customers' fuel cost, and the total cost will be much higher than a typical unit price per kWh.

2.2.3.1.2 *Hedged Pricing / Long-Term Fleet Fueling Contracts*

Predictable rates are critical for the total cost of ownership for many fleet vehicles. This is consistent with traditional petroleum fuel hedging performed by these companies today. Variations throughout the day and across utility area boundaries create uncertainty for fleet managers, and we must work to provide sufficient pricing certainty so that customers can justify investments in electric fleets. PGE is committed to finding solutions that work for our fleet customers and also support efficient grid integration. Table 56 below summarizes key program dates and deliverables:

Table 56 – Long-Term Fleet Fueling Rate Development

Metric		Detail
Anticipated development timeline (subject to change)		2020-2021
Potential launch date (subject to change)		2021-2022
Potential impact on	Accelerating TE by:	Increase price certainty and predictability for fleets
	Addressing barriers to adoption	Minimizing TCO; Increasing predictability of long-term TCO
	Extending access to underserved communities	n/a
	Supporting efficient grid integration	Though this could be challenging, creating a long-term pricing plan for customers could include incentives for right-timed charging or disincentives for periods charging at inopportune times.

2.2.3.2 *Infrastructure*

Fleets need access to reliable fueling infrastructure to make the conversion to EVs. Capital costs of replacing fleet vehicles with EVs is high, so we must find ways to reduce the financial burden for our customers. To successfully encourage fleet EV adoption, we must make planful investments to ensure that infrastructure is right-sized, future-proofed, and optimally located to minimize integration costs.

To date, PGE's involvement in fleet charging infrastructure has been primarily focused on fueling infrastructure for our own fleet and for TriMet's first electric bus route. However, PGE has also supported several customers in deploying their own quick charging infrastructure. These efforts have given us valuable insights into how to support the efficient roll-out of future customer fleet infrastructure.

Much more work needs to be done to ensure our region's fueling infrastructure does not fall behind our customers' needs as they adopt EVs. It is critical that we work with our business customers and EVSPs to accelerate the rollout of charging infrastructure.

Over the next few years, we anticipate developing several infrastructure offerings to support EV adoption: make-ready, electric truck demonstration project, and charging as a service. These are detailed in the sections below.

2.2.3.2.1 Make-Ready

See 2.2.1 at page 116 for a discussion on make-ready infrastructure.

The make-ready infrastructure offering described for business charging assets will be applicable to fleet customers as well. In many cases, make-ready will be significant for large fleets, providing such infrastructure for a customer could solidify a customers' decision to transition to electric fuel.

2.2.3.2.2 Electric Truck Demonstration Charging Sandbox

To build on our early learning about public quick charging garnered through Electric Avenue, we are exploring opportunities to better familiarize ourselves with the technical requirements and customer needs regarding electric truck charging infrastructure.

For a sandbox site, we are evaluating opportunities to test high-powered charging infrastructure, utilization of energy storage (possibly second-life batteries), and vehicle-to-grid technologies. We are exploring opportunities for a project in 2020.

2.2.3.2.3 Charging as a Service

See page 126 of *Passenger* Vehicle Adoption for information on Charging as a Service. The charging as a service offering as described for business charging assets would likely also apply to fleets. In the immediate term, we do recognize that transit agencies and schools are two unique fleet segments that support our communities' transportation needs. For many individuals, the transit bus or the school bus are their primary (or only) modes of transportation. To ensure those customers can share the benefits in clean, emissions-free, electric transportation, we will support their transition to electric with the necessary infrastructure to enable and accelerate their electric bus transition.

The high up-front cost of converting bus fleets will be a limiting factor in the pace of bus electrification. By investing in make-ready and charging infrastructure for school and transit buses, PGE can help accelerate the rate at which our customers transition to electric buses. Starting in 2020, we plan to invest in behind-the-meter infrastructure at schools and other public transportation agencies: we will install, own, operate, and maintain charging stations for these customers.

In the future, we may explore options to offer a similar model to other fleet customers who would like our support. For those customers, we may also explore charging asset management services to allow charging site hosts to focus on their primary business needs. Such asset management services may include but are not limited to:

- Charging optimization;
- Energy management/bill management; and
- Charger maintenance (preventative and responsive).

Table 57 below summarizes key program dates and deliverables:

Table 57 – Charging as a Service Infrastructure Development

Metric		Detail
Anticipated development timeline (subject to change)		Through Q1, 2020
Potential launch date (subject to change)		Q1 2020
Potential impact on	Accelerating TE by:	Removing first cost associated with charger installation; Removing complexity of figuring out charging needs
	Addressing barriers to adoption	Reducing friction in deploying charging infrastructure; Increase fueling infrastructure availability; Electrifies fleet for customers who may not have means to procure their own EV
	Extending access to underserved communities	Transit agencies and schools serve all customers.
	Supporting efficient grid integration	By leading the deployment of charging infrastructure, PGE will be able to work with customers to right-size infrastructure and develop charging management strategies to minimize integration costs and to maximize grid/customer value

2.2.3.3 *Customer Programs:*

2.2.3.3.1 Fleet/Charging Planning

We recognize our customers are increasingly interested in electrifying their fleets. As more vehicle options become available, companies are making commitments to transition fleets of all types of vehicles to electric. Unfortunately, not all our customers have EV experience, and in some cases, they have very little electrical experience.

Fleet electrification is inherently a cross functional process: it requires fleet managers, facilities managers, energy mangers, sustainability mangers, fleet operations staff, leadership, etc. all to be aligned in objectives. Additionally, we need to have better insight into customers' fleet electrification plans to effectively plan our distribution system upgrades. This is especially important as customers' needs regarding vehicle fueling are likely to come at a faster pace than traditional new service requests (e.g. a new truck can be ordered and delivered in a matter of months, where a new building might be years in the planning and construction before service is required).

We plan to build upon our successful technical assistance pilot to offer customers comprehensive fleet electrification planning services. Within this function, we aim to support customers by:

- Establishing a current/future fleet needs assessment;
- Creating a fleet replacement schedule and support with budgeting;
- Establish a needs assessment for the charging infrastructure required to support the e-fleet;
- Determine facilities and distribution system upgrades required to support the new charging infrastructure; and
- Create a charging optimization plan to minimize system impacts.

This information will give the customer the tools they need to start investing in an electric fleet, whilst also providing PGE a roadmap of our large fleet customers' distribution system needs, which will feed into our DRP process. Table 58, below, summarizes key details:

Table 58 – Fleet/Charging Planning Program Development

Metric		Detail
Anticipated development timeline (subject to change)		Through Q1, 2020
Potential launch date (subject to change)		Limited launch in 2020
Potential impact on	Accelerating TE by:	Giving business customers a roadmap, budget, and tools to plan for and incorporate EVs into their fleets
	Addressing barriers to adoption	Removing complexity and uncertainty out of planning and technology evaluation process
	Extending access to underserved communities	The program will support all types of fleet customers, including supporting transit agencies
	Supporting efficient grid integration	By understanding our customers' electrification schedules, we can effectively do bottom-up resource planning for our distribution system. This will ensure that we are making right-size, right-time, and right-location investments in our system

2.2.3.3.2 Business Charging Rebates

See Section 2.2.2.3.2 at page 130 for a discussion on the business charging rebate program.

The rebate program described for business charging assets will be applicable to fleet customers as well.

2.2.3.3.3 Fleet Smart Charging

We currently have no plans to establish a new DR program for fleet EVs. Rather, our plan is to engage these business charging customers via the existing Energy Partner Demand Response Program, where we can create custom DR solutions to meet each customers' unique needs.

2.2.3.4 *Clean Fuels Program:*

Unlike the residential program, PGE does not aggregate the credits generated by our business customers. A business customer can register as a credit generator with the Oregon Department of Environmental Quality (ODEQ) and claim their own credits directly, based on the number of kWh dispensed through their charging stations.

As established in the original Electric Mass Transit pilot with TriMet, PGE took ownership of the credits generated by the project to reduce the costs of the project. It is our intent that we will claim CFP credits when we support customers with infrastructure (make-ready or charging infrastructure) to offset the impact to non-participants. This will be applicable for fleet charging and other business charging applications (e.g. workplace or MF).

Section 3 Supporting Data & Analysis Used to Develop the Plan:

Electric vehicles are creating value for all our customers today-we estimate over $1 billion of new benefits from electric transportation through 2050.

In this section, we outline relevant data that has informed our TE Plan, including an evaluation of costs and benefits of EVs, considerations on rate design, load dynamics, and customer engagement.

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(d) Supporting data and analysis used to develop the TE Plan, which may be derived from elements such as review of costs and benefits; rate design, energy use and consumption, overlap with other electric company programs, and customer and electric vehicle user engagement;*

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3.1 Cost and Benefits

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(d) Supporting data and analysis used to develop the TE Plan, which may be derived from elements such as review of* ***costs and benefits*** *[emphasis added]; rate design, energy use and consumption, overlap with other electric company programs, and customer and electric vehicle user engagement;*

3.1.1 Background and Methodology

Oregon Laws 2016 Chapter 28 and corresponding Oregon Administrative Rule 860 Division 087 have created the opportunity for utilities to demonstrate to the OPUC and to regulatory stakeholders that TE programs can result in a net benefit for customers of the electric utility:

> *Deploying transportation electrification and electric vehicles creates the opportunity for an electric company to propose, to the Public Utility Commission, that a net benefit for the customers of the electric company is attainable;*[145]

Although the Legislature-in its direction for utilities to accelerate the TE market-contemplated TE's ability to create net benefits for utility customers, net benefits were not one of the six factors established for the Commission to consider in approving utility programs. However, as noted in a 2012 Commission order, net benefits may be a consideration when considering prudency, which *is* one of those six factors.[146]

[145] Oregon Laws 2016, Chapter 28, Section 20(2)(f).
[146] OPUC Order No. 12-013 available at: https://apps.puc.state.or.us/orders/2012ords/12-013.pdf.

PGE utilizes a framework for assessing costs and benefits to utility customers that can inform the size, scale, and direction of future investments designed to accelerate TE. The basis of this framework is drawn from the cost effectiveness methodologies outlined in California's *Standard Practice for Cost-Benefit Analysis of Conservation and Load Management Programs* (1983), which describes cost-tests and approaches for determining cost effectiveness. Cost benefit test options are outlined in Table 59:

Table 59 – Cost Effectiveness Tests[147]

Test	Acronym	Approach	Focus
Ratepayer Impact Measure	RIM	Compares administration costs and potential bill reductions to a supply-side resource	What are the economic benefits of the program compared to the costs of a supply-side resource?
Total Resource Cost	TRC	Determines whether the total costs of energy in the utility service territory will decrease	Builds on the economic foundation of the RIM test, in some states, this test can include the monetized benefits of avoided emissions or other resource-driven savings
Societal Cost Test	SCT	Determines whether the municipality/state/nation is better off due to the program	Includes economic principles like the RIM and TRC costs. Can also include non-cash costs and benefits such as environmental impact
Participant Cost Test	PCT	Assesses whether the participants benefit from the program	Comparison of the costs and benefits of the customer participating in the program.

Source: Standard Practice Manual: Economic Analysis of Demand-Side Programs and Projects

While Oregon has established methodologies that differ from the tests in the California Standards and Practice Manual, we believe that the Manual provides a useful basis for economic cost effectiveness tests that are nationally recognized, and that fit within the OPUC's mission. The Ratepayer Impact Measure test, which focuses on what the economic benefits of the program are when compared to a supply-side resource, provides this economic basis.

The Commission has the overarching responsibility to ensure customers have access to safe, reliable, and high-quality service at just and reasonable rates. The OPUC also executes state policies as directed in legislation.

We realize that the basis of cost effectiveness tests in Oregon must first and foremost focus on economic regulation, that is, just and reasonable prices. However, we also acknowledge the opportunity for rapid cross-sector decarbonization that can be achieved through TE, as directed by the Legislature. Therefore, we believe that the Commission should also consider this state policy on a limited basis when considering cost-effectiveness tests.

In contrast to traditional utility investments including other customer-sited technologies, utility involvement in accelerating TE is a relatively new and emerging area nationally and methods to assess prudence are evolving in turn. Analyzing the cost effectiveness of TE investments requires a different framework than traditional energy efficiency and DR programs because of the following characteristics of TE:

[147] California's *Standard Practice for Cost-Benefit Analysis of Conservation and Load Management Programs* (1983)

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- Increases electricity consumption;
- May increases the need for electricity infrastructure;
- Involves substituting electricity for gasoline, diesel, and other combustible fuels;
- Includes mobile technology, which may travel in and out of a utility's service territory, as well as provide locational flexibility (ability to add an energy sink or source at varying locations on the utility's system); and
- Includes several demonstrable benefits (environmental, health, economic, etc.) attributable to reducing emissions from another sector.

Figure 64 – Summary of benefits and costs for valuing EVs on the system

Benefits of new TE included are:	Costs of new EVs included are:
• Increased utility revenue from new electricity sales to help decrease customer costs • DR and/or flexible load capability • Additional benefit streams for programs and portfolios may be included for a portion of EVs based on program design (e.g. TOU rates, Ancillary services/Power quality, Vehicle to Grid) • Avoided supply costs (capacity and energy) • Revenues from market participation • Reduced particulate matter or other air quality metrics • Marginal environmental benefits because of carbon legislation – as currently used in the approved Resource Value of Solar (RVOS) methodologies and in each company's IRP	• Necessary system upgrades to support new EV loads • Incremental supply costs (capacity and energy, including any incremental compliance costs) • Applicable EV program costs: - Program administrative costs - Participant incentives - EV-related infrastructure costs

In this section, we are largely aiming to identify what benefit EVs can bring to the system and the cost to serve those vehicles without intervention from PGE. In other words, if our EV forecasts are realized and if we undertake no TE activity-neither rates, infrastructure, nor programs-how much incremental revenue (tariff and environmental market) from, and what cost to serve (energy and capacity) on the system is attributable to those EVs. Figure 64, above, illustrates the benefits and costs of new TE.

3.1.2 Electric Vehicles Create Value for All Customers

Within our 2019 IRP, we've forecasted that there will be more than 25,000 EVs in our service area by end of year 2020. We expect those vehicles to use about 10 MWa of energy and generate over $9 million in revenue in 2020. However, the marginal cost to serve those vehicles is only about $3.7 million (cost of energy and capacity). This net benefit creates value for all customers through decoupling. Additionally, we anticipate those vehicles to generate over $5 million in CFP revenues in 2020. Though those credits are not directly refunded to customers, they do create incremental value for them through programs to support EVs. Assuming no drastic changes to our rate structures or market prices, this could mean over $65 million of value through 2025 from passenger vehicles alone.

Table 60 illustrates that passenger EVs can create $1.4 billion in benefits to our customers through 2050:

Table 60 – Annual Benefits Accrued to Customers – Passenger EVs

Benefits	NPV	2020	2025	2030	2035	2040	2045	2050
Tariff Revenue* ($M/yr.)	$1,440	$9	$36	$90	$162	$257	$377	$506

*Assumes current tariff rate escalated at inflation

We estimate that the energy and capacity costs to serve those EVs (without intervention--e.g. smart/managed charging) to be about $971 million:

Table 61 – Annual Costs to Serve Passenger EV Load

Costs	NPV	2020	2025	2030	2035	2040	2045	2050
Energy and Capacity* ($M/yr.)	$971	$4	$18	$57	$108	$187	$278	$371

*Capacity cost is the real levelized cost of IRP capacity resource escalated at inflation; energy is based on long-term forecast of wholesale energy prices

Forecasted tariff revenue benefits in Table 60 are based on Navigant's base case vehicle and energy usage forecast for EVs in PGE's service territory. For light-duty vehicles and non-fleet vehicles, we assumed 85% of total energy usage would be at home (75% Schedule 7 and 10% TOU), 10% would take place at a workplace (Schedule 38), and 5% would take place at a public charging station (Schedule 38). The analysis assumes tariff rates escalate at inflation.

Forecasted energy costs are based on assumed load shapes for residential non-TOU, residential TOU, workplace and public changing. A weighted average energy price is calculated based on the hourly load shape and the long-term Aurora forecast of hourly energy prices. Energy expense in each year is calculated by multiplying the weighted average energy price and the forecasted energy usage.

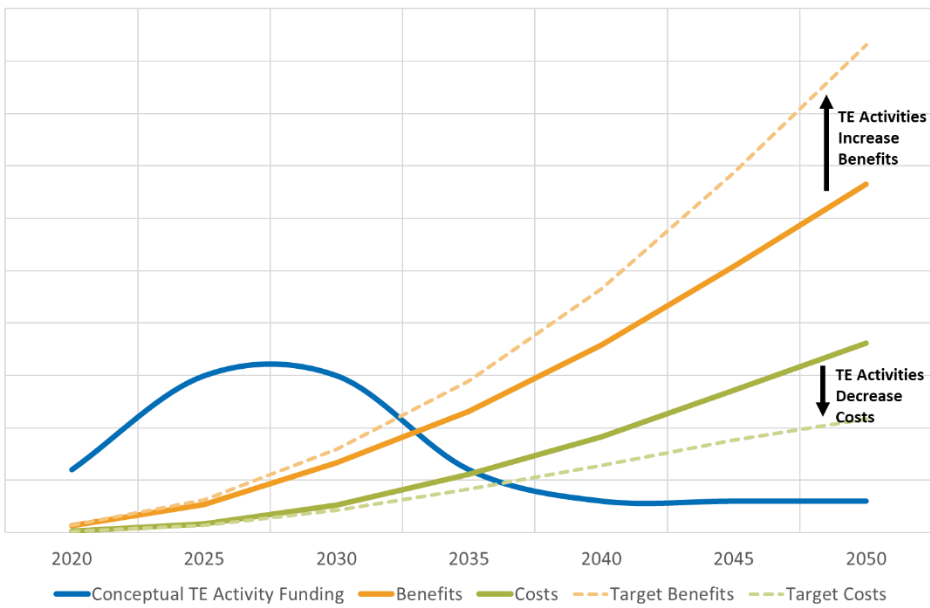
Forecasted capacity cost is the economic cost of incremental increase in load. PGE calculated the marginal MW of capacity needed for each average MW of EV load based on capacity needs for charging at homes, workplaces, and public charging stations. In each year of the forecast, capacity expense is equal to MWs of capacity need, multiplied by the real levelized cost of the capacity resource used in the 2016 IRP update.

This assessment does not include an evaluation of distribution system impacts of new EV loads. We anticipate that distribution system upgrades necessary to support EV loads will be accounted for through our regular course of managing distribution system capital. We will evaluate any incremental distribution system impacts through the DRP process.

3.1.3 We will Fund TE Activities to Increase Benefits Accrued from EVs and to Drive Down the Costs to Serve

It is in customers' interests that we work to drive more benefits and reduce the cost to serve. We believe these values can be captured to fund TE activities. Though the benefits of EVs currently outweigh the costs to serve, we may need to consider front-loading investments in programs and infrastructure to drive incremental benefits or drive down costs to serve. As illustrated in Figure 65, below, starting early may compound the net benefits accrued to customers in the long-term (reflected by target benefits and target costs to serve).

Figure 65 – Conceptualization of TE Costs, Benefits, and Activity Funding



3.2 Rate Design

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(d) Supporting data and analysis used to develop the TE Plan, which may be derived from elements such as review of costs and benefits;* ***rate design****, energy use and consumption, overlap with other electric company programs, and customer and electric vehicle user engagement;*

PGE employs a variety of rate design methods to support EV adoption as well as minimize the costs associated with EVs' load on the system: Schedule 38 includes a demand charge waiver to encourage the deployment of quick charging infrastructure; Schedule 50 provides a charging subscription offering to simplify customers' experience with EV charging; and we also have a variety of rates that employ TOU rates to encourage off-peak charging. These rates have been used to model projected EV revenues included in this plan and are discussed in further detail below.

3.2.1 Schedule 38

PGE's Schedule 38 (Large Nonresidential Optional Time-of-Day Standard Service) is available to customers who are served at secondary voltage with monthly demand under 200 kW. This rate does not include a demand component and assesses energy charges for both on-peak and off-peak periods. Charging infrastructure can be included on this price along with existing business service or can be separately metered. The lack of a demand charge on this rate makes it particularly attractive to providers of public charging infrastructure receiving relatively light usage.

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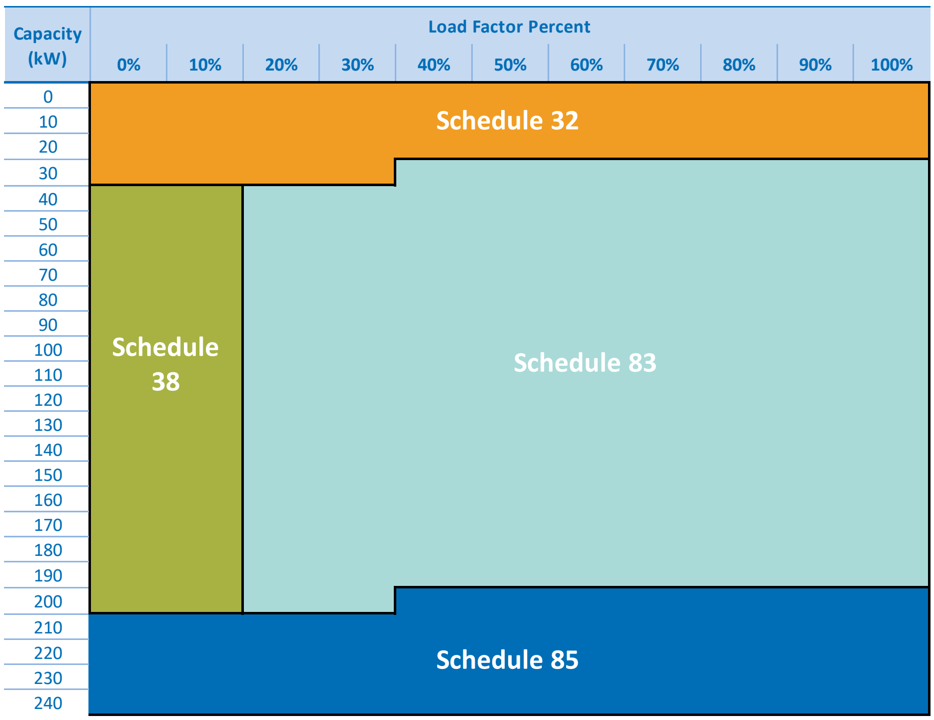
PGE will continue to offer and educate charging service providers and site owners about Schedule 38. We recognize that demand charges can be a barrier to deployment of EV charging infrastructure. We will continue to offer this pricing option as part of our effort to help customers select the best rate for their circumstances. However, as illustrated in Figure 66, economics is a function of load factor. As charging sites utilization rates rise, it is more advantageous for the customer to opt into a rate with a demand charge:

Figure 66 – Lowest Customer Cost Rate Schedule as a Function of Load Factor and Capacity



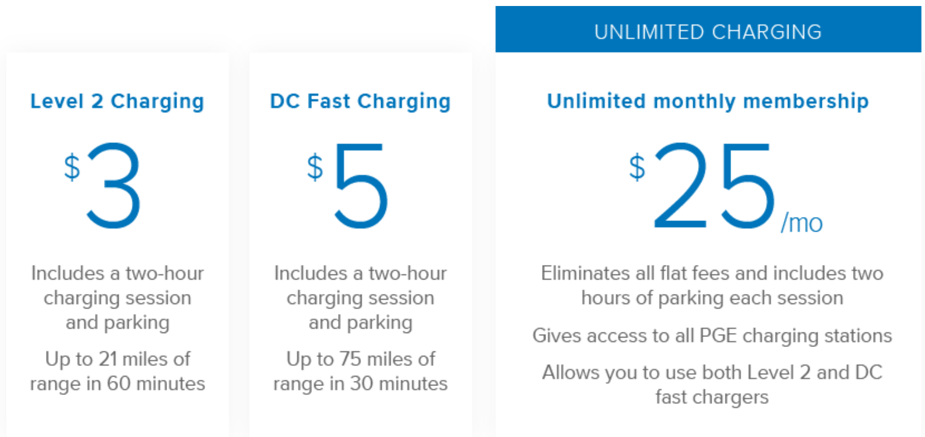
3.2.2 Schedule 50

At the time, the approval of the Electric Avenue expansion marked the first time in over two years that a utility had been approved to construct and operate competitive DC Fast Charging (DCFC) stations. This allowed PGE the opportunity to price electricity as an end-use fuel, and to test pricing of value-add services beyond our standard electric service.

At launch, we developed a subscription-based model to price this service for simplicity and ease for customers. This simplified subscription pricing aims to make it easier for customers and car dealers to understand costs associated with EV fueling. In addition to the simplicity of-and customer preference for-pricing as a subscription, our approved pricing mechanism also provides greater revenue stability to the company through fixed charges.

Additionally, we recognized that on weekdays between 3-8pm, system constraint could be an issue. During those hours only, the charging rate becomes a two-part tariff that recovers the marginal service cost of a customer's on-peak charging. PGE's approved fuel rate is shown below:

Figure 67 – Preliminary Customer Pricing Schedule at Electric Avenue (Schedule 50)



**Customers pay a $0.19/kWh premium during on-peak times (weekdays from 3 to 8 p.m.)*

If a customer purchases more than 100 subscriptions at a time (a possibility for transportation network companies such as Lyft or Uber), the per-subscription price drops to $20.

3.2.3 DC Rate Consideration

PGE currently offers multiple voltage delivery options (primary, secondary, sub-transmission) for many non-residential customers. These service voltage differences show up as small volumetric mark-ups or discounts on the bill and are rolled into the underlying energy charge for a customer's basic service. PGE could use "DC transformation" as simply another voltage option and include it as a small mark-up or discount to customers selecting that option. A word of caution in this scenario though-volumetric design is generally preferable if the customer knows in advance that they will be served by this infrastructure for a long period of time. Currently, the load factor associated with EV charging is quite low, meaning that there are often few kilowatt hours upon which to spread the volumetric price.

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3.3 Energy usage and consumption

In this section we will discuss the following elements of OAR 860-087-0020 :

> *(3)(d) Supporting data and analysis used to develop the TE Plan, which may be derived from elements such as review of costs and benefits; rate design,* ***energy use and consumption*** *[emphasis added], overlap with other electric company programs, and customer and electric vehicle user engagement;*

Energy usage and consumption information can be found in Sections 1.3 (Charging Usage Patterns) and 1.71.7 (Distribution System Impacts).

3.4 Overlap with other PGE programs

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(d) Supporting data and analysis used to develop the TE Plan, which may be derived from elements such as review of costs and benefits; rate design, energy use and consumption,* ***overlap with other electric company programs*** *[emphasis added], and customer and electric vehicle user engagement;*

As we have discussed, our TE activities aim to create customer value by accelerating EV adoption and to reduce cost to serve by intelligently managing the new loads that are integrated onto the system. In this section we will explore how those activities overlap with our demand response portfolio, our renewable energy offerings, pricing programs, and our new construction builder support.

3.4.1 Demand Response/Flexibility

In many cases, EVs are very flexible loads, as cars sit idle (parked) for more than 90% of their useful life. This suggests that there is a lot of opportunity to choose when (and maybe in the future, where) to charge a vehicle.[148]

There are several ways we anticipate integrating customers' vehicle charging into our DR portfolio:

[148] Modified from: Adam Langton and Noel Crisotomo. Vehicle-Grid Integration, California Public Utilities Commission, October 2013, Available at: www.cpuc.ca.gov/WorkArea/DownloadAsset.aspx?id=7744 (Accessed 9/9/19)

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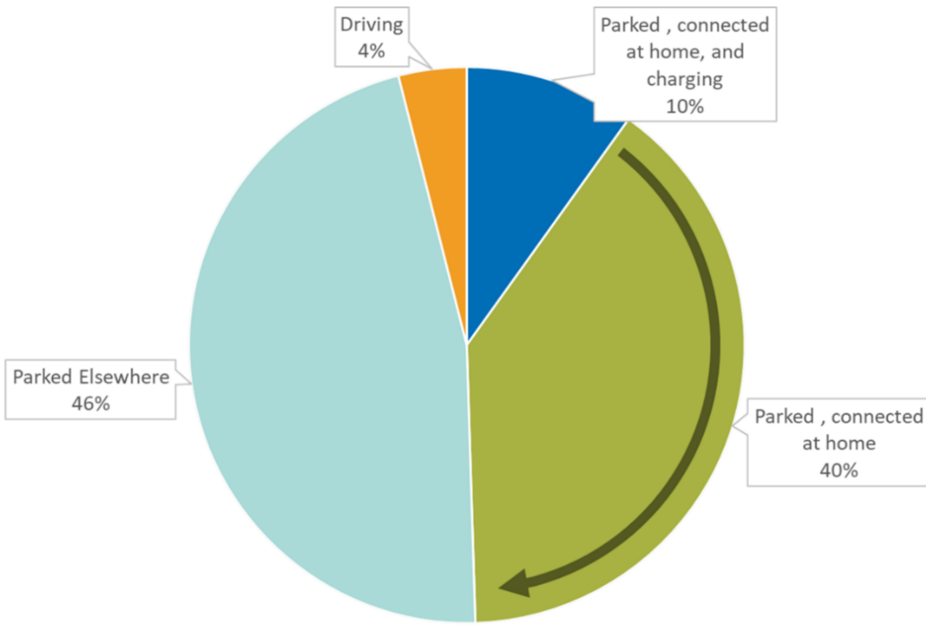
- **Residential smart charging:** we expect this to be a stand-alone offering to enable flexible charging and control at residential premises. It will operate in a manner similar to how smart thermostats are operated today. Though the program will operate independently from other residential programs, the offerings will likely be bundled for customers when it makes sense (e.g. a customer might learn about smart thermostats at the time of install of their home charging station). Figure 68 illustrates that the time PEVs need to charge in order to meet customers' mobility needs may be shifted throughout the time they are connected at home. The utility can manage that time of charging to accommodate grid operations (CPUC).

Figure 68 – PEVs are Capable of Shifting Charging Time



- **Business smart charging**: we anticipate additional complexity with business charging applications. Our business customers are typically not the end users of public, workplace, and destination charging stations. We must work with those customers over the long term to ensure that there is a positive customer experience with the end user. For fleet charging applications, schedules will ofttimes be inflexible and therefore unable to accommodate pricing signals. In either case, our business customers will need a custom-designed protocol that meets their needs. We believe our Energy Partner program is the right channel to develop that customized approach. As such, our approach for business charging is to: (1) encourage deployment of infrastructure to support EV adoption; (2) ensure infrastructure that we support (via rebates, make-ready, or charging infrastructure) is grid-connected and DR-enabled; and (3) refer those customers to the Energy Partner team to engage the customer on smart charging opportunities.

3.4.2 Renewables Programs

Many customers are buying EVs because of the environmental benefits of buying an EV. As such, customers are likely to expect that their vehicle is powered by 100% renewables. To meet those expectations, we purchase RECs for all energy served at the public chargers we own and operate (e.g. Electric Avenue). TriMet also purchases wind RECs for their electric bus route. As illustrated in Figure 69 below, TriMet's new all-electric bus's renewable synergies are on full display. We will work to find our EV customers (residential and business) an appropriate green energy program to meet their needs.

Figure 69 – TriMet's First All-Electric Bus

3.4.3 Time-of-Use (TOU)

TOU rates are a great opportunity for customers to minimize the cost to serve EV loads. We anticipate giving residential customers an opportunity to enroll in a TOU rate when they participate in a residential charging rebate program.

As we deploy more charging-related infrastructure, we are also likely to explore means for a customer's rate to follow them, as opposed to their premises. This could mean that future Electric Avenue rates could be bundled with a customer's home TOU rate.

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3.5 Customer & EV user engagement

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(d) Supporting data and analysis used to develop the TE Plan, which may be derived from elements such as review of costs and benefits; rate design, energy use and consumption,* ***overlap with other electric*** *company programs, and* ***customer and electric vehicle user engagement*** *[emphasis added];*

PGE actively works with our customers to better understand their needs and challenges as they relate to EV vehicles and charging infrastructure. Table 62 summarizes studies and focus groups have informed this plan:

Table 62 – Summary of Key Customer Engagements related to TE

Subject	Date	Audience	Objective(s)
Customer EV Survey (MSI)	October, 2018	PGE Residential Customers (n=1,736)	Assess customer awareness and consideration of EVs among PGE residential customers.
National Drive Electric Week	September, 2019	Ride and Drive attendees	Measure customers attitudes related to EV ownership and adoption and to identify barriers to adoption. Results will be evaluated and compared to previous years' survey results.
Ride Share Electrification	October/ November, 2018	Lyft EV Drivers Lyft non-EV Drivers	Identify barriers to TNC drivers' adoption of EVs and develop messaging and programs to address those barriers. Results will be evaluated and compared to prior year survey results.
Residential Customer EV Survey	(upcoming, 2019)	PGE Residential Customers	Assess the awareness and consideration of EVs among PGE residential customers.
TE Underserved Communities Focus Groups	(upcoming, 2019)	Underserved communities	Engage underserved communities and evaluate their needs related to transportation, evaluate how their transportation decisions are made, and identify their barriers to TE adoption.
Public charging station field ethnographic research	(upcoming, TBD)	Public charging users	We plan to field intercept surveys of customers as they use public quick charging to better understand who they are, why they are using public charging, their experiences with the equipment, etc. This would help inform future charging program/infrastructure deployments.

Section 4 Discussion of electric company's potential impact

PGE has a critical role to play in supporting the rapid, safe, affordable, equitable, and clean deployment of EVs in Oregon.

PGE's unique role ensures that customers have affordable and reliable access to increasingly clean electric fuel. This role will become more integral to our customers' lives as TE adoption grows. PGE will lead the way down this critical pathway to decarbonization of the transportation sector by facilitating frictionless interconnection between our system, customer vehicles, and charging stations. Building, operating, and maintaining make-ready and charging infrastructure represents an extension of our management of the distribution system. As such, PGE will undertake the following: 1) make prudent and timely investments in charging-related infrastructure to support accelerated EV adoption; 2) efficiently integrate EV charging into the grid; and 3) stimulate innovation to deliver benefits to all customers.

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(e) A discussion of the electric company's potential impact on the competitive electric vehicle supply equipment market, including consideration of alternative infrastructure ownership and business models, and identification of a sustainable role for the electric company in the transportation electrification market;*

Electricity is a necessity, and its production and distribution are complex. It is increasingly multi-faceted in its impact and it should serve the public good. We have an obligation to ensure that the transformation of the electric system does not leave anyone behind. We want all customers to share in the benefits and opportunities of a clean energy future, and PGE will continue to do our part to reduce the threat of climate change, improve air and water quality, and promote a more sustainable way of life. To this end, we are committed to reducing our GHG emissions by more than 80% below 2010 levels by 2050, consistent with Oregon's economy-wide emission goals.

PGE's vision for a clean energy future relies on three interrelated and overarching strategies:

1) **Decarbonize**: develop clean, reliable resources while supporting the capture of all cost-effective energy efficiency;
2) **Electrify**: empower our customers to transition to clean and affordable electricity; and

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3) **Perform**: deliver operational excellence and serve as sound stewards of the energy ecosystem. This includes modernizing and enhancing the grid to be smarter, more flexible and resilient. This work will support the transition to a clean energy future, as well as effectively integrate new technologies.

These goals work in tandem: a decarbonized energy supply may not enable clean TE if there is not a modern integrated grid to support the fueling of vehicles; likewise, a decarbonized energy supply may be harder to realize if we do not have a robust network of flexible loads, such electric vehicles, on the system to manage the variability of renewables.

4.1.1 PGE has a critical role to play in supporting the rapid, safe, affordable, equitable and clean deployment of EVs in Oregon

We believe that electricity is an essential public service that serves the public good. As the transportation sector electrifies, we believe that access to clean and affordable electricity as a transportation fuel is a simple extension of the essential and public good served by PGE.

PGE's role in ensuring customer access to electric fuel will continue to grow. As customers power their transportation needs with electric fuel, the essential service provided by PGE will become even more integral. As transportation electrification progresses, it will continue to be important for PGE to find solutions to continue to service customers at least cost while ensuring that customers are able to reliably interconnect their vehicles and charging stations into our system.

Because the PGE system is networked, used, and leveraged by our customers, PGE unique amongst other providers, in our ability to capture various benefits from EV adoption. In order to do this, PGE must **remain flexible** and quickly identify solutions to address the challenges in serving new EV loads.

As a vertically-integrated electric utility, PGE creates value for Oregonians every day by maintaining the following core competencies:

- Physical infrastructure asset management, namely the planning, construction, building, operation, and maintenance of electrical infrastructure;
- Customer service (billing, pricing, metering, call center operations, customer experience, etc.);
- Supply and energy management;
- Distribution management/operations;
- Demand management;
- Reliability management; and
- Cybersecurity.

By leveraging our size and economies of scale, we can establish rates, programs, and infrastructure to do our part to accelerate TE and efficiently integrate it into the grid. The skills and value we bring to the EV marketplace will enable our customers to adopt EVs with confidence. That in turn will support healthy market opportunities for vehicle and charging manufacturers, mobility service providers, and charging service providers.

A sustainable role for PGE in the TE market will be one that empowers our customer to choose an EV with the same level of confidence that they enjoy with an ICEV today. We must work expediently to meet the state's climate and transportation electrification goals. Rapid TE will require a diverse portfolio of offerings for our customers, and our future role must therefore include:

- Production and delivery of clean energy to our customers' vehicles;
- Ensuring power is reliability and affordable;
- Supporting our customers with solutions that meet their needs and create value-add for the grid;
- Ensuring charging resource adequacy;
- Data management and communications;
- Ensuring our customers have equitable access to charging solutions; and
- Driving change to policy, codes, standards, that have a meaningful impact on EV adoption and utilization in Oregon.

To distill the case for utility key role in TE to its simplest terms, regulated utilities uphold their public interest obligations and their ability to help drive large-scale, beneficial changes to serve public policy and community interests should be leveraged. Absent this, there is no guarantee that any other provider in the market can deliver on the core tenets of the electric system's intrinsic social compact: namely, clean, accessible, affordable, reliable, safe electric fuel for all.

4.1.2 Early deployments of public charging infrastructure by third parties have created lessons that we should learn from

As a regulated vertically-integrated utility, PGE can both responsively meet the needs of customers in the market and accelerate the decarbonization of the transportation sector pursuant to Oregon's goals. Conversion to an electric transportation sector has not been smooth, and market failures in recent years have demonstrated the risks to customers absent strong oversight of the process. For example, in 2013 we witnessed the bankruptcy of ECOtality. As a result, hundreds of public chargers were abandoned with no agreements in place to maintain the equipment. PGE has since taken ownership of eight ECOtality quick chargers (which were part of Schedule 344: Oregon Electric Vehicle Highway Pilot Rider) to ensure they remain accessible and reliable. **PGE 's activities must leverage learnings from past market failures and be designed to protect the interest of our EV drivers and all customers**.

4.1.3 New customers are emerging, and their needs are evolving

As the transportation sector transforms, existing customers have new requirements and new customers are demonstrating unique needs:

- **Existing customers**: many businesses that operate fleets are not typically major electricity consumers. These customers need a high level of support to understand utility integrations, rates (e.g. demand charge), charging needs, etc.
- **New customers, EVSPs** (e.g. Electrify America, Tesla, etc.): need streamlined interconnection processes, support to evaluate potential interconnection locations, guidance regarding the right rate for their particular application.

- **New customers, mobility service providers** (e.g. Share Now, Lyft, etc.): need access to charging infrastructure.
- **Transient Vehicles**: individuals, families, or businesses (e.g. long-haul trucks) that travel across state or service area boundaries will require robust access to quick charging infrastructure.

4.1.4 PGE can and will own and operate charging infrastructure while stimulating innovation, competition, and customer choice

PGE has an inherent role to support and stimulate innovation, competition, and choice regardless of who owns the charging infrastructure.

- **Stimulate Innovation:** PGE's core business is providing safe and reliable electricity. As an owner-operator of charging hardware from several different vendors, PGE can provide direct feedback to equipment manufacturers on how to make their products better to provide a better experience for EV drivers. As our program and infrastructure portfolios grow, we will continue to challenge our suppliers to innovate to create a frictionless experience for our customers.
- **Competition**: through PGE's competitive procurement process, we continue to see very high engagement from many EVSE providers. The process allows vendors to demonstrate their technologies and compete on features, price, product, maintenance, business models, etc.
- **Customer Choice**: PGE believes that a variety of choices available to customers-both within and without the utility framework- represent tools that could potentially help achieve carbon reduction and other policy goals and objectives. In order to address these evolving charging needs, PGE will work with the market to address the desire for individual choices, balanced with the prudent operation of the electric system, collective system goals, and fairness and equity for all customers. As we establish EV activities for the future, we must ensure that "choice" for one customer does not result in an increased energy burden for others.

That said, we recognize that several ownership models exist, which is why PGE has launched or proposed a variety of offerings that test the following ownership models: PGE owned and operated, customer owned, and third-party owned. Table 63 summarizes these EVSE ownership models:

Table 63 – Summary of EVSE (Charging Station) Ownership Models

Ownership Model	Description	Examples of PGE Activities
PGE owned and operated charger	PGE buys equipment, operates, and maintains	• Electric Avenue • Some of our workplace charging stations • Proposed transit charging program
Customer owned charger	Customer buys charging equipment and is responsible for O&M and, where applicable, billing	• Planned make-ready offering • Proposed residential charging pilot
Third-party owned charger	Customer leases charging equipment and is responsible for O&M and, where applicable, billing Proposed residential charging pilot	• Planned make-ready offering • Proposed residential charging pilot • Some of our workplace charging stations

The EV market is still emerging. If customers want their utility to own and operate charging equipment at their premises, we should not preclude it. Enough barriers to EV adoption and charger deployment exist already, and we should not create new ones. To effectively accelerate TE, we must not close the door on options that customers want. As our customers' trusted energy advisor, we will offer infrastructure solutions that meet customers' needs.

We believe our make-ready infrastructure offering and charging station deployments will give EVSEs and EVSPs opportunity to compete for our customers' business and our own, and that this will drive companies to be innovative. Ultimately, this approach will drive more adoption of EVs in Oregon, creating more opportunity for the competitive EVSE marketplace to thrive.

4.1.5 PGE's leadership role in accelerating transportation electrification has and will continue to have a positive impact on the competitive EVSE market

By taking an early role in investing in charging-related infrastructure, EV program, and creating rates that are spurring early adoption of EVs, PGE is creating opportunities for EVSE's to compete and get their products to market. By leveraging our size and economies of scale, we can establish rates, programs, and infrastructure to do our part to accelerate TE and efficiently integrate it into the grid. The skills and value we bring to the EV marketplace will enable our customers to adopt EVs with confidence, which will, in turn, support healthy market opportunities for vehicle and charging manufacturers, mobility service providers, and charging service providers.

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Section 5 System impacts resulting from TE and PGE's portfolio of actions

EV Charging will create over 100-MW of distributed flexibility that will mitigate peak conditions and support integrating renewables into the grid.

PGE's actions today in building effective rates, infrastructure, and customer programs will enable us to partner with our customers over the long-term to fuel their vehicles in a manner that creates value for all customers. In the future, PGE intends to employ a variety of best practices to ensure we maximize the value from EVs: smart charging, vehicle to grid, and integrated-customer planning.

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(f) A discussion of current and anticipated electric company system impacts resulting from increased transportation electrification and the electric company's portfolio of actions, how transportation electrification can support the efficient integration of renewable energy, and how the TE Plan is designed to address these system impacts; and…*

5.1 How TE can support efficient integration of Renewables

As new loads arrive on the PGE system, we must ensure those loads are "smart" (i.e., controllable). This approach must be undertaken in partnership with customers, EVSPs, and EV OEMs. As discussed in PGE's 2019 IRP, PGE's system and the Western grid continue to experience higher penetrations of variable renewable energy resources. These changes to the system will contribute to a growing need for clean, flexible capacity, which EVs and smart charging can deliver. By 2050, we estimate that our customers will have invested in nearly a million EVs, which will represent over 40 GWh of energy storage.[149] It is critical that we develop programs to best leverage the advantages of non-emitting EV battery capacity to meet system flexibility needs and provide customer value. Flexible loads help us balance power supply with power use by shifting loads to non-peak times. By communicating with our customers about the best time to charge, we can integrate more renewables onto the grid at a lower cost.

[149] Assuming base case for EV adoption and the following assumptions: LDVBEV: 60 -kWh; LDVPHEV: 10 -kWh; MHDVBEV: 250 -kWh; MHDVPHEV: 50 -kWh

PGE worked with Navigant Consulting on a bottom-up EV forecast (this is a statistically-driven propensity-to-adopt model) in our service area in order to understand the potential impact of EVs on our system. In addition to identifying the resource needs to support EV growth, the 2019 IRP also included an analysis of EV DLC. The model aimed to identify the achievable capacity available by shifting a portion of EV charging from hours of high capacity need (evening) to hours of low capacity need (early morning), while still allowing the same total amount of charging by 6 a.m. Though this model reflects a simple use case for managed charging in the future, it is indicative of the long-term value that EVs will create for the system. Table 64, below, illustrates the estimated achievable potential for EV DLC through 2050:

Table 64 – EV DLC Achievable Potential in PGE service area (MW)[150]

Season	2020	2025	2030	2035	2040	2045	2050
Summer	4	17	39	66	98	134	168
Winter	3	14	32	54	80	109	137

Source: PGE's 2019 IRP: DER Potential Study

Dispatchable EV charging infrastructure represents more than 100 MW of potential resource. Charging stations that are actively managed by the utility create the potential for these resources to provide bulk system and local grid services. EVs represent a promising new distributed technology for providing both participant and utility benefits.

[150] PGE 2019 IRP

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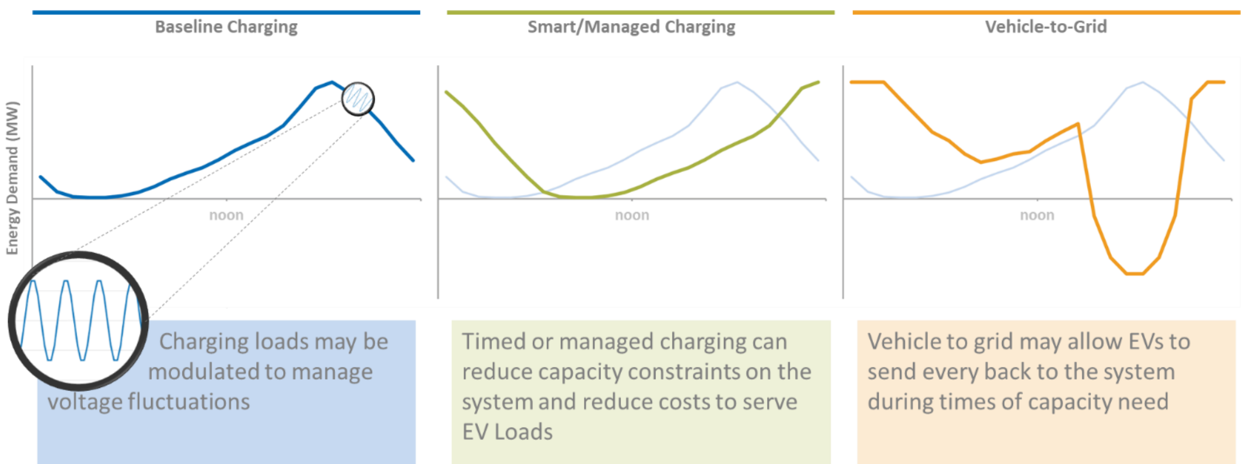
V2G may present another means by which TE can support efficient integration of renewables. As V2G technology matures, the potential may exist to engage parked vehicles to provide two-way energy service, and thereby extract additional value. Unlike petrol- and diesel-powered cars, EV owners may then be able to resell their fuel to the interconnected system we call the integrated grid. This is a benefit of the electric transportation system which cannot be replicated. It offers additional benefits to those taking service from the system *and* to those who connect their resources such as EV to the shared electric system. Figure 70 compares indicative load profiles of baseline EV charging, smart/managed charging, and V2G:

Figure 70 – Conceptual Charging Load Profiles



It is, however, worth noting that the primary utility of an EV is to move people and goods. We must work in the near-term to understand customers' driving, parking, and fueling patterns to better understand the availability that EVs-as-grid-resources will bring to the system.

5.2 How TE Plan is designed to address these system impacts

The design of the TE rates, infrastructure, and programs (see Section 2) is, or will, address these system impacts. Ultimately, successful utilization of EVs as grid resources requires several key enabling factors:

- **Insight (data & visibility)**: it would be useful to know which customers have EVs, where EV chargers are located, the speeds of charging stations, how/when/where our customers charge, and (ideally) real-time resource availability.
- **Controllability**: we must have relationships in place with charging service providers and vehicle OEMs to effectively manage the customer experience.
- **Customer engagement**: we will seek insights into customers' willingness to participate in programs and respond to price signals.
- **EV adoption**: within this plan we have outlined our projections for EV growth in the service area. We are confident in the growth in the market, but if EVs do not materialize, we cannot expect to leverage these resources to provide grid services (e.g. renewables integration).
- **Fleet growth** (e.g. autonomous vs. personal ownership): though autonomous is not required to enable grid resources of EVs, rapid adoption of shared autonomous fleets would impact who the customer is, where charging will occur, vehicle utilization, etc. All these factors may impact how much flexibility EVs may ultimately provide to the system.
- A robust integrated grid to identify, manage, and call upon DERs as grid resources.

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The activities outlined in Section 2 are primarily targeted to insight, controllability, engagement, and EV adoption. A summary of how each of PGE's areas of activity enable us to address system impacts is included in Table 65, below. Specific impacts of each activity are identified in Section 2.

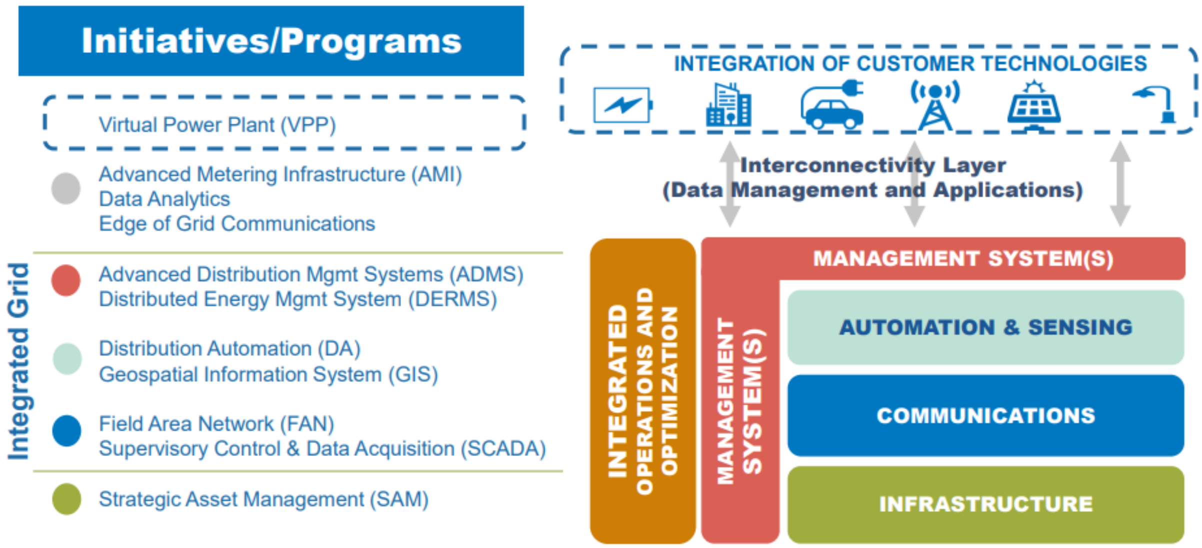
Table 65 – How PGE's Planned Activities Enable PGE to Address System Impact

Enabling Factor	Rates	Infrastructure	Programs
Insight	• Understanding of how customers respond to price signals	• Knowledge of locations and speeds of all charging in service area • Data from hardware (charger utilization)	• ID which customers have EVs • Understand customer charging habits • Where and when fleet customers expect to need charging
Controllability	n/a	• By supporting hardware deployments, PGE can ensure EVSPs are integrated into DERMS to ensure controllability	• Build EVSP integrations Create control protocols and requirements
Engagement	• What price signals customer respond to	• Access to infrastructure allows customers to consider alternative charging speeds or charging locations in responding to grid needs	• Develop best practices on how to engage customers • What price signals customers respond to • Customer experience considerations for scaling engagement in future
Adoption	• Rate design reduces customer friction (and increases likelihood to adopt EV) - Lower TCO - Simpler to understand - Easier to deploy chargers	• Access to infrastructure drives EV adoption	• Programs add to the customer value proposition and reduce the total TCO

PGE requires a robust integrated grid-and the systems to manage it-in order to pull the above component efforts together, integrate TE assets with other DERs, and fully-manage and operate them for grid services.

There are several key enabling components of PGE's integrated grid that are critical to fully leveraging the value of EVs. Figure 71 illustrates how PGE's integrated grid requires a complex network of systems to communicate across its constituent components. EVs are one of a number of future customer DERs that will be aggregated and utilized to provide value to the system.

Figure 71 – PGE's Integrated Grid Architecture



Source: PGE's 2019 Smart Grid Report

The Advanced Distribution Management System (ADMS) and Distributed Energy Resource Management System (DERMS) are operational technology systems that monitor, control, optimize, and safely operate all elements within a distribution system. ADMS and DERMS provide the capability to monitor, control, and optimize two-way energy flow within the integrated grid. This capability is foundational for the management of a modern distribution system and will be critical in partnering with our customers to create value from their EVs.

EVs create a promising opportunity to improve the way we operate our grid. We must continue to make necessary investments in infrastructure and programs to improve our system and customer insights. We must invest in integrations with EVSPs to build our network of connected devises and expand our expertise in controlling DERs. And lastly, we must invest in systems to bring this all together and integrate operations with our power supply and distribution engineering functions.

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Section 6 Relation to State's Carbon Reduction Goals

The transportation sector accounts for 40% of Oregon's GHG emissions—it is imperative to support Oregon's policy goals by decarbonizing our energy mix and enabling our customers' transition to electric vehicles.

We must decarbonize the electricity supply and electrify our transportation – doing so will eliminate nearly 100M metric tons of CO2 by 2050.

In this section we will discuss the following elements of OAR 860-087-0020:

> *(3)(g) A discussion of how programs and concepts in the TE Plan relate to carbon reduction goals, requirements and other state programs, including expected greenhouse gas emission reductions based on publicly available metrics.*

PGE believes we must do our part to reduce the threat of climate change, improve air and water quality, and promote a more sustainable way of life. To this end, we are committed to reducing our GHG emissions by more than 80% below 2010 levels by 2050. Further, we are committed to supporting the transition of the transportation sector to clean, renewable electricity.

As we decarbonize our electricity supply and support our customers' transition to electrification, we anticipate realizing nearly 100 million metric tons of carbon dioxide emissions reduction through 2050. Figure 72 illustrates cumulative GHG reductions over time, and Table 66 shows annual GHG reductions through 2050.

Figure 72 – Cumulative GHG Reductions from EV Adoption in PGE Service Area (Base Case), metric tons CO_2[151,152,153,154,155]

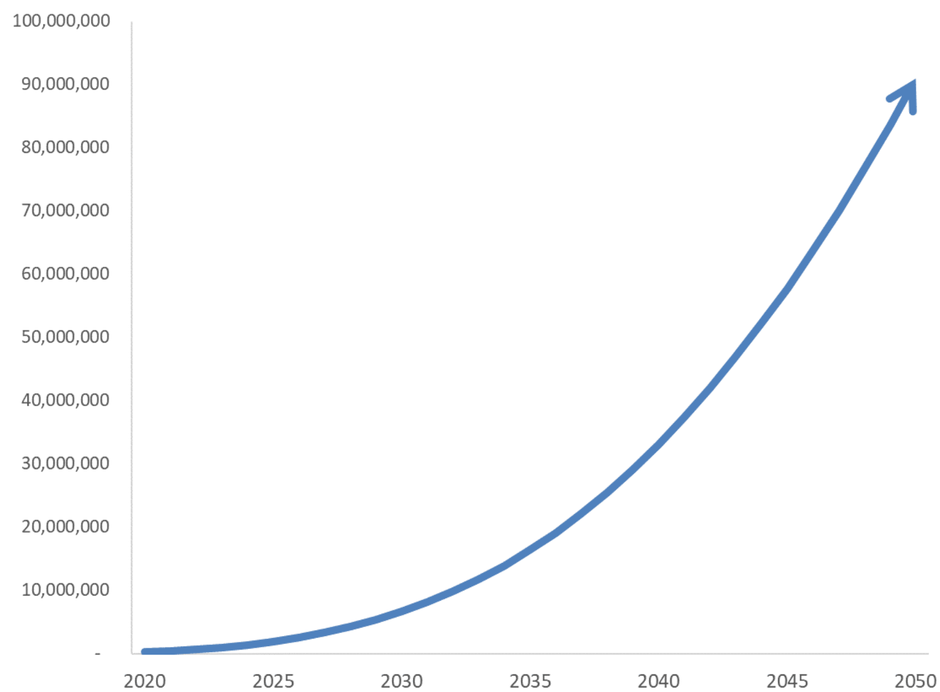

Table 66 – Est. Annual GHG Reductions from Transportation Electrification in PGE Service Area (million metric tons CO_2-equivalent)[156]

2020	2025	2030	2035	2040	2045	2050
0.13	0.51	1.26	2.47	3.91	5.48	7.15

In addition to the state's decarbonization goals, our activities support the state's electric transportation goals as outlined in SB 1044, Executive Order 17-21, and SB 1547. We believe the activities outlined in this plan remove

[151] See: https://nacfe.org/wp-content/uploads/2018/07/determining-efficiency-confidence-report.pdf
[152] "Statewide Greenhouse Gas Emissions." Oregon Department of Environmental Quality, Available at: https://www.oregon.gov/deq/aq/programs/Pages/GHG-Inventory.aspx (Accessed August 15, 2018)
[153] See: https://afdc.energy.gov/data/10309
[154] See: http://www.eia.gov
[155] US DOT Federal Highway Administration. Average Annual Miles per Driver by Age Group. Available at: http://www.fhwa.dot.gov/ohim/onh00/bar8.htm (Accessed Dec. 1, 2016).
[156] PGE 2019 IRP

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barriers to adoption such that they will accelerate our customers adoption of EVs. As outlined in Section 2, our infrastructure offerings will increase access to the use of electricity as a transportation fuel, and our programs will assist in managing the electrical grid.

Further, battery electric vehicles also support local air quality objectives, as they have zero tailpipe emissions and there are no local air emissions associated with their use. EV adoption will drive down local nitrous oxides (NOx), particulate matter (PM10), and volatile organic compounds (VOCs) emissions, amongst other air pollutants. Specifically, we estimate over 37,000 metric tons (mt) of NOx, about 1,500 mt of PM10, and over 19,000 mt of VOC emissions reductions (see Table 67 below). These values are approximations and likely high-end estimates as they do not account for expected fuel economy gains over time.

Table 67 – Est. Annual Air Emissions Reductions from Transportation Electrification in PGE Service Area (metric tons)[157,158]

Pollutant	2020	2025	2030	2035	2040	2045	2050	Cumulative (2018-2050)
NOx	46	183	515	987	1,595	2,326	3,121	37,281
PM10	3	11	26	44	67	92	117	1,553
VOC	40	144	335	563	828	1,117	1,387	19,189

Decarbonization of the transportation sector is achieved through a rapid transition to electric fuel, while removing carbon from the energy supply. Through that transition we will also remove toxic air pollutants from our local communities. PGE is committed to this transition and looks forward to working with stakeholders to realize that low-carbon future.

[157] PGE 2019 IRP
[158] Cai, et al. 2013. *Updated Emission Factors of Air Pollutants from Vehicle Operations in GREET™ Using MOVES*

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