Chapter 4. Planning

4.1 The Planning Environment State and Federal Policies, Programs, and Actions

4.1.1 Legislative History

Since 2016, Oregon law has called for utilities to invest in transportation electrification infrastructure. The 2016, the Oregon Legislature (Legislature) defined Transportation Electrification in statute for the first time and found that "transportation electrification … requires that electric companies increase access to the use of electricity as a transportation fuel," and should "assist in managing the electric grid and improving electric system efficiency and operational flexibility".[66] The bill directed the Commission to require utilities to file program applications to accelerate transportation electrification and outlined the considerations under which the Commission could allow cost recovery for program expenditures.

When the OPUC accepted PGE's inaugural TE Plan in February 2020, the Oregon Clean Fuels Program at the Oregon Department of Environmental Quality (ODOE) was already generating Clean Fuels Credits for electric vehicle charging. The 2019 Legislature had also enacted Senate Bill 1044, establishing zero emission vehicle (ZEV) adoption goals for Oregon, and strengthening ZEV purchasing requirements for state fleets.

Since that time, the Legislature and state agencies have continued to prioritize, fund, and require electrification of transportation. PGE has worked collaboratively with state agencies and legislators to inform and support transportation electrification policy that benefits PGE customers.

4.1.1.1 State Legislative Actions

The 2021 Oregon Legislature enacted House Bill (HB) 2165[67], introduced by Governor Kate Brown, to extend and improve Oregon's Clean Vehicle Rebate Program (also known as Oregon's EV Rebate Program)[68] and support utility investment in EV infrastructure. HB 2165 includes the following major elements:

- EV rebate improvements: The bill removes the 2024 sunset on Oregon's Clean Vehicle Rebate Program and makes other targeted changes to better support underserved communities.
- Transportation electrification monthly meter charge: HB 2165 also requires PGE and Pacific Power to collect a charge set to 0.25 percent of the total revenues collected by the utility. The fee is collected as a monthly meter charge from all customers through 2030. Funds from the charge must be used by each utility to support and integrate transportation electrification and must be spent on elements contained in a utility's TE plan. Budgets for the use of these funds must be approved by the Commission. This charge is a minimum amount collected for utility TE activities. The utility must make reasonable efforts to spend not less than half the amount collected through this fee on TE in underserved communities.
- Updating current law on utility investment in transportation electrification infrastructure: HB 2165 also updates ORS 757.357 to ensure clear Commission authority to allow cost recovery

[66] Oregon Revised Statute 757.357, retrieved from https://oregon.public.law/statutes/ors_757.357.
[67] Oregon House Bill 2165, retrieved from https://olis.oregonlegislature.gov/liz/2021R1/Measures/Overview/HB2165.
[68] Oregon DEQ. *Oregon Clean Vehicle Rebate Program*. Retrieved from https://www.oregon.gov/deq/aq/programs/pages/zev-rebate.aspx.

for TE infrastructure measures. The bill recognizes utility investments in TE infrastructure as a utility service, provided the investment both supports greenhouse gas (GHG) reductions in the transportation sector over time and benefits utility customers. HB 2165 also codifies in statute that utility investment to support TE includes behind-the-meter infrastructure. Taken together, these changes and the regular monthly charge underscore that enabling and managing TE, in the eyes of the 2021 Legislature and Oregon law, is a core, ongoing, and recoverable component of utility business to serve customers.

The 2021 Oregon Legislature also enacted House Bill 2180[69], requiring that all new multi-family buildings of five or more units, as well as new commercial buildings, be made EV-ready with provisions for electrical service capacity and conduit to serve 20 percent of parking spots. The bill allows local governments to require a greater percentage of parking spots be made EV-ready, and the Land Conservation and Development Commission adopted a rule in 2022 that requires cities within metropolitan areas to require 40 percent of parking spots be made EV-ready[70].

The 2021 Legislature also moved Oregon's previous deadline for 100 percent of new light-duty state-owned vehicle purchases to be ZEVs from 2029 to 2025 (HB 2027[71]). The Legislature also directed the State Parks and Recreation Department to allow for the installation and service of public EV charging stations in parking spaces in the state park system (HB 2290[72]).

In the 2022 Short Session, the Legislature supported both infrastructure and vehicle purchase incentives. House Bill 4139[73] established the Medium- and Heavy-Duty Electrification Charging Fund at the Department of Environmental Quality, which received $15 million through House Bill 5202[74] for a grant program supporting medium- and heavy-duty ZEV charging and fueling infrastructure projects. The Legislature also allocated an additional $15 million to Oregon's Clean Vehicle Rebate Program, which the DEQ awarded across the state in Spring 2023.

4.1.1.2 State Agency and Executive Actions

In March 2020, Governor Kate Brown issued Executive Order 20-04[75] directing state agencies to take actions to reduce and regulate greenhouse gas emissions. This order includes directives to the OPUC to encourage electric companies to support TE and achieve the state goals established in Senate Bill 1044[76]. The order also directs the DEQ to extend and expand the Oregon Clean Fuels Program and increase credits generated from electricity as a motor vehicle "fuel".

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[69] Oregon House Bill 2180, retrieved from https://olis.oregonlegislature.gov/liz/2021R1/Measures/Overview/HB2180.
[70] Oregon Administrative Rules, Chapter 660, Division 12, Rule 660-012-0410. Retrieved from https://secure.sos.state.or.us/oard/view.action?ruleNumber=660-012-0410.
[71] Oregon House Bill 2027, retrieved from https://olis.oregonlegislature.gov/liz/2021R1/Measures/Overview/HB2027.
[72] Oregon House Bill 2290, retrieved from https://olis.oregonlegislature.gov/liz/2021R1/Measures/Overview/HB2290.
[73] Oregon House Bill 4139, retrieved from https://olis.oregonlegislature.gov/liz/2022R1/Measures/Overview/HB4139.
[74] Oregon House Bill 5202, retrieved from https://olis.oregonlegislature.gov/liz/2022R1/Measures/Overview/HB5202.
[75] Oregon Executive Order 20-04, retrieved from https://www.oregon.gov/gov/Documents/executive_orders/eo_20-04.pdf.
[76] Oregon Senate Bill 1044, retrieved from https://olis.oregonlegislature.gov/liz/2019R1/Downloads/MeasureDocument/SB1044/Enrolled.

In March 2021, the Environmental Quality Commission (EQC) adopted DEQ's revised Oregon Clean Fuels Program rules to increase the amount of clean fuels credits generated from EV charging.[77] The rules now allow additional clean fuels credits to be generated when renewable energy certificates are retired alongside EV charging for both residential and non-residential EVs. PGE takes advantage of this opportunity on behalf of our residential customers, generating $5,394,400 in 2021 credit revenues for the 2023 program year. The new rules also allow public entities like school districts and local governments to generate credits in advance of EV charging to help fund the purchase of EVs or related TE investments. In September 2022, the EQC adopted rules extending the Oregon Clean Fuels Program to 2035 and requiring a 37 percent reduction from 2010 levels in the carbon intensity of motor vehicle fuels.[78]

The EQC also adopted California's medium- and heavy-duty diesel engine standards, including the Advanced Clean Trucks rule[79] that requires manufacturers of medium- and heavy-duty vehicles to sell a certain percentage of ZEVs beginning with the 2024 vehicle model year. In November 2022, the Oregon EQC adopted California's Advanced Clean Cars II rule[80] in Oregon[81] as permitted by the federal Clean Air Act[82], requiring that all light-duty vehicle sales in Oregon be ZEVs by 2035.

4.1.1.3 Federal Actions

The Infrastructure Investment and Jobs Act (IIJA) and the Inflation Reduction Act (IRA)[83], both passed by Congress since PGE's last TE Plan, provide significant funding and incentives to support transportation electrification.

The IIJA provides both formula funds and flexible funds to states, including more than $52 million over five years for Oregon to deploy corridor fast charging under the National Electric Vehicle Infrastructure Formula program (NEVI)[84]. The IIJA also creates a variety of new and substantial competitive grant opportunities for transportation electrification, including for buses and heavy vehicles. The IRA made significant modifications to the EV tax credit, lifting the 200,000-vehicle manufacturer cap for the credit but adding new rules for the credit on domestic manufacturing, supply chain, and vehicle cost. The IRA also created a used EV vehicle tax credit, along with tax credits for commercial EVs and for the installation of EVSE in certain communities.

PGE expects that these funding sources will help drive transportation electrification in our service area, where interest and adoption of EVs is already significant, and complement the state programs

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[77] Oregon Administrative Rules, Chapter 340, Division 253. Retrieved from https://secure.sos.state.or.us/oard/displayDivisionRules.action?selectedDivision=1560.
[78] Oregon DEQ. *Clean Fuels Program Expansion 2022*. Retrieved from https://www.oregon.gov/deq/rulemaking/Pages/cfp2022.aspx.
[79] California Air Resource Board. *Advanced Clean Trucks.* Retrieved from https://ww2.arb.ca.gov/our-work/programs/advanced-clean-trucks.
[80] California Air Resource Board. *Advanced Clean Cars Rule II.* Retrieved from https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program/advanced-clean-cars-ii.
[81] Oregon DEQ. *Advanced Clean Cars II.* Retrieved from https://www.oregon.gov/deq/rulemaking/Pages/CleanCarsII.aspx.
[82] United States Environmental Protection Agency (1970). *Clean Air Act*. Retrieved from https://www.epa.gov/laws-regulations/summary-clean-air-act.
[83] 117th Congress (2021-22) *House Rule 5376 Inflation Reduction Act of 2022.* Retrieved from https://www.congress.gov/bill/117th-congress/house-bill/5376.
[84] U.S. Department of Transportation, Federal Highway Administration *National Electric Vehicle Infrastructure Formula Program.* Retrieved from https://www.fhwa.dot.gov/bipartisan-infrastructure-law/nevi_formula_program.cfm.

and incentives. They also create opportunities for PGE to partner with our customers and communities on grant opportunities to gain external funding support for transportation electrification.

The IIJA also established a new DOT and DOE Joint Office of Energy and Transportation[85] focused on EV infrastructure deployment, with which PGE has been in contact both through trade associations and directly to understand grant opportunities.

Synopsis of Infrastructure Investment and Jobs Act Relevant Transportation Electrification Funding

The IIJA provides a range of formula funds and flexible funds to states as well as a variety of new and substantial competitive grant opportunities for transportation electrification, including for buses and heavy vehicles. The following selected funding streams are particularly relevant for TE in PGE's service area:

- National Electric Vehicle Infrastructure formula program: This program provides $52 million in formula funding to Oregon over five years to deploy fast charging stations within a mile of designated federal highways. ODOT administers these formula funds, and under a federally approved state plan, plans to develop and/or upgrade approximately 65 DCFC stations across Oregon's roadways, totaling a minimum of 260 DCFC ports and doubling the number of DCFC ports in the state. PGE provided expertise and advice to ODOT as it developed its State NEVI plan.
- The Charging and Fueling Infrastructure Grant Program[86]: This five year, $2.5 billion program is split between highway-adjacent corridor public charging grants and community DCFC public charging grants. The program prioritizes rural areas, low-and moderate-income neighborhoods, and communities with low ratios of private parking, or high ratios of multi-unit housing. In recent months, PGE has been in discussions with Forth[87], state agencies, and cities we serve about this opportunity.
- Grants for Buses and Bus Facilities Low and No Emission Bus Grant Program: This combination of new and existing programs offers $5.25 billion for the procurement of buses and upgrades to bus facilities, including purchase of low- and no-emission transit buses. PGE is supporting a customer in their application for this year's funding opportunity for the Low No Emissions Bus Grant.
- EPA Clean School Bus Program: The EPA Clean School Bus Program provides $5 billion total for fiscal years 2022-2026 for a new program for the deployment of low- and no-emission school buses and related infrastructure. The first round of funding has been completed, with the Banks School District receiving funding for three electric buses, and many other districts in PGE service area on the waiting list.

These grant programs create opportunities for PGE to partner with our customers and communities on grant opportunities to gain external funding support for TE, which we detail further in Section 4.8.1.

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85 Joint Office of Energy and Transportation: https://driveelectric.gov/.
86 U.S. Department of Transportation. *Charging and Fueling Infrastructure Grant Program*. Retrieved from https://www.transportation.gov/rural/grant-toolkit/charging-and-fueling-infrastructure-grant-program.
87 Forth: https://forthmobility.org/.

Synopsis of Inflation Reduction Act Funding

The IRA extended, expanded, and modified the existing EV tax credit, lifting the 200,000-vehicle manufacturer cap for the credit but adding new rules for the credit on domestic manufacturing, supply chain, and vehicle price. New rules on vehicle cost (manufacturer's suggested retail price, or MSRP) and income limits will restrict who qualifies: vehicle cost caps for vans, SUVs, and pickup trucks are $80,000, while the cap for other vehicles is $55,000; annual income is limited to $300,000 per household, $150,000 per individual. A used EV credit is created through December 31, 2032, capped at the lesser of $4,000 or 30 percent of the sales price for a 2+ year old vehicle for incomes less than $75,000 for single filers and $150,000 for joint filers. The IRA also created tax credits for commercial electric vehicles and for the installation of EVSE in certain communities.

Starting in 2025, clean commercial vehicles will be eligible for a tax credit of 30 percent of the incremental cost of the clean vehicle relative to a fossil-powered alternative. The Alternative Fuel Vehicle Refueling Infrastructure Tax Credit[88] was extended 10 years, available in both individual and commercial versions. The IRA also supports battery and technology research and manufacturing through the Advanced Manufacturing Production and the Advanced Energy Project tax credits.[89] The Inflation Reduction Act also invests $1 billion to replace dirty heavy-duty vehicles with clean, zero-emission Class 6 and 7 vehicles[90], support zero-emission vehicle infrastructure, and to train and develop the necessary workforce. These funds will be distributed as grants or rebates through the EPA's Clean Heavy-Duty Vehicle Program[91], expected to launch in late 2023.

PGE expects that the tax policies included in the IRA will help drive transportation electrification in our service area, where interest and adoption of EVs is already significant, and also complement the state programs and incentives.

4.2 Regional

4.2.1 Western Resource Adequacy Program

Planning to be resource adequate means having enough generation, efficiency measures, and demand-side resources to serve load with a sufficient degree of reliability across a wide range of conditions. Amid questions about whether the region will continue to have an adequate supply of electricity during critical hours, the Western Power Pool (WPP) began implementing the Western Resource Adequacy Program (WRAP) in 2021. The WRAP includes a forward-showing planning mechanism requiring participants to submit a portfolio of resources seven months ahead of operational need and allows controllable and dispatchable demand response (DR) resources to be

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[88] U.S. Department of Energy. *Alternative Fueling Infrastructure Credit*. Retrieved from https://afdc.energy.gov/laws/11180#:~:text=An%20income%20tax%20credit%20is%20available%20for%2050%25,may%20be%20carried%20over%20into%20future%20tax%20years.

[89] Office of Energy Efficiency and Renewable Energy. *Alternative Fuels Data Center: Federal Tax Credits for Solar Manufacturers*. Retrieved from https://www.energy.gov/eere/solar/federal-tax-credits-solar-manufacturers.

[90] Office of Energy Efficiency and Renewable Energy. *Alternative Fuels Data Center: Vehicle Weight Classes and Categories*. Retrieved from https://afdc.energy.gov/data/10380#:~:text=FHWA%20categorizes%20vehicles%20as%20Light,(GVWR%20%3E%208%2C501%20lb).

[91] U.S. Environmental Protection Agency. *Clean Heavy-Duty Vehicle Program*. Retrieved from https://www.epa.gov/inflation-reduction-act/clean-heavy-duty-vehicle-program.

considered for compliance.[92] Actively managed charging could potentially be used for WRAP compliance if it meets minimum testing criteria and aggregation requirements.[93]

4.2.2 West Coast Clean Transit Corridor

The West Coast Clean Transit Corridor Initiative refers to a collaborative effort between 16 West Coast utilities to support the development of EV charging facilities along Interstate 5 (I-5), from San Diego to British Columbia, for heavy and medium-duty freight haulers and delivery trucks. PGE is one of the 16 utilities with service areas along that corridor, and we are actively working together to plan and build these medium and heavy duty (MHD) truck charging sites. It is estimated that these sites will require upgrades to the PGE distribution network, with power requirements for each site beginning at 1.5 MW, with a five-year growth to 20 MW. The WCCTC model recommends a charging site every 50 miles along the I-5 corridor. In PGE territory, the WCCTC calls for three potential locations. One of these locations appears to be the most feasible, and we are working with our planning groups, the WCCTC, and a large trucking fuel agency to better understand the feasibility, scale, schedule, and cost of this site.

4.3 Service Territory Planning Environment

4.3.1 Number and Forecast of Electric Vehicles in PGE Service Area

PGE uses our AdopDER model to forecast EV growth and related charging demand. AdopDER is PGE's enterprise DER modeling tool used to forecast DER adoption and calculate expected load impacts for critical PGE business functions. PGE uses the tool to forecast DER growth and potential impacts from the bottom-up, aggregating site-level adoption up to the feeder and ultimately the bulk power system level. The tool is used to inform regulatory filings (CEP/IRP, DSP, MYP, and TEP), corporate load forecasting, revenue projections, energy trading decisions, and transmission and distribution (T&D) capital planning.

PGE uses our AdopDER model to forecast EV growth and related charging demand. Our aim in this section is to communicate the key components related to TE within the model (since the model forecasts other DER growth in addition to TE, such as solar PV and building electrification) and not give an exhaustive overview of the model's capabilities or results.[94] For consistency with other Company planning efforts, we focus on communicating results from AdopDER as it is the primary system of record for forecasting future load growth resulting from TE activities within PGE. We understand and appreciate the interest from Staff and other stakeholders in understanding differences between AdopDER and ODOT's TEINA methodology, and we footnote important

[92] Western Power Pool. *Western Resource Adequacy Program Detailed Design, March 2023*,pp71-72. Retrieved from https://www.westernpowerpool.org/private-media/documents/2023-03-10_WRAP_Draft_Design_Document_FINAL.pdf.
[93] Ibid. at pp73 ("Customer resource can be aggregate to the […] minimum requirement of 1 MW") and at pp72 ("meet testing criteria for load reduction for periods of up to five continuous hours").
[94] For detailed overview of AdopDER, see PGE. *DSP Part I Appendix G*, as well as PGE. *DSP Part II,* Section 5.1, retrieved from https://portlandgeneral.com/about/who-we-are/resource-planning/distribution-system-planning/dsp-resources-materials.

distinctions accordingly throughout this section. We also provide a more thorough comparison of port count results in Section 4.4 stemming from these different modeling approaches.[95]

4.3.1.1 AdopDER Vehicle Sales Forecast Methodology

PGE uses our AdopDER model to forecast EV and related EVSE adoption over the short- and long-run planning horizons (1-20 years). Key outputs for system planning purposes are energy and capacity needs stemming from electrification of transportation. Given recent changes to state and federal policy, PGE undertook an update to our EV forecast in April 2023. Updates to the model were made to capture the IRA and the Advanced Clean Cars II rule, as well as to recalibrate the baseline regression model with additional data from 2020-2022 national EV adoption trends.

A summary of the TE related measures in AdopDER[96] is presented below:

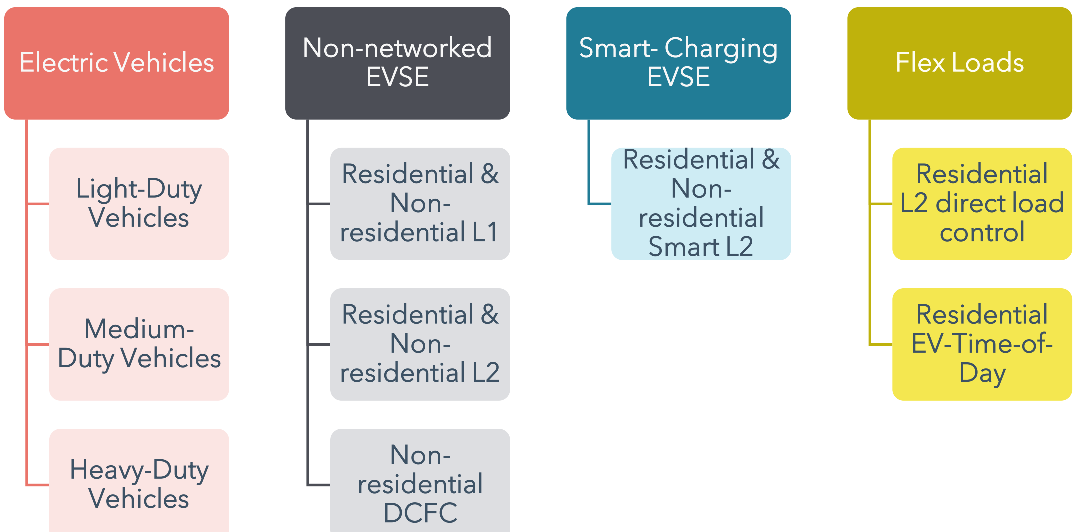

Figure 7. Transportation Electrification-related Measures in AdopDER

AdopDER's overall approach to forecasting EV growth is based on a robust methodology to identify the vehicles in PGE service area and apply detailed vehicle stock turnover and econometric modeling to identify growth trajectories based on underlying market factors. AdopDER blends a top-down econometric forecast of EV market share, which captures percent of new vehicles sold that will be electric in each year, with a bottom-up spatial allocation model to identify geographic clustering patterns useful for distribution system planning.

[95] AdopDER is a forecasting model that estimates adoption of electric vehicles, EVSE, and associated load impacts and is used for utility forecasting and planning efforts. ODOT's TEINA report is an assessment of public charging infrastructure (e.g., EVSE) requirements to support a given amount of EV adoption following the State's goals. Aside from methodological differences, which will be discussed throughout the section, this is an important distinction in scope between the two modeling efforts that should be emphasized up front.

[96] Currently, AdopDER forecasts on-road vehicles across the light-, medium-, and heavy-duty vehicle classes. PGE anticipates expanding AdopDER to include representation of potential impacts from non-road electrification, e.g., forklifts, agricultural equipment, marine, rail, and/or air transport in subsequent updates.

The top-down econometric model includes over 20 discrete variables that have been tuned to historical LDV EV adoption, however, the forecasts are the most sensitive to the following variables:

- Model availability
- Total incentives
- Vehicle and battery price declines

The rest of this section provides a detailed overview of each of these main forecast drivers and then connects the discussion back to the overall AdopDER model flow for TE forecasting.

Electric Vehicle Model Availability

As mentioned in Section 4.6.2.3, globally there were 450 EV models available for consumers to choose from as of 2021. When forecasting future EV adoption, we must account for expected future increases in model availability and incorporate only those models available to the US market. To accomplish this, AdopDER uses the Electric Power Research Institute's (EPRI) forecast of model availability through 2025 and extrapolates these trends through to 2030. Chart 1, below, shows the growth in expected models available in the US by vehicle type:

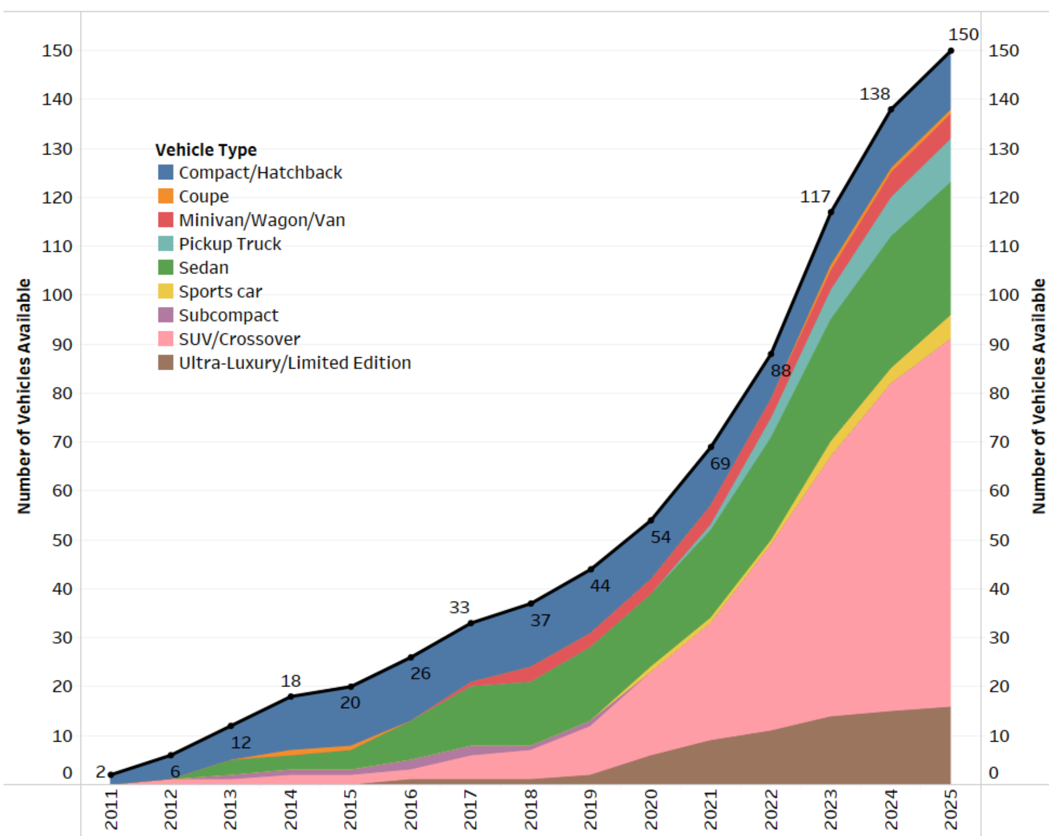

Chart 1. EPRI Forecast of Number of EV Models Available in the US by Vehicle Type

Total Incentives

The IRA is expected to significantly impact the vehicle market landscape. Although much remains to be seen about manufacturer response to some of the incentives (e.g., onshoring manufacturing supply chains) and, more importantly, the resulting effects on consumer retail price, the financial incentives from increased tax credits will nevertheless have an immediate impact.[97] Section 2.3.1.2 details the elements of the IRA related to the vehicle market. Here we only aim to highlight how these incentives have been incorporated into AdopDER.

Previously, AdopDER modeled the vehicle Clean Vehicle Credit as a weighted average of the federal tax credit (FTC) for which major vehicle manufacturers were anticipated to be eligible; accounting for the sales cap in place at the time (200,000 vehicles per manufacturer). Many vehicle makers had begun hitting the cap as early as Q1 in 2020 (Tesla) and as late as Q4 2022 (Toyota). The following table shows the sales-weighted Clean Vehicle Credit predicted before the IRA was passed. The IRA lifted the sales cap, however it also placed additional requirements on claiming the full credit based on final assembly in the U.S., battery mineral content, vehicle purchase price, and customer income.

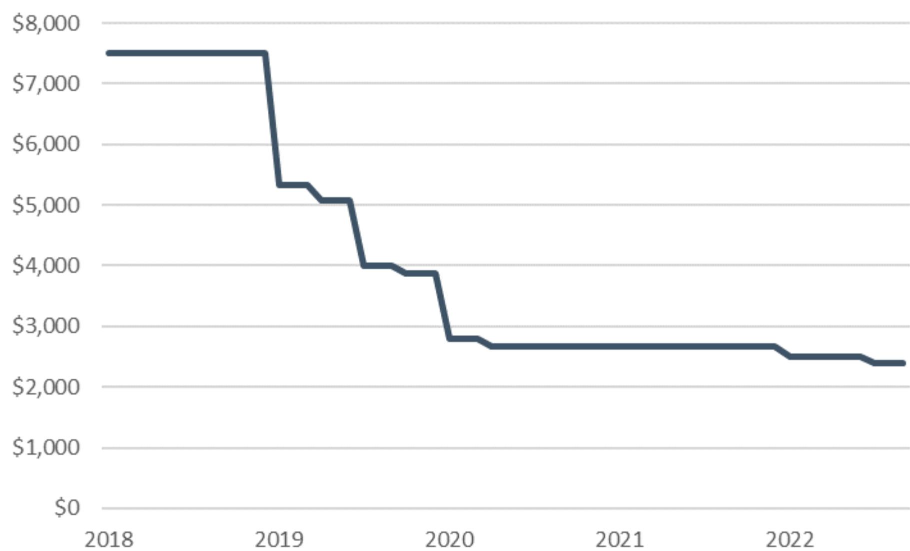

Figure 8. Weighted Federal Tax Credit with Manufacturer's Exceeding pre-IRA Sales Cap

Previously, we accounted for the statewide $2,500 rebate available through the Clean Vehicle Rebate Program.[98] Our recent model update incorporated additional rebates available for low and moderate income (LMI) customers through the Charge Ahead Rebate Program, which offers a rebate of up to $5,000 for the purchase or lease of a new or used EV for Oregon residents with income levels up to 400 percent of the federal poverty guideline.[99]

[97] We will continue to monitor progress and market changes stemming from the IRA with respect to vehicle costs, availability, and customer adoption trends. This includes various battery R&D efforts aimed at developing new battery chemistries, increasing battery charge acceptance rates, and increasing vehicle range.
[98] The state's Clean Vehicle Rebate Program was suspended May 1, 2023 as the program was oversubscribed for the funding available. There is uncertainty about the future funding status for this program and any resulting modifications to the credit.
[99] Oregon DEQ. *Oregon Clean Vehicle Rebate Program: Application Packet*. Retrieved from https://www.oregon.gov/deq/FilterDocs/evrebateapplication.pdf.

To properly account for benefits from both incentive programs, we calculate a weighted average of the two incentive levels based on state income data detailing the share of residents who qualify for the Charge Ahead additional incentive. In Oregon, 57 percent of residents fall below 400 percent of the federal poverty line as of 2021,[100] leading to a weighted average state incentive level of $3,548. All else equal, the increase in available incentives for low-income customers is expected to increase the EV adoption forecast.

Vehicle and Battery Price Declines

The last key driver of the forecast is vehicle price declines, which is largely a function of battery pack prices. We use the Bloomberg New Energy Finance (BloombergNEF or BNEF) Battery Price Survey[101] as a starting point to estimate downward price trends for EVs within the model, adjusting for forecast error in previous years of the baseline period. The following figure shows BNEF's forecast through 2030 for battery cost declines.[102]

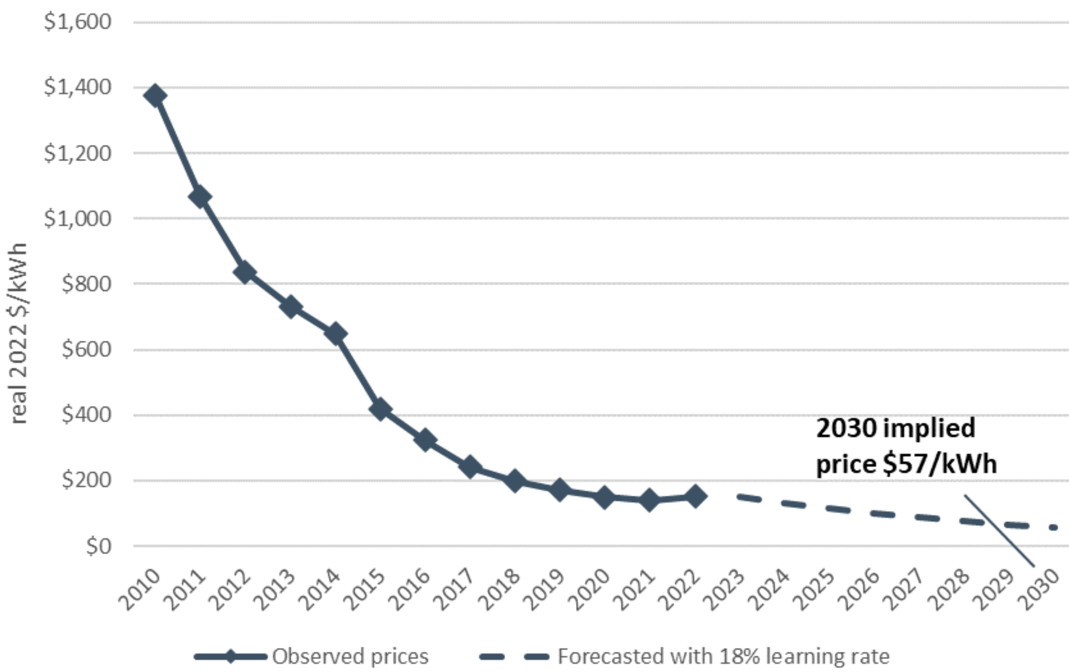

Figure 9. Bloomberg NEF Lithium-ion battery price outlook

[100] Kaiser Family Foundation. *Distribution of Total Population by Federal Poverty Level*. Retrieved from https://www.kff.org/other/state-indicator/distribution-by-fpl/?currentTimeframe=0&selectedDistributions=400percent&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D.

[101] Source: Brattle Group analysis. For BNEF historical battery pack prices and forecasted declines see: https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/ and for short-term impact on battery pack increased in 2022-23 see: https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/. BNEF estimates that the 2022 increase due to supply chain issues will continue into 2023, but that will be short lived and prices will continue their decline thereafter.

[102] Note again that the primary influence captured in this model update from the IRA was change to the FTC. Changes to battery costs will be updated as more information becomes available about manufacturer response to the battery incentives in the IRA.

See Appendix H for the full list of variables used in the LDV regression modeling.

After completing our regression estimation, we compared our estimates of new EV sales to various publicly available forecasts adjusted to PGE service area, shown in the following figure[103]:

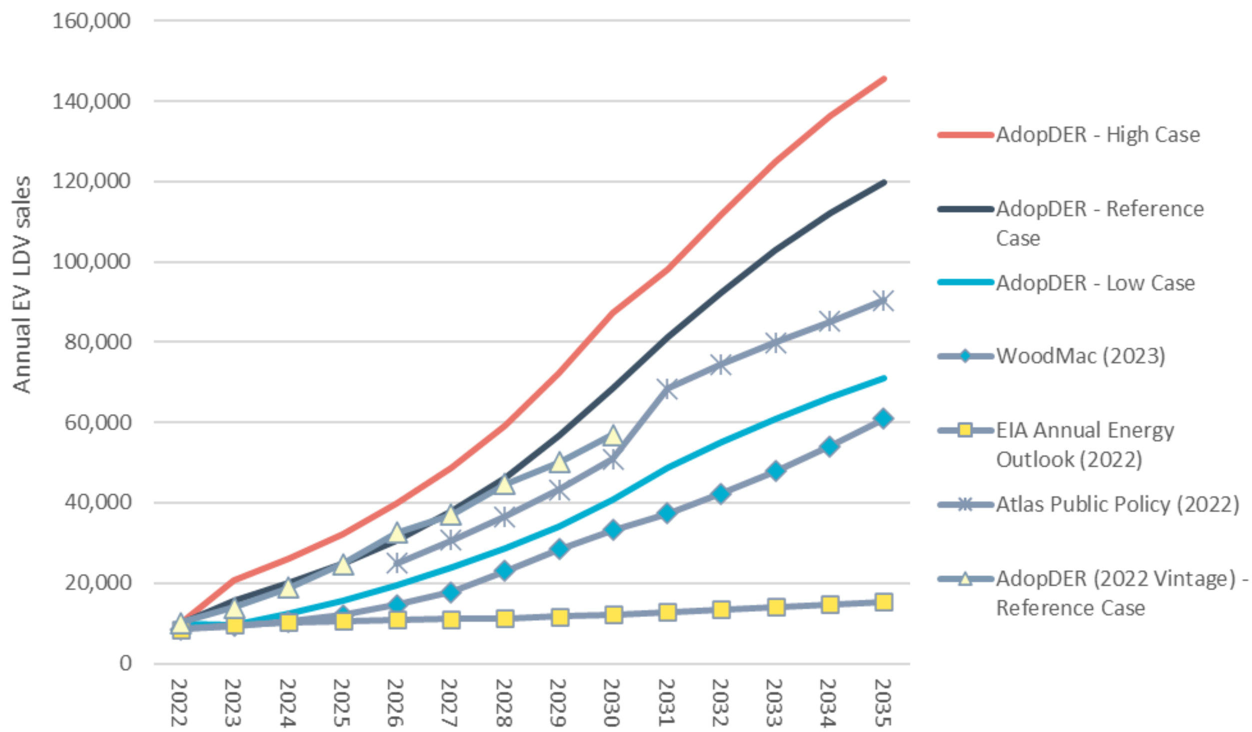

Figure 10. Benchmarking of Annual EV LDV Sales between AdopDER and Public Forecasts

For MDHDV, we leverage the annual percentage targets from the California Advanced Clean Truck rule for years through 2035, which Oregon EQC adopted in November 2021. For years beyond the ACT requirement window, we calibrate to our previous market share estimates for MDHDV derived from expert input under our DSP Part I.[104] The following figure shows the CA ACT rule annual percentage requirements for zero emission diesel engine sales during the 2024-2035 period.[105]

[103] Note that the publicly available forecasts are only available at the state level and not for PGE service area specifically. Therefore, we have applied the same percentage factor allocation of state-wide to PGE service area for purposes of comparison.

[104] For the MDHDV market share estimation methodology, see PGE. *DSP Part I,* Appendix G pp. 91-98. Retrieved from https://assets.ctfassets.net/416ywc1laqmd/1sMpwIkeZ0Imb9FuEA7F2i/128e4ffc0bc044f2fde8dcd7cbdc03c6/2021-09-17-pge-der-flex-load-potential-phase1.pdf

[105] ICCT (2020). *California's Advanced Clean Trucks regulation: Sales requirements for zero-emission heavy-duty trucks*. Retrieved from https://theicct.org/sites/default/files/publications/CA-HDV-EV-policy-update-jul212020.pdf

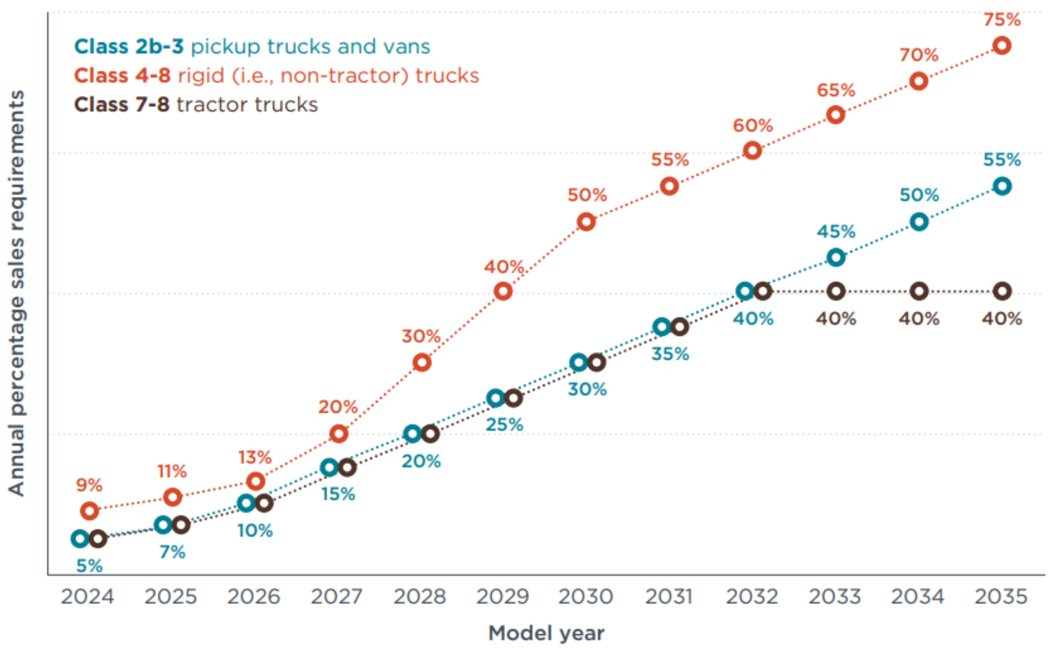

Figure 11. Zero-emission Sales Percentage Schedule for MDHDV by Vehicle Group and Model Year

To account for the overall market picture of HDVs operating in our service area, we partnered with EPRI to leverage national telematics datasets for trucks travelling throughout the state. With this data, we were able to geographically identify vehicle counts and major dwell times within PGE service area down to a 5-mile radius. The data represented HDV travel patterns during the busiest travel day of the year (June 27, 2019) and therefore reasonably approximates the total population of HDVs that will place future demands on the electric grid.[106]

4.3.1.2 AdopDER Vehicle Stock Turnover Modeling and EV Adoption

After developing our market share estimates of new EV sales described above, we must apply these to the proportion of new vehicles bought and sold each year. This is a function called stock turnover and depends on the average vehicle useful life. We begin constructing our stock turnover by taking the overall vehicle population, comprised of vehicle registrations obtained from ODOT, and matched to PGE service area and customer premises, for all vehicle fuel types and weight classes. We then augment the vehicle registration data with the additional HDVs from EPRI's telematics data, as noted above.[107] The following table shows the total count of vehicles across vehicle weight classes used to populate the stock turnover model within AdopDER.

[106] This is because the use of fleet telematics data encompasses both vehicles registered in Oregon and those that may be registered elsewhere but operating within PGE service area. This is particularly true for HDVs, many of which are registered outside of the state (and therefore not represented in the DMV registration data). HDVs must register for the Oregon Weight-Mile Tax but there is not sufficient data for geographic allocation within the state. For more information on the Weight-Mile Tax in Oregon, see DEQ. *Medium- and Heavy-Duty Truck Alternative Fuels Study*, retrieved from https://www.oregon.gov/deq/ghgp/Pages/Truck-Alternative-Fuels-Study.aspx

[107] The adjustments for EPRI's telematics data applies only to Class 7 and 8 HDVs.

Table 10. AdopDER: Vehicle Counts by Weight Class

Gross Vehicle Weight Class	Standardized Weight Class	Vehicle Counts
Class 1: 6,000 lbs. or less[108]	LDV	50,390
Class 1A: 3,000 lbs. or less	LDV	83,587
Class 1B: 3,001 4,000 lbs.	LDV	136,482
Class 1C: 4,001 5,000 lbs.	LDV	806,508
Class 1D: 5,001 6,000 lbs.	LDV	475,924
LDV subtotal		1,552,891
Class 2: 6,001 10,000 lbs.[109]	MDV	4,761
Class 2E: 6,001 7,000 lbs.	MDV	110,031
Class 2F: 7,001 8,000 lbs.	MDV	47,446
Class 2G: 8,001 9,000 lbs.	MDV	10,980
Class 2H: 9,001 10,000 lbs.	MDV	17,737
Class 3: 10,001 14,000 lbs.	MDV	17,871
Class 4: 14,001 16,000 lbs.	MDV	2,232
Class 5: 16,001 19,500 lbs.	MDV	2,846
Class 6: 19,501 26,000 lbs.	MDV	1,838
MDV subtotal		215,742
Class 7: 26,001 33,000 lbs.	HDV	27,552
Class 8: 33,001 lbs. and above	HDV	21,550
HDV subtotal		49,102
Total Vehicles		1,817,735

[108] Note that Class 1 and 2 values include vehicles that could not be matched to more granular weight Classes (e.g., 1A-D and 2E-H, respectively).
[109] Ibid.

As of November 2022, Tesla was the most common vehicle make among PGE customers, in line with national sales trends, followed by Nissan and Chevrolet. Overall LDV EV adoption by manufacturer is shown in Chart 2, below:

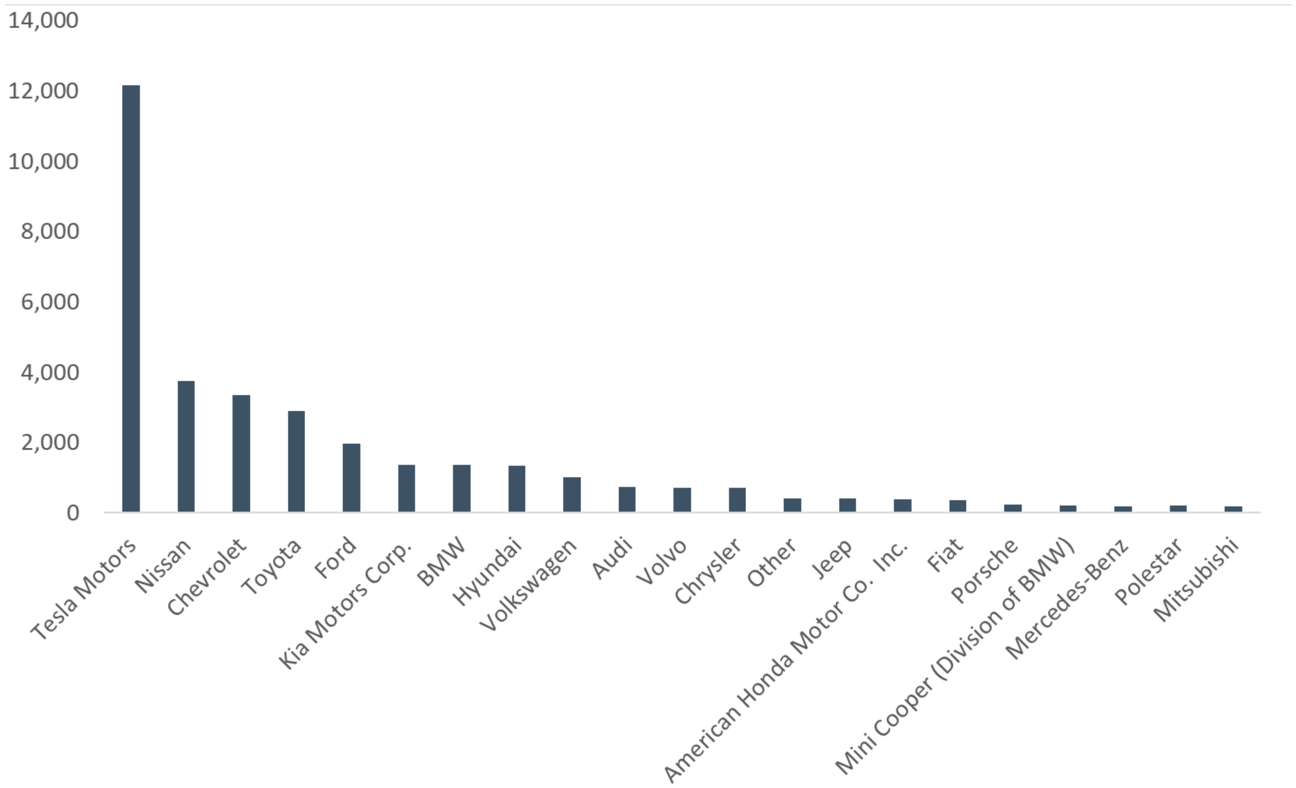

Chart 2. Count of Residential Commuter Electric LDVs in PGE Service Area by Manufacturer

Projecting forward into the forecast years, we then simulate the change in vehicle stock over time (i.e., stock turnover) as new vehicles enter the market and older vehicles are retired, applying the expected growth in EVs based on the econometric regression outputs. AdopDER is an agent-based model, with customer behavioral choices simulated at each time interval: a customer who adopts an EV then encounters a series of choices as to how they will charge the vehicle, what rate they charge at, and so on.[110] In addition, we apply customer data regarding site-level characteristics to constrain the EVSE adoption decision, which has a relationship to relative share of home versus public charging need.[111]

[110] Currently, AdopDER models EV adoption as a standalone customer decision point not related to other DER adoption. PGE is conducting research with EPRI to study co-adoption behavior among PGE customers across EVs, solar, and battery storage, and will include results into future modeling updates. Note that even though we model the adoption decision of EVs separate from other DER adoption decisions, the implications of a customer adopting an EV in the model still has important implications that are captured in the model, such as increasing the annual kWh on the customers' bill, which flows through the model to different bill savings calculations from other adoption decisions (e.g., TOU, flexible load programs, etc.)

[111] Site-level constraints for EVSE adoption include lack of on-site parking and lack of available service panel space. More detail on the site eligibility characteristics and adoption framework for AdopDER can be found in PGE. *DSP Part I*, Appendix G section 4.3.4 pp40-41. Note that site characteristics do not impact the EV adoption decision, which is governed by its own set of customer behavior drivers, but only the type of EVSE (public versus

Chart 3 depicts the change over time in the overall vehicle stock, with forecasted growth in the reference case of EVs increasing and the share of internal combustion engine (ICE) vehicles decreasing over time.

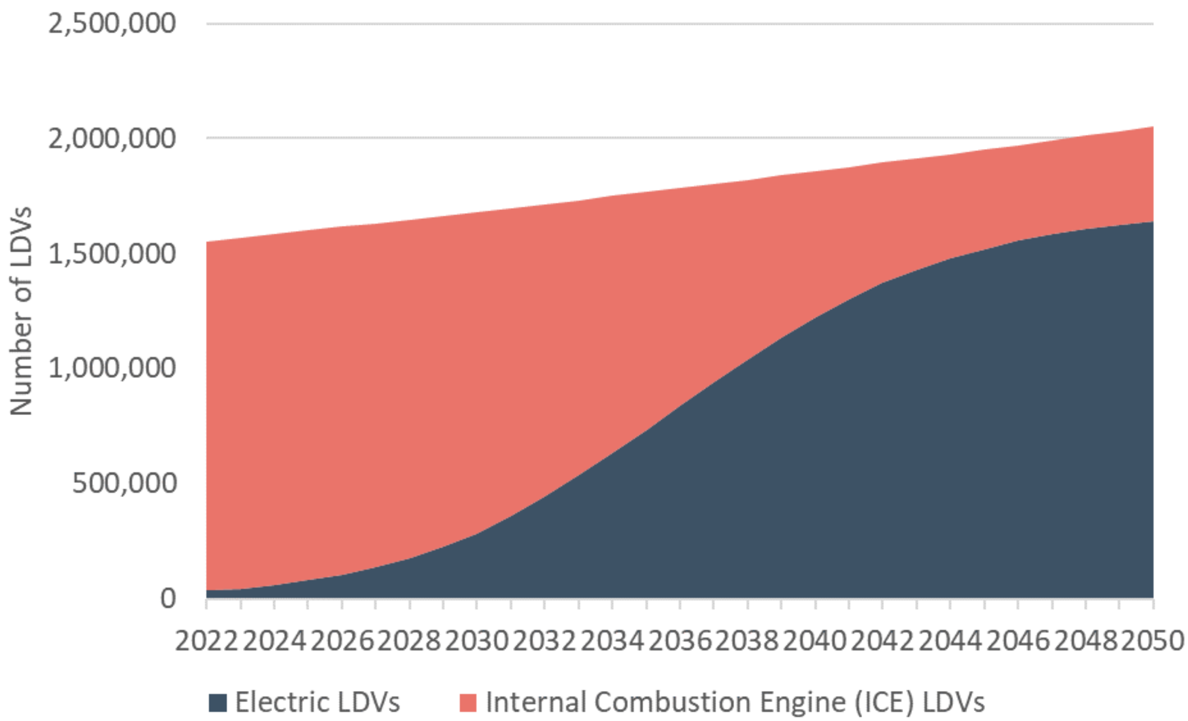

Chart 3. Vehicle Stock Turnover and EV Adoption from AdopDER April 2023 Reference Case LDVs

private) that the vehicle's energy demand of will be served with. We are also currently evaluating ways that panel upgrade incentives could change the customer adoption decision and will incorporate any learnings into future model updates.

The following table shows the detailed forecast results for EV growth through 2033 across all vehicle classes, segmented by residential and non-residential uses:

Table 11. Forecast of EV Adoption in PGE Service Territory (AdopDER model Reference Case)

Market Segment	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Residential Light-Duty Vehicle (LDV) Plugin Hybrid Electric Vehicle (PHEV)	20,635	30,998	41,331	52,233	64,041	77,075	91,298	102,537	114,176	125,423	135,844
Residential LDV Battery Electric Vehicle (BEV)	43,775	64,526	86,801	111,299	139,107	171,644	209,692	259,528	316,787	380,838	449,817
Residential Subtotal	64,410	95,524	128,132	163,532	203,148	248,719	300,990	362,065	430,963	506,261	585,661
Non-Residential LDV BEV	4,659	7,428	10,418	13,507	16,797	20,842	25,544	31,598	38,541	46,113	54,190
Non-Residential LDV PHEV	1,925	3,172	4,349	5,628	6,883	8,182	9,589	10,491	11,287	11,851	12,200
Non-Residential Subtotal	7,601	12,530	17,886	23,579	29,970	37,635	46,341	56,422	67,552	79,518	91,860
LDV EV Type Subtotal	70,994	106,124	142,899	182,667	226,828	277,743	336,123	404,154	480,791	564,225	652,051
Heavy-Duty Vehicle (HDV)	355	796	1351	1,935	2,691	3,603	4,619	5,856	7,156	8,608	10,018
Medium-Duty Vehicle (MDV)	662	1,134	1,768	2,509	3,599	5,008	6,589	8,477	10,568	12,946	15,452
Grand Total	72,011	108,054	146,018	187,111	233,118	286,354	347,331	418,487	498,515	585,779	677,521

AdopDER calculates TE load based on different charger use cases, each with different load profiles, charge speeds, and utilization rates. Chart 4 shows the daily load profiles for different residential charging levels.

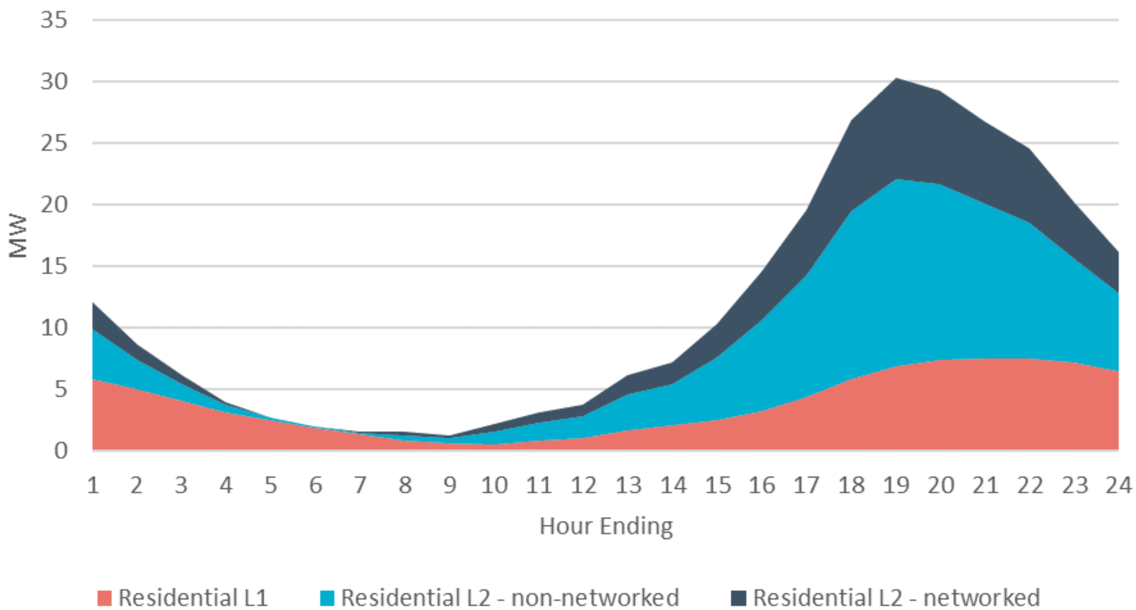

Chart 4. Residential EV Charging Load: Daily Load Profile for July 2023

The following table shows PGE's overall forecasted energy impacts from EV growth through 2030:

Table 12. Transportation Electrification Potential Forecasts (MWa)

Scenario	2023	2024	2025	2026	2027	2028	2029	2030
High	19	36	57	87	119	158	203	252
Ref	17	29	43	63	83	110	141	177
Low	15	23	31	43	55	70	87	106

This forecast update represents an increase relative to the reference case TE load forecast in PGE's 2023 IRP of 66 aMW by 2030 (111 aMW in 2023 IRP forecast versus 177 aMW in the April 2023 update). Section 4.8.3.2 describes how the IRP treats TE load in the different Need Futures.[112] PGE will also be re-running IRP models with updated overall load forecasts in June 2023 as part of LC 80, which will include the updated TE load projections.

4.4 Needed Public and Private Charging Infrastructure

4.4.1 PGE's AdopDER Model Forecasts of Needed Public and Private Charging Infrastructure

PGE's AdopDER model also forecasts the commercial and residential charging ports that are needed to support the forecasted adoption of EVs. Table 13 shows the results for commercial EVSE adoption by charging use case.

Table 13. Summary of Commercial EV Port Counts (AdopDER Forecast Reference Case)

Use Case	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Public DCFC	676	924	1,124	1,328	1,560	1,840	2,156	2,364	2,592	2,820	3,024
Public/ Workplace L2	1,840	2,686	3,705	4,600	5,944	7,322	9,131	11,465	14,826	18,748	24,413
Fleet DCFC	240	479	875	2,154	3,349	5,181	7,243	9,761	12,725	16,343	19,928
Fleet L2	229	495	1,015	1,571	1,852	2,573	2,921	3,816	4,974	6,300	8,513
L1	247	435	498	581	740	962	1,176	1,410	1,483	1,525	1,891
Total	3,232	5,019	7,217	10,234	13,445	17,878	22,627	28,816	36,600	45,736	57,769

AdopDER determines residential charging needs on a site-by-site basis based on customer vehicle adoption and site-level eligibility criteria for home charging. We combine two primary data sources to estimate the amount of residential vehicle adoption that can be served by home charging: 1) presence of a garage or driveway[113], and 2) sufficient available breaker space on the home electrical service panel. In the model, we do not prevent a home from adopting an EV, but if either of these criteria are not met, then the model tracks the unmet home charging need and generates additional demand for public charging ports.[114]

[112] "Need Futures" refers to different hypothetical future scenarios that each have different levels of new resource needs to serve expected load. For example, a "High Need Future" would be one with higher load growth (e.g., TE) and lower resources growth (e.g., solar PV).
[113] United States Census Bureau. *2020 Census Results*, retrieved from https://www.census.gov/programs-surveys/decennial-census/decade/2020/2020-census-results.html.
[114] This marks an important difference from the TEINA methodology, which assumes a starting level of home charging access of 90 percent and decreases linearly to 60 percent by 2035. Note that in our April 2023 model update, we relaxed the criteria for home service panel upgrade barriers given the available rebates and

Table 14 shows results of AdopDER's reference case adoption forecast. We break out the type of home charging between both charging speeds (L1 versus L2) and whether the L2 is networked or not. Networked L2, which are required in PGE programs, represent an opportunity for charging management.

Table 14. Residential EVSE Adoption Forecast (AdopDER Forecast Reference Case)

Residential Charging Type	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Non-networked L1	15,220	24,171	33,863	43,947	54,715	66,343	78,841	92,563	107,207	122,118	136,954
Non-networked L2	9,825	11,675	13,315	14,956	16,417	17,525	16,801	17,413	17,920	17,965	17,825
Networked L2	5,957	10,409	15,769	22,014	29,096	37,060	47,277	56,586	66,629	77,507	88,365
Total Residential Chargers	31,002	46,255	62,947	80,917	100,228	120,928	142,919	166,562	191,756	217,590	243,144

4.4.2 TEINA Model Forecasts of Needed Public and Private Charging Infrastructure

PGE has also calculated a separate forecast of public ports needed to support the forecasted adoption of EVs in our service area, this time using ODOT's TEINA methodology. Per OPUC Staff's guidance, we are using this second port count forecast to inform the infrastructure "guardrail" to guide programmatic investments. In order to maintain consistency across foundational utility planning documents, PGE will continue to leverage AdopDER results from the two tables above to guide its DSP, IRP, and CEP work.

To conduct the adapted TEINA analysis, we took our LDV forecasts from AdopDER and ran them through the public-facing TEINA workbook provided by ODOT and the Rocky Mountain Institute. This provided the number of public charging ports needed by TEINA-specific charging use case for LDV adoption, including urban/rural LDV, corridor charging, and Transportation Network Companies (TNCs).[115] For MDHDV port needs, we relied upon supporting workbooks from ODOT (2021) containing the remaining use cases that were not included in the public-facing tool, including long-haul trucking, local MDV delivery, and school bus.

incentives (both PGE's effort under the Smart Charging pilot and federal incentives expected to be available as a result of the IRA).

[115] Oregon Department of Transportation. *TENIA Study*, retrieved from https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx.

Table 15 shows the public port counts resulting from applying the TEINA methodology (under the "Business as Usual" scenario) to our April 2023 reference case EV forecast using AdopDER.

Table 15. Public EV Charging Ports Needed in PGE Service Area (TEINA Methodology)[116]

TEINA Use Case	Charging Type	2020	2025	2030	2035
Urban/Rural LDV	Workplace L2	587	3,852	10,867	22,487
Urban/Rural LDV	Public L2	381	2,456	6,916	14,304
Urban/Rural LDV	DCFC	210	1,345	3,712	7,590
Corridor LDV	DCFC	117	405	466	770
Disadvantaged Community (DAC) (Adjusted)	Workplace L2	28	185	523	1,080
DAC (Adjusted)	Public L2	19	124	349	720
DAC (Adjusted)	DCFC	9	59	160	324
TNC (Optimized)	DCFC	2	18	136	155
Micromobility[117]	Workplace L2	-1	-55	-422	-1,596
Micromobility	Public L2	-1	-36	-279	-1,058
Micromobility	DCFC	0	-18	-131	-486
Long-haul Trucking	DCFC	0	6	71	236
Local Medium-duty, Delivery	DCFC	2	111	274	554
School/Transit Buses	Public L2	2	229	819	1,793
School/Transit Buses	DCFC	6	82	219	441
Subtotal Workplace L2		614	3,982	10,968	21,971
Subtotal Public L2		402	2,773	7,805	15,760
Total L2		1,016	6,755	18,773	37,731
Total DCFC		345	2,008	4,907	9,585

Chart 5 shows a comparison of the public charging estimates using AdopDER and TEINA methodologies, applied to the same underlying vehicle forecasts.

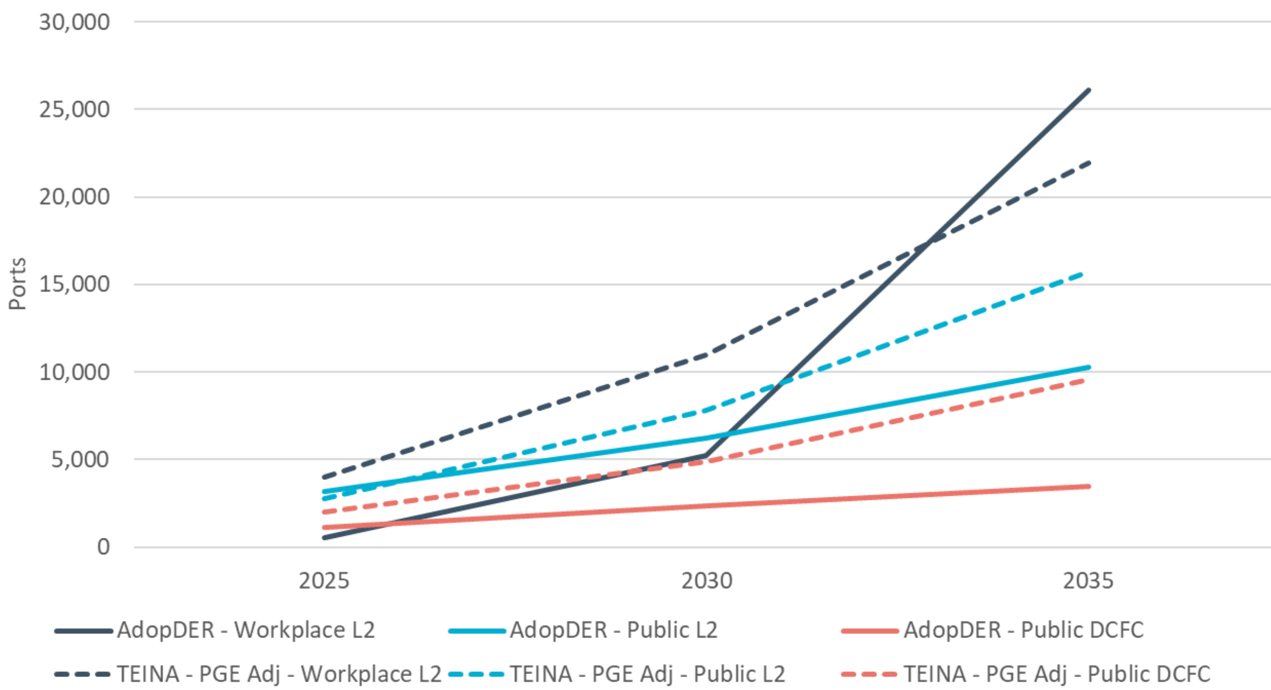

Chart 5. AdopDER and TEINA Public Charging Comparison

To summarize the results that PGE is using to guide this TE Plan: the application of the TEINA methodology to PGE's EV adoption forecast suggests that, by 2025, our service area will require 6,755 public and workplace L2 EVSE and 2,008 public DCFC EVSE. As referenced above, this compares to 1,019 public/workplace L2 EVSE in PGE's service area as of April 2023 (15 percent of the 2025 need), and 187 public DCFC EVSE (9 percent of the 2025 need).

4.5 Other TE Infrastructure

In addition to the light-, medium-, and heavy-duty on-road vehicles that PGE proposes to primarily support through this plan, other segments of the TE market are continuing to emerge and evolve (though many remain in nascent stages).

The following segments of the TE market and related infrastructure, while not proposed for active development and funding with this plan, are areas that PGE will continue to monitor and weigh when considering future proposals:

[116] The following TEINA use cases do not reflect public EV ports and have been excluded: Long-Haul Trucking; Local Medium-Duty, Delivery; and School/Transit Buses.
[117] Micromobility results are negative since they reduce overall port needs.

- Micromobility for equitable access to electric mobility through bicycles, scooters, and mopeds
- Electric aviation and rail
- Electric marine market, which includes passenger, cargo, and other vessels
- Electric farm and off-road equipment
- Electric ground service equipment at airports and seaports
- Megawatt Charging System for large battery EVs
- Autonomous, wireless, and mobile charging

As these technologies continue to mature, PGE will monitor their development through trade groups, research, and demonstration projects. Where appropriate, PGE also supports this work through CFP-funded programming and grantmaking like the Drive Change Fund and Emerging Technology Research and Development activity. The Oregon Clean Fuels Program provides PGE a pathway to engage with customers in these emerging areas to support adoption and understanding of new technologies for future program development.

4.6 Market Barriers

In PGE's inaugural 2019 TE Plan, the Company described the market barriers to EV adoption. With the current plan, we have organized the barriers into the categories of education and awareness, market, equity, and technology. Additionally the Infrastructure Fueling and Infrastructure Availability barriers identified in the 2019 plan are now combined into a single barrier (Fueling Infrastructure and Availability) to reflect their interrelatedness. We also describe a new Vehicle Availability barrier to reflect global supply chain issues affecting the TE market. In the table below PGE's ability to influence the identified barriers are ranked by high, medium, or low. A discussion of the market barriers following with details on how the barriers fit into PGE's strategy to plan for, serve, and manage load.

Table 16. TE Programs Addressing Market Barriers to EV Deployment

Barrier Categories	Specific Barriers to EV Deployment	Utility Ability to Influence	Business EV Charging Rebates	Business and Multi-family Make-ready Solutions	PGE Clean Fuels	Fleet Partner	Heavy Duty Charging	Public Charging – Municipal Charging Collaborations	Residential Smart Charging
Education and Awareness	Customer Awareness	High	✓	✓	✓	✓		✓	✓
Market	Cost	High	✓	✓	✓	✓	✓	✓	✓
	Fueling Infrastructure and Availability	High	✓	✓	✓	✓	✓	✓	✓
	Channel/ Sales Process	Low							✓
	Vehicle Availability	Low							
	Incentives and Policies	High	✓		✓	✓			✓
Equity	Equitable Access	Med	✓	✓	✓			✓	✓
	Vehicle Functionality	Low							
Technology	Vehicle Range	Low							
	Infrastructure Reliability	High	✓	✓				✓	✓

In this section, we detail the above market barriers affecting EV adoption, discuss PGE's role in addressing each barrier, and identify the components of this plan that do so.

4.6.1 Barrier Category: Education and Awareness

This barrier category reflects the lack of information about EVs or charging. It also includes perceptions about electric transportation and factors that complicate the ability to choose to invest in EVs. PGE is one actor of many in this space and will calibrate our activities as the market evolves. It is critical that other market actors such as auto and Electric Vehicle Service Equipment manufacturers also allocate resources to general education about EVs. Examples include:

- Lack of awareness about EV costs, incentives, performance, and availability. Between 2018 and 2022, for those customers who intended to purchase a vehicle within the next five years, their awareness of EVs increased from 76 to 80 percent. However, this increased awareness of EVs still lagged behind awareness of gasoline vehicles (94 percent).[118]
- Range anxiety, defined as a lack of confidence in the ability of an EV to drive a specific distance, or the perception that a driver will be unable find charging along a route or at a destination.

PGE can help address this barrier via targeted program components that facilitate customer familiarity with electric transportation. Within PGE's transportation portfolio this includes total cost of ownership (TCO) tools for residential and non-residential customers, technical assistance and planning support, support for the statewide education campaign, Oregoin' Electric (see Section 7.2.2.7), Ride-and-Drive events (see Section 7.2.2.8 and Appendix A.4, and support for community electric transportation projects through the Drive Change Fund (see Section 7.2.2.6) and Electric School Bus (see Section 7.2.4.7) funds. Additionally, program budgets include specific education and outreach needs for those activities.

4.6.2 Barrier Category: Cost and Market

This category covers the often-significant upfront costs for EVs and installing EVSE infrastructure and also includes global supply chain challenges for certain technologies. Examples include:

- Higher manufacturer's suggested retail prices for EVs across classes compared to a similar ICE vehicles
- High EVSE and installation costs
- EV fueling infrastructure and availability
- Inadequate or unavailable financial incentives to help with upfront EV costs
- EV channel/sales process
- Limitations of EV inventory including lack of available EVs at dealerships
- Long lead times for EVSE, as well as supporting make-ready infrastructure

[118] Opinion Dynamics (2022). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs: 2021 Annual Report*. Figure 2. Respondent Familiarity with Vehicle Fuel Types, by Survey Wave and Segment. pp27 filed May 19th, 2022 under OPUC Docket UM 1938. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.

- Lack of trained specialized workforce to provide EV and EVSE maintenance, repairs, and installation
- Limited cost effectiveness for public EVSE at today's EV adoption levels
- Broad market supply chain challenges

The cost of EVs and supporting infrastructure is an established market barrier that PGE can help address through rates and program design. By providing equitable/affordable rates, utilities have a large influence on the TCO of EVs. Schedule 50[119] and PGE's Time of Day rate[120] can materially influence the TCO of EV ownership, whilst also sending price signals to drivers about the most grid-friendly times to charge. PGE can help mitigate high upfront EVSE costs by providing incentives for EVSE (as via PGE's Residential Electric Vehicle Charging pilot[121]) and also supporting make-ready infrastructure.

The cost of an EV purchase (and potentially EVSE) was the single largest barrier mentioned by customers surveyed in the Company's annual customer survey. Between 2018 and 2022, the percentage of customers who listed this as the top barrier to purchasing or leasing an EV or plug-in hybrid increased from 31 to 36 percent.[122] In September 2022, Kelley Blue Book reported that the average transaction cost for an EV was $65,291, compared to $48,094 for ICE vehicles.[123] At an August 2022 Ride-and-Drive event, 70 percent of PGE customers surveyed listed purchase price as a barrier preventing the purchase or lease of an EV.[124] While more affordable EVs exist, especially when including used vehicles, cost remains a significant a barrier to EV adoption.

4.6.2.1 Fueling Infrastructure and Availability

Customers reported that charging infrastructure availability was the second-highest barrier to purchasing or leasing an electric vehicle or plug-in hybrid.[125] Among customers who were not considering an EV or plug-in hybrid for their next purchase, charging infrastructure availability was the

[119] PGE Schedule 50, retrieved from https://assets.ctfassets.net/416ywc1laqmd/2hNjMQ203TEcCmZttyKCTt/60e36b07499f89b45856a4576d4107ec/Sched_050.pdf.
[120] PGE Schedule 7, retrieved from https://assets.ctfassets.net/416ywc1laqmd/6RgTNk5RU1bldl0LdPpIY9/798481eb9f1171e4ec8ce5ce648bc47f/Sched_007.pdf.
[121] PGE's Schedule 8, retrieved from https://assets.ctfassets.net/416ywc1laqmd/2CrkwfPNPaDoM1tiVX68k0/6e29d4c934d17d55f7911aebba73606d/Sched_008.pdf.
[122] Opinion Dynamics (2022). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs: 2021 Annual Report*. Figure 3. Unprompted Barriers Mentioned to Purchasing or Leasing an EV or PHEV, By Survey Wave and Segment. pp37 filed May 19th, 2022 under OPUC Docket UM 1938. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.
[123] Kelly Blue Book. *Electric Car FAQ: Your Questions Answered: 10. How Much Are Electric Cars?* Retrieved from https://www.kbb.com/car-advice/electric-car-faqs/#link10.
[124] PGE (2022). *PGE Transportation Electrification Pilot Program 2022 Electric Car Guest Drive and EV Charger Exhibit Intercept Survey Results*. Table 7, pp7.
[125] Opinion Dynamics (2022). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs: 2021 Annual Report*. Figure 15. Unprompted Barriers Mentioned to Purchasing or Leasing an EV or PHEV, By Survey Wave and Segment. Page 39. Filed May 19th, 2022 under OPUC Docket UM 1938. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.

top concern, with almost half (45 percent) of customers suggesting this as the primary barrier[126]. For detail on how PGE activities address this fueling infrastructure and availability, see:

- Public Charging - Municipal Charging Collaboration (Section 7.3.1.2 and Appendix C.1)
- Business and Multi-family Make-ready Solutions (Section 7.3.3 and Appendix C.2)
- Residential Smart EV Charging (Section 7.3.1.1 and Appendix A.1)

4.6.2.2 Multi-Channel/Sales Process

Only 15 percent of EV owners surveyed ranked their dealership salesperson as "very high" in EV knowledge.[127] Customers reported partner dealerships with an average score of 6.7 out of 10 in informativeness.[128] The most popular EVs (the Tesla Model 3 and Model Y) are both sold online, and other vehicle manufacturers are considering changes to the purchasing experience.[129] This may streamline the sales process and result in a better customer experience as shoppers rely on internet research and fixed pricing to make buying decisions. While PGE has a low level of influence in this process, PGE coordinates with Chargeway to engage with local dealers and ensure they can direct customers to PGE programs. We will continue to assess the right engagement with dealers to help assist with training and knowledge of PGE programs.

4.6.2.3 Vehicle Availability

Two components of vehicle availability have diverged significantly since the 2019 TE Plan: the number of unique models for sale in the U.S. and the ability to purchase available models. The number of unique battery electric and plug-in hybrid models for sale has increased from 29 to 132 between 2016 and 2022[130]. As of 2022, the Ford F-150 (the best-selling vehicle in America for 40 consecutive years[131]) comes in an electric version, and other electric pick-ups are available as well[132], filling a major gap in available EV types.

However, supply chain concerns continue, with U.S. domestic auto inventories hovering at historic lows (down from 537,000 in April 2020 to 84,000 vehicles two years later[133]). Common configurations

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[126] Ibid. Figure 15. Unprompted Reported Changes Necessary to Consider EV or PHEVE for Next Vehicle amount Non-Considerers, by Survey Year (Multiple Responses Allowed). pp32 UM 1938 Evaluation of PGE's Transportation Electrification Pilot, filed May 19, 2022. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.
[127] Plug-in America (Feb 2022). *The Expanding EV Market: Observations in a year of growth*. Retrieved from https://pluginamerica.org/wp-content/uploads/2022/03/2022-PIA-Survey-Report.pdf.
[128] Opinion Dynamics (2022). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs: 2021 Annual Report*. Table 11. Proportion of EV Owners Who Visited Partner Dealers, Rated Level of Informativeness of Dealer, and Proportion of EV Owners Shown the Educational Kiosk. Pp47. Filed May 19, 2022 under OPUC Docket UM 1938. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.
[129]Trop (June 2, 2022). *TechCrunch+. Ford Wants to Restructure Its Dealership Model to Boost EV Sales*. Retrieved from. https://techcrunch.com/2022/06/02/ford-wants-to-sell-evs-online-only-and-at-a-set-price/.
[130] U.S. Department of Energy. *Alternative Fuels Data Center: Light Duty AFV, HEV, and Diesel Models Offerings by Technology/Fuel*. Retrieved from https://afdc.energy.gov/data/10303
[131] Owusu (December 2, 2021). TheStreet. *Ford F-150 is Top U.S. Car Sold for 40th Straight Year, Top Truck for 45th Straight*. Retrieved from https://www.thestreet.com/investing/f150-top-us-car-brand-again
[132] See Rivian R1T: https://rivian.com/r1t
[133] U.S. Bureau of Economic Analysis. *Gross Domestic Product, First Quarter 2023 (Advance Estimate)*. Retrieved from https://www.bea.gov/data/gdp/gross-domestic-product#collapse86.

of the most popular electric sedans (Tesla Model 3) and compact electric SUVs (Tesla Model Y) have lead times of three to nine months, respectively.[134] As a result, many consumers currently experience difficulty purchasing the EV they desire. At a recent PGE Ride-and-Drive, participants listed "lack of available EVs for purchase or lease" as the second-most-cited barrier (after cost) to purchasing an EV.[135]

The availability of the vehicles that customers will want to drive/buy depends upon the decisions and functioning of the automotive industry. PGE alone has no impact on automotive supply chains, though PGE can work with industry trade groups to have a larger voice with Original Equipment Manufacturers (OEMs). Details regarding automotive manufacturers' investments in electric vehicles are included later in this section.

4.6.2.4 Incentives and Polices

This barrier encompasses incentives and policies spanning local, federal, global, and other states as discussed in Section 3.4 above. While the EV market is now largely driven by OEM production and consumer behavior, major policy changes are expected to have a dramatic impact on vehicle availability, speed of transition, and infrastructure deployment in our region. Oregon expanded elements of the state's EV rebate in 2021[136] but the Clean Vehicle Rebate Program was suspended May 1, 2023 as the program was oversubscribed for the funding available. At the time of publication, there is uncertainty about the funding status and any resulting modifications to the program, and therefore the availability of rebates to PGE customers.

The IRA made significant modifications to the federal EV and fueling equipment tax credits in 2022. The IRA expansion of tax credits toward the purchase of used EV purchases create opportunities for more equitable transitions to electric vehicles for a larger variety of consumers. The updates to the Alternative Fuels Infrastructure Tax Credit[137] help with fueling equipment expansion in non-urban areas. The IRA extends the residential EVSE equipment tax credit through 2032 as well as provides a tax credit toward panel upgrades, if needed to support residential EVSE installations.

While the new IRA policies and updated Oregon rebates will undoubtably support the transition to EVs in the long-term, in the near-term they may cause confusion in regard to which vehicles qualify for different incentives. To mitigate this, PGE continuously updates its online tools for fleet and residential EV cost and savings calculations when policies change and rebates become available (or have their funding depleted). PGE will aim to address confusion around changing policies through education and outreach.

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[134] See EVAdoption: https://evadoption.com/.

[135] PGE (September 15, 2022). *Table 7. PGE Transportation Electrification Pilot Program 2022 Electric Car Guest Drive and EV Charger Exhibit Intercept Survey Results*. pp7.

[136] Oregon DEQ (January 7, 2022). *DEQ implements changes to Oregon Clean Vehicle Rebate Program*. Retrieved from https://deqblog.com/2022/01/07/deq-implements-changes-to-oregon-clean-vehicle-rebate-program/.

[137] U.S. Department of Energy. *Alternative Fuels Data Center: Alternative Fuel Infrastructure Tax Credit*. Retrieved from https://afdc.energy.gov/laws/10513.

4.6.3 Barrier Category: Equity

We recognize the inequities that can occur as we transition to a clean energy future. Often our vulnerable communities experience the most barriers. In this section, we discuss the ongoing barriers that historically excluded communities face in accessing electric transportation. Examples include:

- Lack of affordable EVs
- Limited or low inventory of used EVs
- Older model used EVs have lower battery ranges
- Complicated incentive structures or lack of awareness of incentives
- Perception of EVs as only for wealthy individuals

PGE can help address this issue by providing awareness and education around TE and EVs, as well as incorporating an equity lens into the company's TE rates and program offerings. Using an equity lens can assist in reducing barriers to our customers and the communities we serve. For example: for renters or those without access to off-street parking, public charging at utility-owned charging stations can provide price parity similar to the residential rates paid by those charging at home.

4.6.3.1 PGE EV Customer Survey Results

PGE's 2022 EV customer survey identified several challenges to entering the EV market, with 63 percent of EV purchasers reporting the inability to charge at home as a major barrier.[138] We also found that current EV owners had a higher level of home ownership, with 94 percent owning their home (compared to 67 percent of all respondents).[139] We also found that only 3 percent of current EV owners surveyed lived in multi-family housing (compared to 22 percent of all respondents).[140] These data points illustrate an issue with equitable access for non-homeowners.[141] This was supported by our finding that current EV owners reported higher household incomes, with 59 percent of reporting household income of over $100K (compared to 25 percent of all respondents).[142]

Based on the survey results, PGE will continue to engage with underserved communities to obtain feedback to inform development of EV programs that help reduce barriers and improve access to electric transportation. The Public Charging - Municipal Charging Collaboration pilot is one pathway to work on equitable access to charging for underserved communities. The portfolio also proposes

[138] Opinion Dynamics (2022). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs: 2021 Annual Report*. Figure 14. Prompted Barriers Mentioned to Purchasing or Leasing an EV/PHEV, by Survey Wave and Segment. Pp38. Filed May 19th, 2022 under OPUC Docket UM 1938. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.
[139] Ibid. Figure 31. Respondent Housing Tenure, by Survey Wave and Segment. pp49.
[140] Ibid. Figure 32. Respondent Housing Type, by Survey Wave and Segment. pp50.
[141] We recognize that non-homeowners are a varied socioeconomic population, some of whom might not meet the common definition of an Underserved Community. In our TE planning, we use HB 2165's definition of Underserved Communities which, for the purposes of TE, encompasses all renters and occupants of multi-family residences, whom they deem to have relatively less access to charging infrastructure than do homeowners.
[142] Opinion Dynamics (2022). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs: 2021 Annual Report*. Figure 34. Respondent Household Income, by Survey Wave and Segment. pp51. Filed May 19th, 2022 under OPUC Docket UM 1938. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.

working with low-income multi-family properties on installing make-ready infrastructure and providing a rebate for their purchase and ownership of chargers. With input from community members, we will continue to shape our offerings as well as future rates/tariffs which will better serve the needs of underserved community members.

4.6.4 Barrier Category: Technology

This category includes barrier areas where EV or EVSE technology or performance limitations decrease the likelihood of EV adoption. Examples include:

- Class and style of vehicles offered by automakers
- Absence of EVSE standardization
- Multiple EV charging connector types
- EVSE network requirements
- EVSE reliability

PGE has minimal influence over what types of vehicles or chargers manufacturers produce. PGE's ability to exercise influence is achieved primarily through engagement in industry associations such as the Edison Electric Institute (EEI), the Electric Power Research Institute (EPRI), and the Association for Transportation Electrification (ATE). The Company can also incorporate technical requirements and institute competitive bidding processes to support specific technologies and performance outcomes.

4.6.4.1 Vehicle Functionality

The availability of product with features that customers expect is dependent on the automotive industry. PGE alone has no impact on automotive supply chains and the features OEMs offer. As mentioned previously, 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.

4.6.4.2 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 though prices are currently experiencing an increase due to inflation and supply chain issues[143]. If longer term cost reductions do not materialize, affordability barriers to EV adoption may continue for longer than expected.

4.6.4.3 Vehicle Range

Between 2017 and 2021, the global average EV range increased from 150 miles to 217 miles.[144] The most popular electric sedan (Tesla Model 3) and compact electric SUV (Tesla Model Y) in the U.S.

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[143] BloombergNEF (December 2022). *Lithium-ion Battery Pack Prices Rise for First Time to an Average of $151/kWh*. Retrieved from https://about.bnef.com/blog/lithium-ion-battery-pack-prices-rise-for-first-time-to-an-average-of-151-kwh/.

[144] Carlier (June 8, 2022). statistica. *Average driving range of electric vehicles worldwide bye 2017 and 2021, by type*. Retrieved from https://www.statista.com/statistics/1312369/average-ev-range-worldwide-by-type/.

market both offer over 250 miles of range[145],[146]. However, when prompted with different potential barriers, customers still reported EV range as their single largest concern (80 percent of respondents).[147] More than half (57 percent) of respondents reported that a range of greater than 250 miles would be required to alleviate their concern.[148] Despite the fact that currently available EVs are capable of delivering this range, this remains a perceived barrier.

PGE expects that used EVs will become increasingly popular with the addition of recent federal incentives. For low-income customers, a used EV becomes even more tempting in combination with Oregon's own Charge Ahead rebate. PGE recognizes that used EVs typically offer a lower range in comparison to similar new vehicles. While range anxiety might therefore be a larger concern with used EVs, PGE hopes that properly placed chargers (such as those installed as part of the Public Charging - Municipal Charging Collaboration) can help mitigate that anxiety for used car owners.

4.6.5 Emerging Challenges

PGE has identified the following emerging challenges to transportation electrification:

4.6.5.1 Load Profiles from COVID-19

The COVID-19 pandemic has impacted nearly all aspects of daily and economic life since March 2020. PGE has observed changes in public charging utilization (see Chart 6), and regional transit utilization has also been affected (see Chart 7). PGE has also observed impacts on charging infrastructure, electrical equipment, and vehicle infrastructure availability, detailed in previous sections and below. Since PGE's Residential Smart EV Charging pilot only launched in October of 2020 (mid-pandemic), we do not yet have direct historical data to assess the impacts of the pandemic on home charging.

Electric Avenue charging has made strong recovery since facing sharp usage declines as the COVID-19 pandemic began. Since Oregon lifted the majority of COVID-19 restrictions in July 2021, overall Electric Avenue usage has increased 72%.

[145] Argonne National Laboratory. *Light Duty Electric Drive Vehicles Monthly Sales Updates.* Retrieved from https://www.anl.gov/es/light-duty-electric-drive-vehicles-monthly-sales-updates.
[146] Tesla Model 3 Rear-Wheel Drive has an estimated range of 267 miles, Tesla Model Y Long Range has an estimated range of 318 miles. See Tesla Model 3 and Model Y at: https://www.tesla.com/model3/ and https://www.tesla.com/modely/.
[147] Opinion Dynamics (2022). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs: 2021 Annual Report*. Figure 14. Prompted Barriers Mentioned to Purchasing or Leasing an EV/PHEV, by Survey Wave and Segment. pp38. Filed May 19th, 2022 under OPUC Docket UM 1938. Retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf.
[148] Ibid. Figure 15. Unprompted Reported Changes Necessary to Consider EV or PHEV for Next Vehicle among Non-Considerers, by Survey Year. pp40.

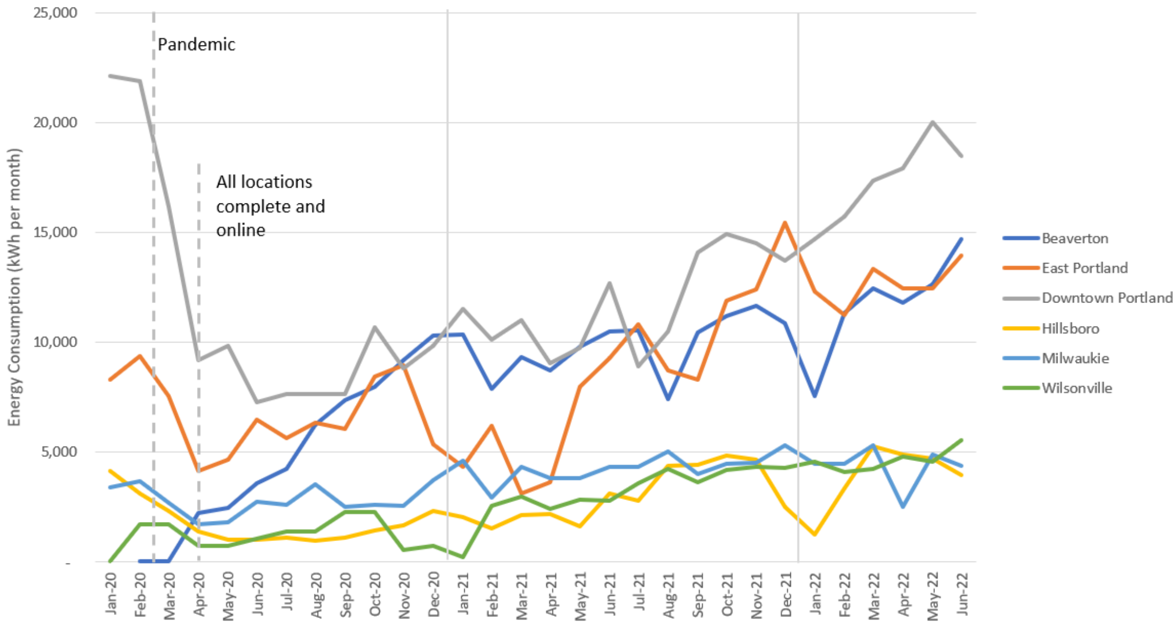

Chart 6. Effects of Pandemic on Electric Avenue Energy Usage

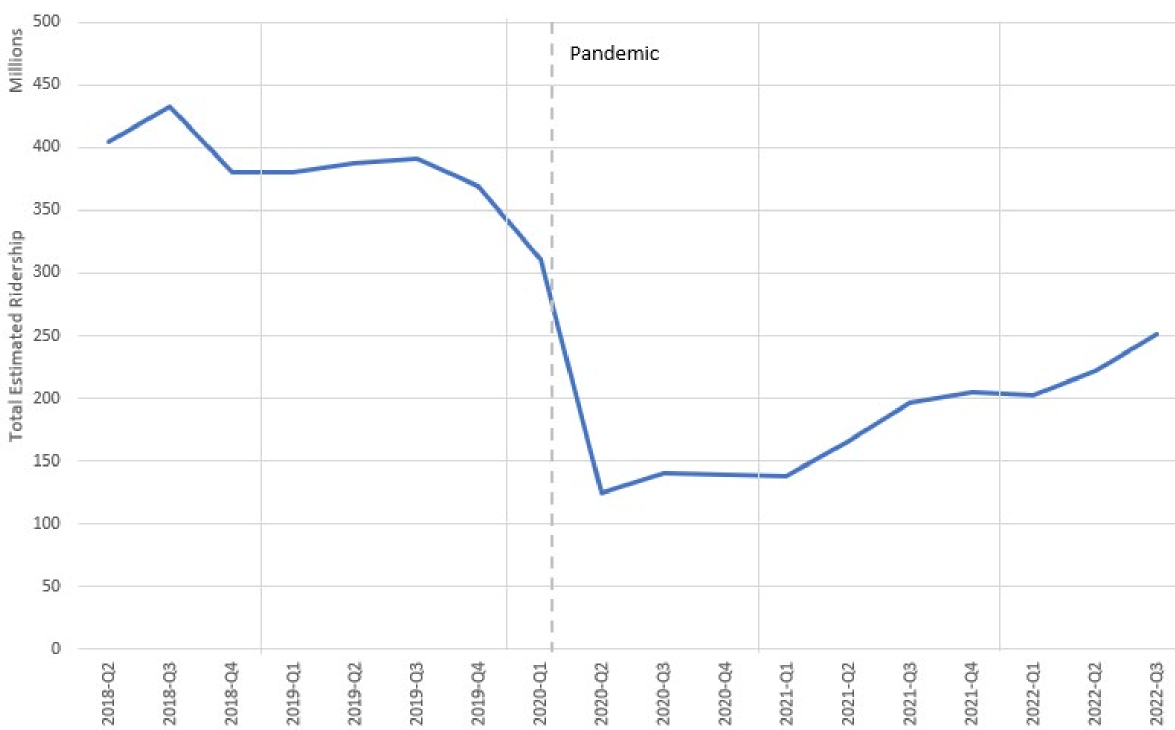

Chart 7. Effects of Pandemic on Pacific U.S. Transit Ridership[149]

[149] American Public Transport Association (October 6, 2022). *PTA Ridership Trends. American Public Transportation Association*. Retrieved from https://transitapp.com/APTA.

4.6.5.2 Supply Chain Challenges

In 2022, PGE observed significant increases in electrical equipment lead times for components like panels/switchboards, meter bases, and current-transformer enclosures. PGE has also observed longer than normal lead times for charging infrastructure (especially DC fast charging equipment). Supply chain challenges have generally complicated the shipping of products from overseas and the availability of products that utilize semiconductors[150],[151]. These factors are challenging the pace and scale of EV infrastructure deployment globally. PGE is adopting strategies in vendor engagement and project management within our TE programs to help overcome this barrier.

4.6.5.3 Charging Infrastructure Reliability

A number of publications have recently detailed the challenges faced by drivers who rely on public charging infrastructure.[152,153,154] PGE has observed and corroborated findings on charging infrastructure reliability issues with peer utilities and others and has developed a reliability strategy in response. In 2022, PGE established a maintenance team to service Electric Avenue chargers and partner with contractors to maintain PGE workplace chargers. That team is preparing for maintenance of pole chargers and anticipates the need to scale as PGE charger populations grow. The team has found that charger maintenance requires a skillset unique from other electrical work, which can impact the ability to staff this work. Learnings from the first year of team operations include challenges obtaining parts for legacy/first generation chargers, and also that reliability has improved with subsequent models. The team continues to address vandalism of chargers (e.g., graffiti on the units and damage to display screens) and theft of components (e.g., copper wire in charger cables).

4.7 Charging Station Availability, Reliability, and Usage

Understanding charging needs in PGE's service area begins with an assessment of current charging availability. This analysis informs our role in more fully developing the charging infrastructure that is needed both today and into the future.

Charging infrastructure in PGE's service area is insufficient to meet the needs of current EV drivers, let alone new EV drivers in the next several years. As illustrated in the following table, on a per-vehicle basis, EV charging availability has substantially worsened in PGE's service area since our last TE Plan (2019). As noted in Section 4.6.2.1, fueling infrastructure and availability remain one of the top barriers to potential EV drivers' adoption of an EV.

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[150] Jones (May 3, 2022). Reuters. *Snarled up Ports Point to Worsening Global Supply Chain Woes Report*. Retrieved from https://www.reuters.com/business/snarled-up-ports-point-worsening-global-supply-chain-woes-report-2022-05-03/

[151] Consumer Reports (June 2022). *Global Chip Shortage Makes it Tough to Buy Certain Cars*. Retrieved from https://www.consumerreports.org/buying-a-car/global-chip-shortage-makes-it-tough-to-buy-certain-cars-a8160576456/

[152] Wired (April 2022). *Broken Charging Stations Could be Stalling the EV Movement*. Retrieved from https://www.wired.com/story/ev-charger-broken-us-electric-cars/.

[153] Rempel, Cullen, Bryan, Cezar (April 7, 2022). *Reliability of Open Public Electric Vehicle Direct Current Fast Chargers*. Retrieved from https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4077554.

[154] Hogan (April 23, 2021). Road and Track. *EV Charging Infrastructure in America Still Sucks.* Retrieved from https://www.roadandtrack.com/news/a36175755/ev-charging-infrastructure-in-america-still-sucks/

Table 17. Publicly Available Charging Ports in PGE Service Area (as of April 2023)

	2019[155]		2023[156]			
Port Type	Installed and Planned Ports	Registered Vehicles per Port	Installed Non-Tesla Ports	Installed Tesla Ports	Total Ports	Registered Vehicles per Port[157]
L2	822	31	928	91	1,019	40
DCFC	157	162	113	74	187	216
Total	927	27	1,041	165	1,206	34

By contrast, ODOT's TEINA study suggests that in order to support the state's goal of 250,000 EVs by 2025, the state will need 11,494 workplace and public L2 ports and 4,411 public DCFC ports, ratios of 21 and 56 vehicles-per-port, respectively. EV charging has not materialized at a level that meets current and future EV driver needs.

4.7.1 Availability, Reliability, and Usage of Customer-Owned Electric Vehicle Chargers

As most chargers in PGE's service area are owned by PGE customers or third parties, PGE lacks insight into the reliability and usage of much of the charging infrastructure referenced above. To gain more insight, in the last couple years PGE has developed and launched TE programs such as Fleet Partner, Business EV Charging Rebates, and Residential Smart Charging which are beginning to provide data to help us better understand the local EV charging landscape. The proposed Business and Multi-family Make-ready Solutions activity which should provide additional learnings in this regard. PGE looks forward to sharing insights from this data in its next TE Plan Report.

4.7.2 Availability, Reliability, and Usage of PGE-Owned Electric Vehicle Chargers

PGE has gained valuable insights into the utilization patterns and performance of public, workplace, and transit heavy duty charging infrastructure via a decade of experience in equipment ownership and operation. The following sections detail insights PGE has gleaned from our work with the Electric Avenue Network and workplace, transit, and public pole charging infrastructure.

4.7.2.1 Utilization and Performance of PGE Electric Avenue Network

PGE built, owns, and operates a network of seven public charging locations with four 50 kilowatt (kW) DCFC ports and two 7 kW L2 ports per site (exception: Salem Electric Avenue has two 50 kW DCFC ports and two 7 kW L2 ports). Six of these sites were built as part of PGE's UM 1811 pilot (Electric Avenue Network Expansion).

Since commissioning the final location in April of 2020, PGE has observed the following network-wide trends:

[155] PGE (2019). PGE's 2019 Transportation Electrification Plan, pg. 33.
[156] *USDOE: Alternative Fuels Data Center*. See: https://afdc.energy.gov/. Accessed April 23, 2023
[157] Registered Vehicles per Port includes both Tesla and non-Tesla models.

- Year-over-year energy use increased across the network, with 2021 showing 41 percent more energy dispensed than 2020.[158] PGE dispensed approximately 487,695 kilowatt hour (kWh) in 2021, powering an estimated 1.5 million miles of electric travel.
- Utilization varied greatly by location, with the least utilized location (Hillsboro) providing just one quarter the energy of the highest utilized location (Downtown Portland) in 2021.

Customers were highly responsive to a peak time pricing signal of an additional $0.19/kWh from 3 PM to 8 PM on weekdays (PGE Schedule 50).[159]

Table 18. 2022 Electric Avenue Energy Output by Location (kWh)

Station ID	Q1	Q2	Q3	Q4	Total
Beaverton	31,349	39,143	37,961	42,828	**151,281**
East Portland	36,882	38,836	39,528	50,409	**165,655**
Downtown Portland	47,783	56,351	56,179	74,666	**234,979**
Hillsboro	9,887	13,546	15,865	24,640	**63,938**
Milwaukie	14,317	2,973	15,247	15,416	**47,953**
Wilsonville	12,938	14,940	19,794	23,421	**71,093**
Total	153,156	165,789	184,574	231,380	734,899

PGE faced the same reliability issues as many other network operators in the industry, with many units falling below PGE's uptime targets in 2020 and 2021. PGE took the following actions in response to these issues:

- Acted on approximately 180 maintenance tickets
- Established performance improvement plans and equipment refurbishment campaigns with vendors
- Received and installed warranty replacement units
- Held regular check-in meetings with vendors to address ongoing issues
- Increased equipment testing and inspection activities

[158] Note that some of this increase can likely be attributed to low utilization at the height of the COVID-19 pandemic (see Section 4.6.5 for more detail on the effects of COVID on TE activities).
[159] PGE (2021). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs 2021 Annual Report*, retrieved from https://edocs.puc.state.or.us/efdocs/HAD/um1938had165623.pdf, and also PGE (2020). *Evaluation of Portland General Electric's Transportation Electrification Pilot Programs 2020 Annual Report*, retrieved from https://edocs.puc.state.or.us/efdocs/HAQ/um1938haq14233.pdf.

These actions have improved network performance and resulted in improved customer scores on PlugShare[160]. Despite improvements from working with the vendor and replacing some faulty equipment, multiple sites have experienced intermittent downtimes for a variety of reasons. In a recent survey, Electric Avenue respondents stated concerns with charger reliability at six of the seven sites.

Uptime is one of the factors which PGE considers when assessing charger functionality and performance. To do this, we assess both the number of maintenance tickets and uptime reports.

PGE's calculated uptime excludes any time when a charger is not available to the customer due to the error codes received from the charger. PGE's downtime includes when there is a busy network signal, preventative maintenance, a charger has faulted, the charger is offline, or we have received other unknown error codes from the charger. PGE will work with our charging vendors in the coming months to bring our uptime reports in line with those of other regional utilities.

Electric Avenue uptime by site location (2022):

- Beaverton Electric Avenue = 73.3%
- Eastport Plaza Electric Avenue = 80.0%
- Hillsboro Electric Avenue = 80.0%
- Milwaukie Electric Avenue = 91.8%
- Wilsonville Electric Avenue = 88.2%
- Downtown Portland Electric Avenue = 78.9%

Not all of PGE's workplace (non-public) chargers have software which allows for the tracking of uptime. Those PGE workplace chargers for which tracking of uptime *is* available have an 85.5% uptime.

Some of those Electric Avenue chargers which ran intermittently during 2022 are no longer working and available in 2023. PGE has replaced several chargers through warranty replacement and worked with the vendor on solutions to fix their first generation charging infrastructure. To further improve reliability as Electric Avenue utilization continues to increase, PGE will need to replace the chargers with updated technology that meets customers' needs. PGE is exploring whether chargers can be replaced as part of the Clean Fuels Public Charging Infrastructure project.

4.7.2.2 Utilization and Performance of PGE Workplace Charging Infrastructure

PGE built, owns, and operates approximately 108 Level 2 workplace charging ports across 20 PGE locations. Ports typically offer approximately 7 kW of output and were installed incrementally over the past decade as charging technology evolved and employee and fleet use of EVs increased. PGE has observed the following trends:

- Workplace charging was dramatically impacted by changes in work from home patterns, with a steep decrease in utilization seen in April of 2020
- Workplace charging infrastructure was generally reliable and required significantly less effort to maintain than DCFC public charging infrastructure, with only 69 tickets created since PGE began tracking in 2021.

[160] Electric Avenue's average PlugShare score has improved from 7.5 to 8.8 of a maximum score of 10 over the period for which PGE has collected data (April 2021 to October 2022).

4.7.2.3 Utilization and Performance of PGE Transit Charging Infrastructure

PGE owns and operates three electric transit bus charging systems on behalf of the Tri-County Metropolitan Transit Authority (TriMet). One such system is located at Sunset Transit Center and serves as an on-route pantograph (overhead) charger, recharging buses at rates up to 450 kW as they complete each service loop. The remaining two charging systems are located at TriMet's Merlo Garage and charge buses overnight at rates up to 150 kW. PGE has observed the following trends:

- On-route charging infrastructure was highly utilized and, based on the design and structure of the electric buses and charging routines, provided most energy required to serve the electrified bus route.
- Overnight charging was lightly utilized, as bus battery and charging technology was optimized for on-route charging. Future bus deployments may rely more on overnight charging as bus battery sizes increase and the need for on-route charging decreases.
- On-route charging infrastructure was generally reliable, while overnight charging systems suffered reliability issues. Sustained work with charging vendors helped improve performance.

"Early production" electric buses also suffered from reliability issues, decreasing utilization of both on-route and overnight charging infrastructure. Subsequent servicing has increased bus reliability. Future bus deployments are expected to improve reliability further.

As Tri-Met considers future electrification options, PGE can use the charging patterns from both the short-range and long-range buses to help plan for grid needs, rates, tariffs, and managed program effectiveness. As future rates, tariffs, and managed charging programs are created, PGE will use lessons learned from the pilot (i.e., ability to charge during off-peak hours due to battery size and routes of buses) to determine ability to manage the load since short-range buses have less flexibility in charging during off-peak timeframes.

Table 19. 2022 Transit Energy Output by Location (kWh)[161]

Station ID	2022 Q1	2022 Q2	2022 Q3	2022 Q4	2022 Total
Sunset TC (450 kW on-route)	6,896	66,341	47,334	32,596	153,167
Merlo Garage 1 (150 kW depot)	1,621	5,420	11,258	20,776	39,075
Merlo Garage 2 (150 kW depot)	1,904	19,344	20,474	23,278	65,000
Total	10,421	91,105	79,066	76,650	257,242

4.7.2.4 Utilization and Performance of PGE Public Pole Charging Infrastructure

PGE owns and operates two Level 2 charging ports installed on utility poles in the City of Portland. Each port is capable of approximately 7 kW of output. PGE observed that pole charging utilization increased 83 percent from 2021 to 2022. Pole chargers also had higher utilization than other PGE-

[161] Bus performance has had a large impact on variations in energy use across quarters.

owned Level 2 chargers at Electric Avenue locations.[162] The high utilization of these chargers and the relatively low cost to install them (in comparison to the more common pedestal chargers) illustrates that pole charging is a cost-efficient way for PGE to deploy level 2 charging infrastructure. PGE believes that deploying Level 2 pole charging is even more effective in underserved areas, where public charging infrastructure and private off-street parking may be lacking. Deployment of pole chargers in those areas may help underserved communities enjoy the myriad of benefits of owning an EV, including but not limited to charging close to their residence.

Table 20. 2022 Pole Charging Energy Output by Location (kWh)

Station ID	Q1	Q2	Q3	Q4	Total
SE 29th Ave	4,893	5,633	4,605	4,820	**19,951**
SE 35th Place	5,242	1,975	307	2,916	**10,440**
Total	10,135	7,608	4,912	7,736	30,391

4.8 Coordination

4.8.1 Federal Funding

As referenced in the Federal Actions Section 3.4.1.2, the IIJA and the IRA provide multiple sources of federal funding to support the transition to electric transportation. PGE has created an internal team to track these various federal grant partnership opportunities. Outside entities are also working with our partners on grant applications requiring PGE support to assess areas where potential charging infrastructure may be located, were the grant approved. PGE provides input on distribution system impacts and also tracks these potential future infrastructure sites to help inform grid planning.

PGE worked with the Portland Bureau of Transportation (PBOT) and multiple other parties on a recently-awarded USDOE grant which would support our Public Charging – Municipal Charging Collaboration and testing out permitting processes for right-of-way (ROW) charging. This year, PGE has been collaborating with Forth and a group of cities we serve to support a Charging and Fueling Infrastructure grant application for the 2023 funding opportunity.[163]

[162] Shrestha (PGE) *Pole-Mounted EV Charger Whitepaper*. November 2020, retrieved from https://edocs.puc.state.or.us/efdocs/UAA/adv1081uaa17201.pdf) surmised that the relatively higher utilization rate of pole chargers might be due to the fact that pole charging was provided free-of-charge. However, utilization has continued to outperform Electric Avenue even after PGE began charging for it in October 2021. While a formal evaluation has not yet been performed, preliminary analysis indicates that customer preference for residential locations may be driving higher pole charger utilization.

[163] Charging and Fueling Infrastructure Grant The U.S. Department of Transportation (DOT) Federal Highway Administration (FHWA) Charging and Fueling Infrastructure Discretionary Grant Program (CFI Program) offers funding to deploy publicly accessible electric vehicle charging and alternative fueling infrastructure in urban and rural communities and along Alternative Fuel Corridors (AFC). The CFI Program offers two types of funding opportunities: the Community Charging and Fueling Grants (Community Program) and the Alternative Fuel Corridor Grants (Corridor Program).

Most federal funding grants require a public entity to be the primary applicant on a grant application. Multiple cities have expressed to PGE that they are interested in applying on grants for electric transportation infrastructure but have neither the bandwidth nor staff, or are not aware of all the opportunities. PGE was approved to use grant coordination funds through the 2023 Monthly Meter Charge budget filing.[164]

PGE also partners with other utilities and public partners on activities beyond grant opportunities. Since the release of the West Coast Clean Transit Corridor report[165], PGE has worked with other utilities to identify the need and placement of heavy-duty charging along the I-5 corridor. We have also worked with ODOT to inform its program design for its recently-announced Community Charging Rebates Program, and provided information about cost of installation for DCFC chargers to be installed through the NEVI formula program. PGE has also worked with the Oregon DEQ to inform their planning, program development, and deployment of grant funds to support medium and heavy duty EV charging infrastructure. We have also engaged with the Portland Clean Energy Fund Community Benefits Fund[166] as they draft their Climate Investment Plan.

PGE will continue to seek external grant opportunities to maximize funding for deployment of the TE Portfolio. PGE expects these federal and state funding sources will help drive transportation electrification in our service area and create opportunities for PGE to partner with customers on grant opportunities to gain external funding support for TE.

4.8.2 Northwest Energy Efficiency Alliance and Energy Trust of Oregon

Regional partnerships are key to promoting beneficial electrification and enabling flexible load. Building electrification and transportation electrification are beneficial if they result in cost savings for customers, enable better grid management, and reduce negative environmental impacts. Decades of investment in energy efficiency via customer funded Energy Trust of Oregon programs and Northwest Energy Efficiency Alliance (NEEA) market transformation efforts, have served to demonstrate these benefits. According to the American Council for an Energy Efficient Economy's (ACEEE) 2022 State Energy Efficiency Scorecard, Oregon remains a "national leader in energy efficiency through strong transportation policies, newly adopted appliance standards, and a greater focus on energy equity through utilities and state government processes." [167]

Infrastructure deployments funded by the Community Program must be located on public roads or publicly accessible locations, including public parking facilities, public buildings, public schools, or public parks. Low-income, underserved, rural, and high-density communities will be prioritized for Community Program funding. Corridor Program grants are available to infrastructure deployments along designated AFCs. Eligible applicants include metropolitan planning organizations; U.S. territories; special purpose districts and public authorities; and state, local, and tribal governments.
Retrieved from https://afdc.energy.gov/laws/12732

[164] PGE. *Proposed Monthly Meter Charge Budget for 2023*. Retrieved from https://apps.puc.state.or.us/edockets/edocs.asp?FileType=HAH&FileName=um2033hah162334.pdf&DocketID=22127&numSequence=54.

[165] West Coast Clean Transit Corridor Initiative (June 2020). *Interstate 5 Corridor California, Oregon, Washington Final Report*. Retrieved from https://westcoastcleantransit.com/resources/Final%20Report%20Files.zip.

[166] Portland Clean Energy Community Benefits Fund: https://www.portland.gov/bps/cleanenergy.

[167] ACEEE. *Oregon EE Scorecard (2022)*. Retrieved from https://www.aceee.org/sites/default/files/pdfs/State_Scorecard/2022/one-pagers/Oregon.pdf

PGE continues to expand the scope of partnership with Energy Trust of Oregon to promote energy efficiency as a least cost/least risk resource and further enable flexible loads like electric vehicles. In addition to drawing inspiration from, and aligning to, Energy Trust's EV-ready electrical and charger installation requirements[168] and their Energy Performance Score (EPS) New Construction Net Zero and Energy Smart Home Incentives[169], which include an EV-ready rebate, PGE also has sought to leverage Energy Trust's trade ally network for its electric panel upgrades and associated rebates.[170] PGE seeks to build upon this partnership to deliver additional enabling technologies to further its decarbonization and electrification goals. Additionally, PGE sees an opportunity for EVs to provide locational peak relief and equity benefits within grid constrained areas, such as in the design and deployment of non-wires solutions (NWS) with Energy Trust.

Historically, PGE customer funding for NEEA flows through Energy Trust of Oregon. This partnership, though indirect, has given rise to permanent market changes that drive energy efficiency in the region. In addition to funding provided to core projects, PGE advocated for expansion of NEEA's scope, and plans to fund a special project that will serve to demonstrate the resource adequacy and customer value of flexible load management in the Pacific Northwest. Accelerating technology advancement in sensors, controls, and communications is lowering their cost, increasing their efficiency, and creating new opportunities for load flexibility. These technologies are being integrated into end-use devices and buildings so they can be activated to support flexible grid needs. They can also support the ability to aggregate and control a multitude of smaller end-use loads, creating significant capacity resources. While providers of generation-based flexible resources face growing challenges, flexible demand resources are relatively untapped in the Northwest. They can enable low-cost energy storage in electric water heaters (thermal storage) and EVs, signal smart thermostats to heat and cool off-peak (or work on the edges), and provide sub-hourly pricing information to consumers. There is a role for NEEA to play as both convener/developer of Northwest use cases and in employing its existing Emerging Technology scanning processes to identify appropriate products, solutions, and potential interventions, such as EV flex communications and operations such as vehicle-to-building or vehicle-to-grid.

4.8.3 Related Plans

4.8.3.1 Distribution System Plan

PGE's Distribution System Plan (DSP) provides a more granular look at the forecast of electric vehicle adoption and the effects of TE load on the distribution system. In our DSP Part II filing we highlighted our methodology for allocating EV forecasts to the individual feeder level and provided projected TE load by substation through 2030.[171] The forecast vintage that fed into the DSP Part II filing has been

[168] Energy Trust. *EV-Ready Residential Construction Recommendation* (2022). Retrieved from https://insider.energytrust.org/wp-content/uploads/EPS-EV-Ready-Installation-Requirements_2022-2.pdf.
[169] Energy Trust. *Net Zero and EHS Requirements Guide* (2021). Retrieved from https://insider.energytrust.org/wp-content/uploads/Net-Zero-and-EHS-Requirements-Guide.pdf#:~:text=The%20home%20must%20meet%20Energy%20Trust%20Electric%20Vehicle,Product%20List%20installed%20at%20the%20time%20of%20construction.
[170] PGE. *Charging Your EV at Home*. Retrieved from https://portlandgeneral.com/energy-choices/electric-vehicles-charging/charging-your-ev/charging-your-ev-at-home.
[171] PGE (2022). *DSP Part II: Section 3.5 and Appendix M*. Retrieved from https://portlandgeneral.com/about/who-we-are/resource-planning/distribution-system-planning/dsp-resources-materials.

incorporated into our 2024 Transmission and Distribution (T&D) capital planning process. This means that PGE is now developing future grid investments with consideration of forecasted TE load growth on a locational basis.

In Chapter 3 of the DSP Part II, we provided an overview of the annual load allocation process conducted by PGE's Distribution Planning engineers. This annual planning process provides an opportunity to assess changes to demand patterns on a regular basis (e.g., new service requests or planned customer expansions) that will include updates to our TE forecast going forward. In line with that cadence, we have updated our AdopDER model (discussed in Sections 4.3 and 4.4) in April 2023 to inform the 2025 T&D capital planning process. Figure 12 shows a high-level process flow of how the AdopDER forecast flows into DSP and annual capital planning processes:

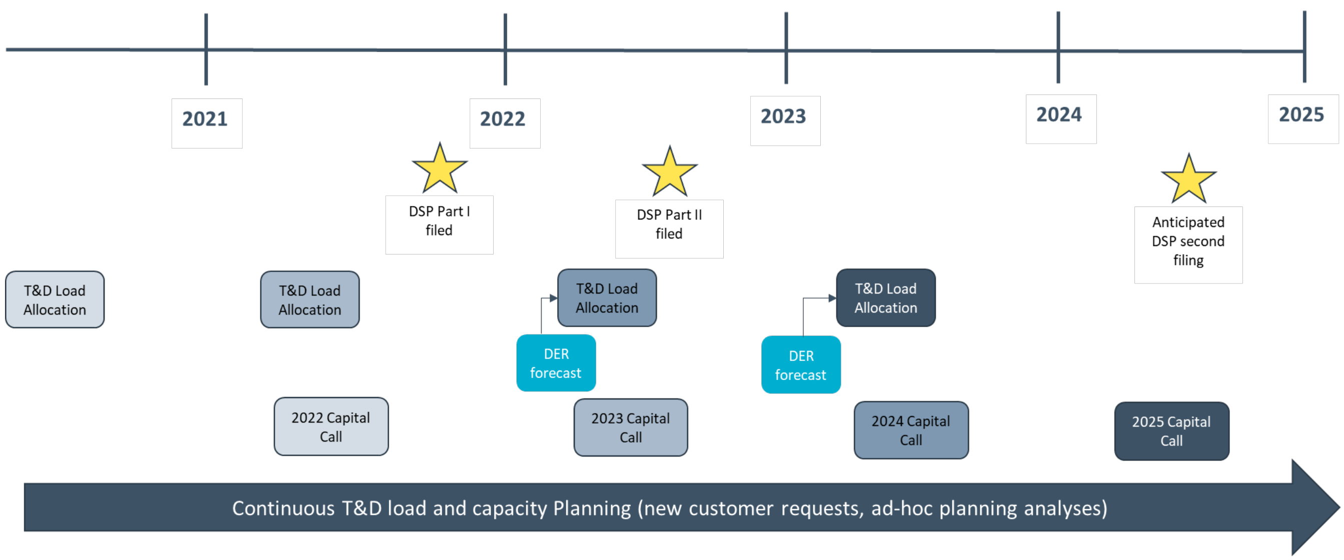

Figure 12. DSP Timeline with Overlay of DER Forecast and Annual T&D Capital Planning Cycles

We discussed in Sections 4.3 and 4.4 how the improvements we are making to our TE forecasting will continue to increase the granularity with which we can anticipate and plan for localized TE growth. For example, we will continue to work with telematics vendors and research partners like EPRI to identify areas of high medium- and heavy- duty vehicle traffic and what the anticipated loads will look like for the distribution grid. In addition to better telematics data and associated understanding of vehicle dwell locations on the grid, PGE is also engaging with EPRI and other utilities to complete a "Wide-Area Distribution Assessment" study that has the following high-level outcomes:

- Assessing electrification opportunity across PGE's service area
- Identifying under-utilized assets to incentivize fleet electrification
- Identifying high-priority feeders for grid-strengthening measures
- Helping prioritize infrastructure investment to proactively anticipate fleet electrification

Key among the research tasks with EPRI is to conduct more granular and extensive hypothetical load modeling of different HDV charging profiles under different managed and un-managed scenarios that will inform future model updates.

Staff also highlighted in their DSP memo[172] an interest in more analysis and discussion around the sensitivity of proposed grid investments to different levels of EV adoption. In our current 2025 T&D capital planning, PGE will evaluate grid needs utilizing both a reference and a high EV adoption scenario. We will present results of this analysis to Staff and stakeholders through our DSP Learning Labs to help inform solution identification, and will include a more robust discussion of EV-related distribution investments in our next DSP filing.

The TE forecast produced in Q2 2023 is utilized for the 2025 capital planning cycle (2024 planning cycle concludes in Q2 2023). This forecast is combined with the full AdopDER output (spanning LDV, MDV, and HDV growth at the feeder-level), as well as known load additions outside of EVs (e.g., large customer additions), to produce a comprehensive load forecast to utilize in distribution planning studies.[173]

4.8.3.2 Integrated Resource Plan/Clean Energy Plan

How TE was modeled in the IRP

The 2023 IRP evaluates three need futures to determine a wide range of resource needs. As shown in the following figure, each need future is the aggregate impact of load growth, distributed energy resources (DERs), and market access assumptions. The DER impact includes PGE's assumptions for:

- Transportation electrification, which increase resource needs, and
- TE-related demand response programs such as managed charging and time of use rates, which decrease resources needs

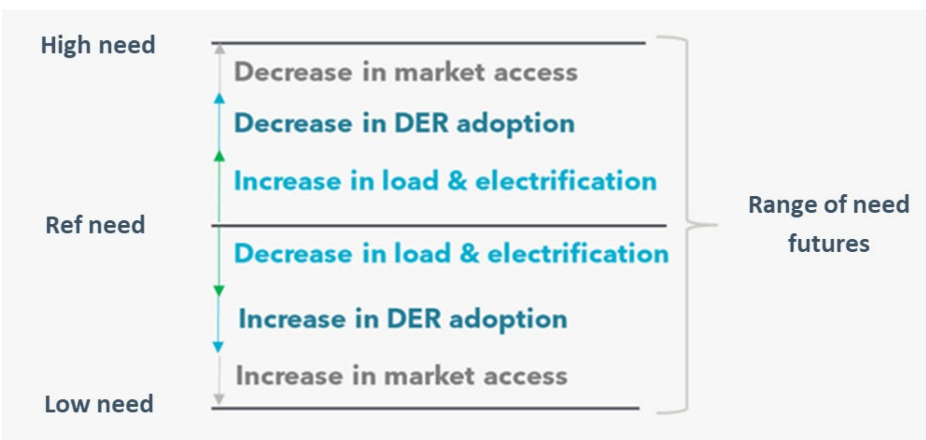

Figure 13. Visualizing the Need Futures

[172] OPUC. Docket 2197, Order 23-069. Retrieved from https://apps.puc.state.or.us/edockets/docket.asp?DocketID=23043.
[173] These studies will follow the DSP process and include community engagement and NWS evaluation. Separately, a high level, statistical analysis will be performed to determine when feeders and transformers may exceed their limits based on the load forecast. From there, conceptual mitigations and project costs will be developed with the intention to include this information in a mid-cycle update for the TE Plan. In order to ensure that infrastructure is ready for the TE growth, regulatory changes may be required to build infrastructure based on the forecast, without a committed customer or TE installation.

PGE's IRP leverages the analytical work within PGE's DSP Part 2 to determine the energy demand impacts of TE. The expected impact is illustrated in Figure 14.[174]

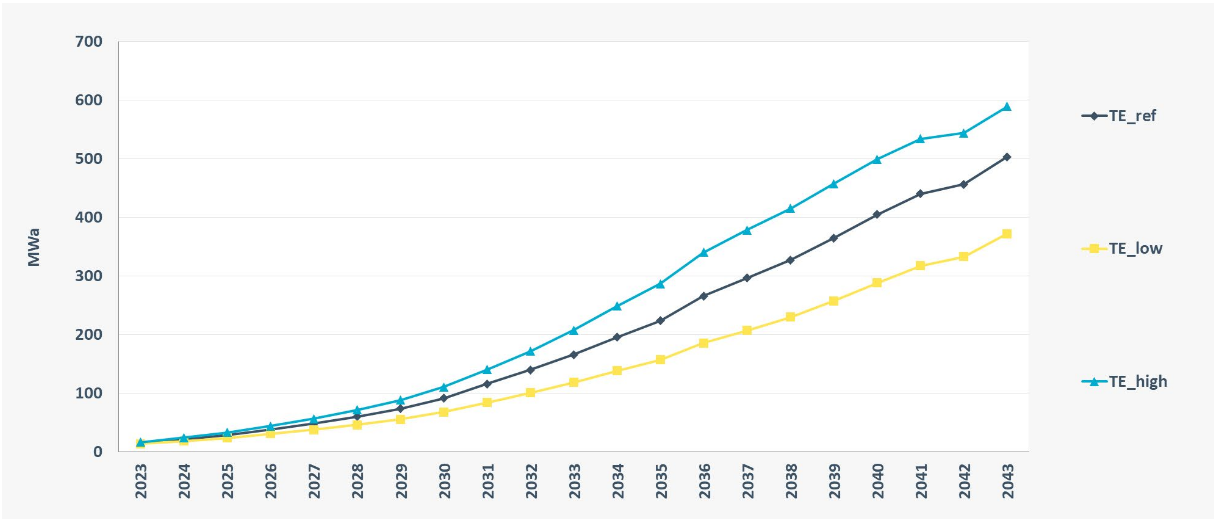

Figure 14. MWa Impact of Transportation Electrification Over the Planning Horizon

In addition to capturing this within the IRP need futures, PGE also performed a need sensitivity to capture the potential impacts of the Advanced Clean Cars II policy in addition to Climate Protection Program[175] for both accelerated MDHDV electrification and additional building electrification. This sensitivity only looks at the change in resource need. It does not include additional energy efficiency and demand response opportunities that will result from this increase in electrification. Additional details are available in the IRP.[176]

4.8.3.3 PGE's Flexible Load Multi-Year Plan

PGE Flexible Load Multi-Year Plan (MYP) is informed by the DSP and the resource acquisition goals set in the IRP and CEP. The MYP reviews these materials to determine what activity the PGE Program Team will undertake to acquire flexible load. Flexible load is an important component of managing TE load. The PGE TE and Programs teams are working cross functionally to develop activities which inform how best to manage TE load. This work includes the Smart Grid Testbed activities.

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[174] Additional detail on Need Futures available in PGE (2023). *Clean Energy Plan and Integrated Resource Plan 2023*. pp74. Retrieved from https://edocs.puc.state.or.us/efdocs/HAA/lc80haa8431.pdf#page=174
[175] Oregon DEQ. *Climate Protection Program*. Retrieved from: https://www.oregon.gov/deq/ghgp/cpp/pages/default.aspx.
[176] Accelerated load growth sensitivity is available PGE (2023). *Clean Energy Plan and Integrated Resource Plan 2023*. pp135. Retrieved from https://edocs.puc.state.or.us/efdocs/HAA/lc80haa8431.pdf#page=135