Portland General Electric Company
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portlandgeneral.com

May 31, 2023

Via Electronic Filing

Public Utility Commission of Oregon
Attention: Filing Center
P.O. Box 1088
Salem, OR 97308-1088

Re: UM 1938 Evaluation of PGE's Transportation Electrification Pilot

Dear Filing Center,

In accordance with PGE's Transportation Electrification (TE) Plan approved by Commission Order No. 18-054 in Docket No. UM 1811 and the TE Pilots Deferral in Docket No. UM 1938, enclosed is the 2022 evaluation of Portland General Electric Company's (PGE's) TE pilots: Electric Mass Transit (TriMet), Electric Avenue (EA), and Outreach & Education. This evaluation addresses the required learnings agreed to by parties in Docket No. UM 1811 and approved in Order 18-124. The UM 1938 Pilot Deferral also includes cost detail regarding the evaluation.

The Evaluation

PGE contracted with a third-party evaluator, Opinion Dynamics or ODC, to track progress towards pilot goals; document implementation successes, challenges, and key learnings; and offer recommendations for continuing implementation. ODC's 2022 evaluation report is enclosed.

This is the fourth of five evaluation reports that will be produced, and the report appendix lists evaluation activities planned from 2023 through 2024.

Some of the key findings from ODC's 2022 evaluation include:

Outreach & Education:

- Impact of business technical assistance: Multiple survey waves with business technical assistance recipients show PGE's business charging and fleet electrification technical assistance was successful in helping customers to electrify and has been moderately influential in recipient's decision-making processes. Nearly two-thirds (60%) of technical assistance recipients who had onsite parking installed charging equipment and about half (46%) of recipients with fleet vehicles had electrified at least a portion of their fleet after interacting with PGE. About two-thirds of recipients who had installed charging (64%) or electrified fleet vehicles (60%) reported the assistance they received from PGE was at least moderately influential in their decision-making. Further, nearly one-quarter (22%) of surveyed technical assistance recipients indicated that their consultation increased their

organizations' likelihood of purchasing or leasing EVs a great deal and about half (48%) indicated that their organization is very likely to purchase or lease an EV in the next three years (after responding to the evaluation survey).

- Future commercial charging opportunities: Most (88%) business charging technical assistance recipients who had not installed chargers were still considering installing charging in the future, with about half (47%) reporting they were very likely to install charging within the next three years (after taking the survey). Respondents were more concerned about the cost of site upgrades than the cost of the chargers themselves.

- Increasing customer exposure to EVs: Providing customers with opportunities to personally experience EVs is critical to increasing customer familiarity. Ride-and-drives are effective venues for increasing interest, familiarity, and understanding of both EVs, charging technologies, and utility TE offerings. PGE's 2022 ride-and-drive event was attended by over 250 people, highlighting customer interest in such events. Surveyed event attendees reported high satisfaction with the event. Further, most (76%) surveyed attendees indicated that the event had increased their likelihood to buy or lease an EV in the future.

Electric Avenue:

- Marketing of PGE's EAs: General users of PGE's EA sites and Transportation Network Company (TNC) drivers like Lyft and Uber who use EA sites mostly learn about PGE's EA sites from driving by, word of mouth, or from wayfinding apps. Fewer than one-fifth (13%) of surveyed EA users and only one of eight TNC focus group participants recalled learning about PGE's EAs from PGE marketing. Further, interviews with multifamily building owners in 2021 also revealed limited awareness of PGE's EA sites among multifamily owners, managers, and tenants.

- Growth in EV charging load: EA charging load has fluctuated throughout the pilot. The report shows the fluctuations in charging prior to 2022 due to new sites coming up, the impacts of the COVID-19 pandemic, and issues at downtown EA stations necessitating replacement of the chargers in the summer of 2021. Between January 2021 and October 2022, overall charging load from the EA system increased at a rate of approximately 6.3% per month and delivered 79 MWh in October 2022. During the same time, the number of non-subscriber customers increased by 324% and the number of subscriber customers increased by 137%.

- Increase in utilization: The EA network has experienced increasing utilization. From April 2019 to October 2020, the average monthly load factor across all sites was 13% while the average monthly load factor was 19% in 2022. The average number of charging sessions per day has also increased over time. Despite the increase in utilization, at all sites except Downtown Portland, more than three chargers were in simultaneous use at a station less than 2% of the time over the study period, suggesting that chargers are generally available for customers to use and there is little congestion in the network.

- Charger availability and expansion opportunities: Surveyed EA users would like more chargers at the Downtown Portland and Beaverton EA sites, which are among the highest utilized sites in the network. TNC focus group participants often charge at these locations and would like more fast-charging equipment to increase user turnover. Surveyed EA users also had lower levels of satisfaction with the Downtown Portland EA due to availability of

open chargers and charger reliability. TNC EA users desire additional charging sites due to increased EV adoption, especially in the Tigard and Lake Oswego areas.

- Pricing structure and system peak impact: Analysis of EA charging data shows charging load is not highly coincident with PGE's system peak and that the peak pricing component is highly effective in shifting charging away from system peak load periods. Surveys of EA users show that most (71%) of EA users are charging outside of the peak hours (3:00 p.m. to 8:00 p.m.) and nearly two-thirds (60%) report being aware of the $0.19/kWh peak surcharge. The EA stations also do not contribute significantly to distribution system peak loads. The charging capacity of the stations is about 1-2% of the total capacity of feeders serving EA stations and charging load has low coincidence with peak load of feeders.
- Preferred payment options: EA users are generally satisfied with the EA pricing structure and the payment process, with three-quarters (75%) of surveyed EA users being very satisfied with both the cost of EA charging and the payment process. Surveyed EA users prefer having a mix of payment options, including paying an hourly flat rate, a monthly subscription, and paying per kWh (not currently offered). About two-thirds of EA users who are PGE customers would like to pay for EA charging on their home electric bill.
- Misuse of EA sites: TNC focus group participants reported issues at the Downtown Portland EA site, including EV drivers parking vehicles in charging stations without charging, vehicles left to charge overnight, and non-electric delivery vehicles blocking the station. The Downton EA site was also reported as being one of the most heavily used by both general EA users and TNC users.
- Improving customer experience at EAs: Nearly all (90%) of surveyed EA users mentioned they would like to see improvements made to PGE's EA sites. Most suggested improving charging reliability, and other suggested changes included the ability to reserve a charger (26%) and shelters from the elements (20%). TNC focus group participants noted that amenities similar to those provided at gas stations, such as trash cans, bathrooms, and vending machines, would improve their charging experience. Sheltered charging stations would prevent their cars from overheating while charging on hot days.

Electric Mass Transit:

- Technical issues with buses and chargers: The short-range New Flyer buses running on Line 62 were halted at several points during the study period due to technical issues. Issues with the en route charger at Sunset Transit Center persisted throughout the study period.
- System peak impact: Bus charging load does not currently contribute significantly to PGE's system peak or distribution system. A large portion of bus charging occurs during the peak period in the tariff applicable to TriMet due to its broad peak period, Monday through Saturday, 6 a.m. to 10 p.m., and the use of en route charging. While average charging load is low during PGE system peak hours, en route bus charging is likely to occur during the highest load hours. Neither the Sunset Transit Center nor the Merlo Garage feeders are at risk of overloading despite the use of high-powered chargers. TriMet and PGE staff report there are limited opportunities to use rates to influence bus charging

behavior, as the ability to shift bus charging is constrained by the limited capacity of the buses' batteries and the route configuration. Bus charging at Merlo Garage is also influenced by staffing considerations, as daily bus operations and maintenance require appropriately trained staff.

- Long-range buses: Opinion Dynamics compared the charging load patterns of Gillig long-range buses that were procured by TriMet outside of the pilot to those of the short-range New Flyer buses in the pilot. The long-range buses do significantly less charging during system peak hours as they do not rely upon en route charging during daytime or peak period hours. The long-range buses have a higher non-coincident peak load at Merlo Garage than the short-range pilot buses, as the long-range buses mostly charge during early morning hours before going into service. Based on current load patterns, expanding the number of chargers could lead to high distribution system upgrade costs.

Following are ODC's recommendations to PGE, and PGE's response:

Pilot Area	**ODC Recommendation**	**Actions**
Outreach and Education	Results from the business technical assistance surveys highlight the importance of transportation electrification (TE) technical assistance for PGE's commercial customers. PGE should continue to support commercial customers in TE, as it is currently doing through the Fleet Partner and Business EV Charging Rebates Pilots.	PGE will continue to offer technical assistance through make-ready programs as well as support commercial customers applying for business EV rebates. PGE will continue to look for ways to support customers through self-accessible digital venues for frequently asked questions.
	In addition to financial assistance provided through the Business EV Charging Rebates Pilot, consider providing commercial customers, including multifamily building owners, additional options for installing charging infrastructure. For example, PGE could consider providing customers with a utility-owned turnkey option, where make-ready and charging equipment is provided by PGE, with minimal operational costs to customers. PGE could also consider partnering with a third-party charging as a service (CaaS) provider to offer customers a full-service charging option. Offering additional options for installing charging could be particularly impactful for current and	An additional Business and Multi-Family make ready program was requested through a 2023 Monthly Meter Charge Budget filing, approved by the PUC in April 2023. PGE will take learnings from this pilot to determine future offerings and rate structures.

	future EV owners who live in multifamily properties and for commercial customers located in environmental justice communities.	
	Continue to provide opportunities for customers to experience EVs and learn about charging technologies and PGE's TE offerings. Ride-and-drive events can be an effective venue and should include the newer popular EV models to generate increased interest and attendance. PGE may also consider revamping the dealership referral program in the Residential EV Smart Charging Pilot.	PGE will expand the number of ride-and-drive events in 2023 through the Clean Fuels Outreach and Education funding. PGE is also exploring changes that can be made to the dealership referral and training program.
Electric Avenue	Consider expanding direct marketing to PGE customers to increase awareness and utilization of EA sites. PGE could consider partnering with TNCs and on-demand delivery companies, dealerships, and multifamily properties near EA sites to help increase EA awareness.	PGE will focus on improving up-time at under-performing EA sites and then will work on marketing efforts to increase awareness for TNC and multifamily properties.
	Continue to monitor the growth of charging load at EA stations for increasing utilization or decline in charging load due to equipment issues.	PGE will continue to monitor the growth in charging utilization as well as work on improving up-time at EA sites.
	Continue to monitor utilization of EA stations for continued growth and the potential for congestion to develop in the network.	PGE will continue to monitor charging growth and may be limited in expansion due to spending limits of the EA pilot. PGE will explore partnerships in ownership to potentially support future expansion needs, as well as explore charging rate changes such as idle fees to support reducing congestion in the near term.
	Increase the number of charging ports at highly utilized EA sites to accommodate the increasing number of EV drivers. Consider additional EA sites in PGE's service territory where there are currently gaps in public fast charging.	PGE will continue to monitor charging growth and may be limited in expansion due to spending limits of the EA pilot. PGE will explore partnerships in ownership to potentially support future expansion

		needs, as well as explore charging rate changes such as idle fees to support reducing congestion in the near term.
	Consider providing outreach to EA users informing them that they can use apps such as PlugShare and Shell Recharge to report issues at EA sites. Outreach could include emails to EA users and additional signage at EA sites. Continue to have staff monitor and address user-reported issues as they occur.	PGE will continue to assess outreach and issue reporting changes if there is a decrease in reports provided through those venues.
	Continue to implement the peak pricing component and monitor utilization as usage of the EA sites increases to determine system impacts.	PGE plans on continuing the peak pricing component to support decreased usage during peak energy hours.
	Continue to provide customers with a mix of pricing options, and potentially offer an additional option to pay per kWh. Consider providing a payment option for PGE customers to pay for their EA charging on their home electric bill.	PGE is evaluating potential changes to Schedule 50 which could include transitioning to a per kwh pricing structure to better align with the market and support the variety of EVs and battery ranges.
	Increase enforcement for illegal parking in EV spaces and EVs parking in charging spaces without charging, especially at the Downtown Portland EA.	Each city is responsible for monitoring the parking enforcement at the various EA sites and PGE will continue to work with them on enforcement.
	Consider implementing charger idling fees similar to private charging companies to prevent drivers from leaving their vehicles connected to chargers for extended periods of time.	For Schedule 50 changes, PGE is also evaluating the option for idle fees to support EV drivers moving their cars more timely, once charging is complete.
	Consider designing future EA sites with overhead shelters and provide amenities similar to those offered at gas stations, or co-locate new chargers near shopping centers, restaurants, and public bathrooms.	PGE will keep this feedback in mind if future site expansions occur.
TriMet	Continue to monitor the evolution of the electric mass transit bus market and related charging solutions to better	PGE will continue to monitor the evolution of the electric mass transit bus market and

	support reliable operations for transit and other customers with heavy-duty EVs.	related solutions to support communities' transition to electric as needed.
	Continue to monitor usage to confirm that there is not a negative peak impact once all buses on Line 62 have been in operation over a longer period of time. Conduct additional research to understand if there is flexibility to leverage rates to influence charging behavior with the adoption of longer-range buses that are less reliant on en route charging. Both the monitoring and additional research can be used to inform future expansion of electric buses at TriMet as well as future investment in medium- and heavy-duty EVs and associated infrastructure.	PGE will continue to monitor impacts of charging as electric buses continue to expand to support customers and grid planning for future load.
	Work with TriMet to manage bus charging to reduce peak charging load as TriMet continues to expand its electric bus network with long-range buses.	PGE will continue to evaluate bus impacts to peak charging load and work with customers on charging solutions to minimize peak charging load as the technology can support.

If you have any questions or require further information, please contact Jaki Ferchland at 503-464-7488. Please direct all formal correspondence and requests to the following e-mail address pge.opuc.filings@pgn.com.

Sincerely,

/s/ Robert Macfarlane
Manager, Pricing and Tariffs

Enclosure

cc: UM 1811 and UM 1938 Service Lists and Eric Shierman, OPUC Staff

Opinion Dynamics

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Evaluation of Portland General Electric's Transportation Electrification Pilot Programs

2022 Annual Report

April 20, 2023

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1. Executive Summary

1.1 Pilot Summary and Evaluation Activities

Portland General Electric (PGE) launched a coordinated set of three pilot programs in late 2018 that encouraged greater electrification of the transportation sector. While each pilot program had its specific activities and immediate targets, they worked together to bring about several overlapping near-term outcomes including increasing customer awareness and use of electric vehicles (EVs), buses, and charging stations to lower barriers to the adoption of EVs. The following summarizes each pilot's objectives and related evaluation activities conducted by Opinion Dynamics ("the team") in 2022.

Outreach, Education, and Technical Assistance (OE&TA) Pilot

- **Residential customers:** In 2022, PGE sponsored the 2022 Electric Car Guest Drive and EV Charger Exhibit. Prior to 2022, PGE provided outreach to potential EV purchasers and lessees by sponsoring ride-and-drive events, worked with a transportation network company (TNC) to increase adoption of EVs among TNC drivers, exhibited at the Portland International Auto Show, and engaged EV dealerships.

  Evaluation approach: Online focus group with TNC drivers, intercept survey with ride-and-drive attendees, and documentation of pilot performance metrics.

- **Nonresidential customers:** Up until 2022, PGE provided technical assistance and education through the OE&TA pilot to customers interested in fleet electrification or workplace charging and provided fleet electrification assessments.

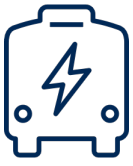
  Evaluation approach: Surveys with recipients of technical assistance consultations and PGE-sponsored education, and documentation of pilot performance metrics, including effectiveness of technical assistance consultations in helping organizations install chargers and electrify fleets.

Electric Avenue (EA) Pilot

- PGE installed six EA charging sites, consisting of 12 Level 2 (L2) and 22 Direct Current Fast Charging (DCFC) chargers, geographically dispersed throughout its service territory.

  Evaluation approach: Intercept and online surveys with EA site users and impact analyses documenting charging patterns, distribution system impacts, and charging behaviors by user groups.

Electric Mass Transit 2.0 (TriMet) Pilot



- PGE installed, owns, and operates two bus depot charging stations and one en route charging station, while TriMet procured five electric short-range buses with 200 kWh batteries.

  Evaluation approach: An impact analysis documenting charging profiles, distribution system impacts, and bus performance.

1.2 Key Findings and Recommendations

The following section provides key evaluation findings and recommendations by pilot. Evaluation activities will continue through 2023, which will allow the team to monitor and expand on these findings.

1.2.1 Outreach, Education, and Technical Assistance (OE&TA) Pilot

- **Impact of business technical assistance:** Surveys with business technical assistance recipients through March 2022 show PGE's business charging and fleet electrification technical assistance has been successful in helping customers to electrify and has been moderately influential in recipient's decision-making processes. Nearly two-thirds (60%) of technical assistance recipients who had onsite parking installed charging equipment and about half (46%) of recipients with fleet vehicles had electrified at least a portion of their fleet after interacting with PGE. About two-thirds of recipients who had installed charging (64%) or electrified fleet vehicles (60%) reported the assistance they received from PGE was at least moderately influential in their decision-making. Further, nearly one-quarter (22%) of surveyed technical assistance recipients indicated that their consultation increased their organizations' likelihood of purchasing or leasing EVs a great deal and about half (48%) indicated that their organization is very likely to purchase or lease an EV in the next three years.
  - **Recommendation:** Results from the business technical assistance surveys highlight the importance of transportation electrification (TE) technical assistance for PGE's commercial customers. PGE should continue to support commercial customers in TE, as it is currently doing through the Fleet Partner and Business EV Charging Rebates Pilots.
- **Future commercial charging opportunities:** Most (88%) business charging technical assistance recipients who had not installed chargers indicated that they were still considering installing charging in the future, with about half (47%) reporting they were very likely to install charging within the next three years. When considering installing charging, respondents were more concerned about the cost of site upgrades than the cost of the chargers themselves, suggesting a need for additional assistance with make-ready infrastructure. Further, findings from the focus group with TNC drivers found those who live in multifamily buildings without access to charging were less likely to purchase another EV in the future due to lack of charging infrastructure, suggesting a need for charging infrastructure at multifamily properties.
  - **Recommendation:** In addition to financial assistance provided through the Business EV Charging Rebates Pilot, consider providing commercial customers, including multifamily building owners, additional options for installing charging infrastructure. For example, PGE could consider providing customers with a utility-owned turnkey option, where make-ready and charging equipment is provided by PGE, with minimal operational costs to customers. PGE could also consider partnering with a third-party charging as a service (CaaS) provider to offer customers a full-service charging option. Offering additional options for installing charging could be particularly impactful for current and future EV owners who live in multifamily properties and for commercial customers located in environmental justice communities.
- **Increasing customer exposure to EVs:** Providing customers with opportunities to personally experience EVs is critical to increasing customer familiarity. Education and outreach activities such as ride-and-drives are effective venues for increasing interest, familiarity, and understanding of both EVs, charging technologies, and utility TE offerings. PGE's 2022 ride-and-drive event was well attended, highlighting customer interest in such events. Surveyed event attendees reported high satisfaction with the event. Further, most (76%) surveyed attendees indicated that the event had increased their likelihood to buy or lease an EV in the future.

- **Recommendation:** Continue to provide opportunities for customers to experience EVs and learn about charging technologies and PGE's TE offerings. Ride-and-drive events can be an effective venue and should include the newer popular EV models to generate increased interest and attendance. PGE could also consider expanding partnerships with additional dealerships that are not already included in the Residential EV Smart Charging Pilot.

1.2.2 Electric Avenue (EA) Pilot

- **Marketing of PGE's EAs:** Both general users of PGE's EA sites and TNC drivers who use EA sites are more likely to report learning about PGE's EA sites from driving by, word of mouth, or from wayfinding apps than through PGE marketing efforts. Fewer than one-fifth (13%) of surveyed EA users and only one of eight TNC focus group participants recalled learning about PGE's EAs from PGE marketing. Additionally, one TNC focus group participant reported that their local car dealerships were unaware of PGE's EA sites when they purchased their EV. Further, interviews with multifamily building owners in 2021 also revealed limited awareness of PGE's EA sites among multifamily owners, managers, and tenants.
  - **Recommendation:** Consider expanding direct marketing to PGE customers to increase awareness and utilization of EA sites. PGE could consider partnering with TNCs and on-demand delivery companies, dealerships, and multifamily properties near EA sites to help increase EA awareness.
- **Growth in EV charging load:** EA charging load has fluctuated throughout the pilot. Between April 2019 and February 2020, charging load increased with the opening of new EA sites and increasing utilization. In March and April 2020, charging load declined due to the impacts of the COVID-19 pandemic and began to recover in the second half of 2020. In early 2021, a sharp decline in charging load was observed at the Downtown Portland location likely due to issues with the charging equipment, which was replaced during the summer of 2021. Between January 2021 and October 2022, overall charging load from the EA system increased at a rate of approximately 6.3% per month and delivered 79 MWh in October 2022. During the same time, the number of non-subscriber customers increased by 324% and the number of subscriber customers increased by 137%.
  - **Recommendation:** Continue to monitor the growth of charging load at EA stations for increasing utilization or decline in charging load due to equipment issues.
- **Increase in utilization:** The EA network has generally experienced increasing utilization. From April 2019 to October 2020, the average monthly load factor across all sites was 13% while the average monthly load factor was 19% in 2022. The average number of charging sessions per day has also increased over time. Despite the increase in utilization, at all sites except Downtown Portland, more than three chargers were in simultaneous use at a station less than 2% of the time over the study period, suggesting that chargers are available for customers to use upon arriving at a station and there is little congestion in the network.
  - **Recommendation:** Continue to monitor utilization of EA stations for continued growth and the potential for congestion to develop in the network.
- **Charger availability and expansion opportunities:** Surveyed EA users would like to see more chargers at the Downtown Portland and Beaverton EA sites, which are among the highest utilized sites in the network. TNC focus group participants most commonly charge at these locations and would like to see more fast charging equipment to allow for increased user turnover. Surveyed EA users also tended to have lower levels of satisfaction with the Downtown Portland EA due to availability of open chargers and charger reliability. Further, TNC EA users mentioned that additional charging sites are needed in PGE's service territory due to increased EV adoption, especially in the Tigard and Lake Oswego areas.

  - **Recommendation:** Increase the number of charging ports at highly utilized EA sites to accommodate the increasing number of EV drivers. Consider additional EA sites in PGE's service territory where there are currently gaps in public fast charging.

- **Improvements to charger reliability and reporting outages:** TNC focus group participants are satisfied with EA chargers and have noticed that uptime has generally improved over the past year;[1] however, they would like to see greater consistency across charging sites. TNC EA users also noted that chargers listed as online on EV charging apps are sometimes not online upon arrival. About two-fifths (38%) of surveyed general EA users also mentioned wanting to see improved charger reliability. TNC EA users mentioned that monitoring real-time user input on apps such as PlugShare and Shell Recharge would help PGE quickly identify issues and fix chargers.
  - **Recommendation:** Consider providing outreach to EA users informing them that they can use apps such as PlugShare and Shell Recharge to report issues at EA sites. Outreach could include emails to EA users and additional signage at EA sites. Continue to have staff monitor and address user-reported issues as they occur.
- **Pricing structure and system peak impact:** The EA network does not significantly contribute to PGE's system peak and the EA pricing structure has been effective at influencing charging behavior. Analysis of EA charging data shows charging load is not highly coincident with PGE's system peak and that the peak pricing component is highly effective in shifting charging away from system peak load periods. Further, surveys of EA users show that most (71%) of EA users are charging outside of the peak hours (3:00 p.m. to 8:00 p.m.) and nearly two-thirds (60%) report being aware of the $0.19/kWh peak surcharge. The EA stations also do not contribute significantly to distribution system peak loads. The charging capacity of the stations is about 1-2% of the total capacity of feeders serving EA stations and charging load has low coincidence with peak load of feeders.
  - **Recommendation:** Continue to implement the peak pricing component and monitor utilization as usage of the EA sites increases to determine system impacts.
- **Preferred payment options:** EA users are generally satisfied with the EA pricing structure and the payment process, with three-quarters (75%) of surveyed EA users being very satisfied with both the cost of EA charging and the payment process. Surveyed EA users prefer having a mix of payment options with PGE's EAs, including options for paying an hourly flat rate, a monthly subscription, and paying per kWh (not currently offered). Additionally, about two-thirds of EA users who are PGE customers were interested in paying for EA charging on their home electric bill.
  - **Recommendation:** Continue to provide customers with a mix of pricing options, and potentially offer an additional option to pay per kWh. Consider providing a payment option for PGE customers to pay for their EA charging on their home electric bill.
- **Misuse of EA sites:** TNC focus group participants who use PGE's EAs reported issues at the Downtown Portland EA site, including EV drivers parking vehicles in charging stations without charging, vehicles left to charge overnight, and non-electric delivery vehicles blocking the station. The Downton EA site was also reported as being one of the most heavily used by both general EA users and TNC users. TNC drivers felt additional accountability is needed to rectify illegal parking and charger idling to facilitate charging at this location.
  - **Recommendation:** Increase enforcement for illegal parking in EV spaces and EVs parking in charging spaces without charging, especially at the Downtown Portland EA.

[1] "Uptime" is the amount of time that a charger is online and available for use.

  - **Recommendation:** Consider implementing charger idling fees similar to private charging companies to prevent drivers from leaving their vehicles connected to chargers for extended periods of time.

- **Improving customer experience at EAs:** Additional amenities at EA sites would improve users' charging experience. Nearly all (90%) of surveyed EA users mentioned they would like to see improvements made to PGE's EA sites. Most suggested improving charging reliability, and other suggested changes included the ability to reserve a charger (26%) and shelters from the elements (20%). TNC focus group participants noted that amenities similar to those provided at gas stations, such as trash cans, bathrooms, and vending machines, would improve their charging experience. Additionally, TNC EA users reported that sheltered charging stations would prevent their cars from overheating while charging on hot days.

  - **Recommendation:** Consider designing future EA sites with overhead shelters and provide amenities similar to those offered at gas stations, or co-locate new chargers near shopping centers, restaurants, and public bathrooms.

1.2.3 Electric Mass Transit 2.0 (TriMet) Pilot

- **Technical issues with buses and chargers:** The short-range buses running on Line 62 were grounded at several points during the study period due to technical issues. Issues with the en route charger at Sunset Transit Center persisted throughout the study period.

  - **Recommendation:** Continue to monitor the evolution of the electric mass transit bus market and related charging solutions to better support reliable operations for transit and other customers with heavy-duty EVs.

- **System peak impact:** Bus charging load does not currently contribute significantly to PGE's system peak or distribution system, suggesting there is not currently a need to change bus charging behavior. A large portion of bus charging occurs during the peak period of the tariff TriMet is on due to its broad peak period, Monday through Saturday, 6 a.m. to 10 p.m., and the use on-route charging. While average charging load is low during PGE system peak hours, en route bus charging is likely to occur during the highest load hours. Neither the Sunset Transit Center nor the Merlo Garage feeders are at risk of overloading despite the use of high-powered chargers. Further, TriMet and PGE staff report there are limited opportunities to use rates to influence bus charging behavior, and the ability to shift bus charging is constrained due to the limited capacity of the buses' batteries and the route configuration. Bus charging at Merlo Garage is also influenced by staffing considerations as daily operations and maintenance of the buses require staff with appropriate training.

  - **Recommendation:** Continue to monitor usage to confirm that there is not a negative peak impact once all buses on Line 62 have been in operation over a longer period of time. Conduct additional research to understand if there is flexibility to leverage rates to influence charging behavior with the adoption of longer-range buses that are less reliant on en route charging. Both the monitoring and additional research can be used to inform future expansion of electric buses at TriMet as well as future investment in medium- and heavy-duty EVs and associated infrastructure.

- **Long-range buses:** The team compared the charging load patterns of Gillig long-range buses that were procured by TriMet outside of the pilot to those of the short-range New Flyer buses in the pilot. The long-range buses do significantly less charging during system peak hours as they do not rely upon en route charging during daytime or peak period hours. The long-range buses have a higher non-coincident peak load at Merlo Garage than the short-range pilot buses as the long-range buses mostly charge during early morning hours before going into service. Based on current load patterns, expanding the number of chargers could lead to high distribution system upgrade costs.

- **Recommendation:** Work with TriMet to manage bus charging to reduce peak charging load as TriMet continues to expand its electric bus network with long-range buses.

2. Introduction

2.1 Transportation Electrification Pilot Background

PGE launched a coordinated set of pilot programs in late 2018 to encourage greater electrification of the transportation sector. While each pilot program had specific activities and targets (Table 1), they were intended to work together to bring about overlapping near-term outcomes: (1) PGE customers would learn about, see and use EVs, buses, and charging stations, helping to lower barriers to the adoption of EVs; (2) Multifamily and low-income customers would have better access to EV transportation; and (3) Businesses, municipalities, and governmental agencies would receive technical assistance and education to improve their ability to support an EV-ready infrastructure and encourage adoption of EV fleets.[2]

Table 1. Description of PGE's Pilot Activities

Outreach, Education, and Technical Assistance Pilot (OE&TA)
This pilot has relied on the following strategies to increase the adoption of EVs in PGE's territory: ▪ EV technical assistance to commercial and industrial customers, municipalities, governmental agencies, non-profits, mass transit agencies and providers, low-income service providers, and community-based organizations (CBOs) that are considering fleet electrification, workplace charging, or procurement of EVs ▪ EV ride-and-drive events ▪ Educational kiosks and education of auto dealer staff on a proprietary EV charger labeling system and mobile application for EV drivers who reside in PGE territory ▪ Partnerships with OEMs (BMW, Chevrolet, and Nissan) to offer combined PGE and OEM incentives for an EV to PGE customers (referred to as "bulk purchase partnerships") ▪ Partnerships with TNCs to educate drivers about the benefits of driving EVs and increase EV utilization through discounted charging initiatives
Electric Avenue Pilot
PGE installed six EA charging sites geographically dispersed throughout its service territory. The pilot tested pricing signals to encourage off-peak charging and charging when excess renewable energy is available. The pilot also examined the impact of community charging on increasing adoption of EVs by PGE customers (including multi-family residents) and TNC drivers.
Electric Mass Transit 2.0 ("TriMet") Pilot
PGE owns two bus depot charging stations (150 kW each) and one en route charging station (450 kW), while TriMet procured five electric buses with 200 kWh batteries. The pilot gathered bus charging data from the stations to assess the energy and cost impacts of electrifying an entire bus route over time as well as operations impacts to TriMet.

2.2 Evaluation Objectives and Activities

This report is the fourth annual report as part of a five-year evaluation and covers pilot activities that began in late 2018 and continued through December 2022. There are three primary objectives for the 5-year evaluation:

- Understand how PGE can improve its program implementation during and after the pilots;
- Quantify the impacts of the pilots on EV awareness, sales, use, and barriers; and
- Determine the load impacts of public and electric bus chargers.

[2] Note fleet electrification and technical assistance is not offered through PGE's Fleet Partner.

This report covers the fourth year of pilot activities. The team conducted five research activities in 2022, beginning in January 2022 and ending in December 2022. The final research activity conducted for this five-year evaluation will be the third wave of the General Population Residential Customer and EV Owner Survey in 2023.

2.2.1 Business Technical Assistance and Training Recipient Surveys

The team completed three waves of surveys between 2019 and 2021 with organizations who received technical assistance consultations from PGE staff for installing workplace charging and/or fleet electrification. The team attempted to survey each organization who received technical assistance twice; the first survey (the "initial survey") was conducted with 50 organizations between five and twelve months (typically six months) following receipt of the technical assistance (Table 2). The second survey (the "follow-up survey") was fielded about six months later to better understand how their project(s) were progressing toward electrification. Between 2020 and 2022, 29 follow-up surveys were conducted with organizations that had received technical assistance consultations and completed the initial survey.[3]

The key objectives of the Business Technical Assistance surveys were to understand:

- Recipient experience and satisfaction with the technical assistance received;
- How recipient understanding of charger siting, maintenance, and costs changed because of the technical assistance; and,
- The influence the technical assistance had on charger installations and/or EV fleet purchases.

Combined results from the initial surveys conducted in 2019 and 2020 and the follow-up surveys conducted in 2020, 2021, and 2022 are presented below in Table 2.

Table 2. Business Technical Assistance Survey Dispositions

Survey Wave	Number of Attendees Invited	Initial Surveys Completed	Follow-up Surveys Completed	Total Surveys Completed
1	76	14	8	**22**
2	43	17	11	**28**
3	32	19	10	**29**
Total	**151**	**50**	**29**	**79**

Respondents represent a variety of organizations, including: cities, hospitals, universities, research centers, state services, a port district that oversees aviation and marine activity, non-profits, apartments, a school district, a park, a zoo, a water district, a nature conservation center, transit operators, and businesses. Businesses included a real estate firm, vehicle manufacturer, dealership, auto repair shop, air filtration business, construction companies, design and architectural business, and trucking companies.

2.2.2 Ride-and-Drive Survey

[3] Note all three waves of the initial survey were conducted between 2019 and 2021. Because the follow-up survey was fielded after the initial survey was conducted, the final follow-up survey was not conducted until March 2022.

In August 2022, the team conducted a third round of the ride-and-drive intercept surveys at the 2022 Electric Car Guest Drive and EV Charger Exhibit at Portland Community College's Sylvania campus.[4] The event targeted higher-income, residential homeowners who were enrolled in a PGE Green Future renewable energy program. These customers were invited via email to attend the event. The event included 10 EVs, which attendees could register to test drive, in addition to demonstration chargers.[5] The key objectives of the survey were to understand:

- How attendees heard of the ride-and-drive event and reasons for attending;
- Satisfaction with the event and the EV(s) they test drove;
- Consideration and intention to purchase or lease an EV in the near future;
- Attendee exposure to other PGE outreach and education campaigns or resources; and,
- Characteristics of those attending (income, location, ridesharing/on-demand delivery vehicle use, and experience with an EV).

The team attempted to survey attendees who test drove an EV at the event. In total, the team completed 37 surveys at this event (Table 3).[6] The event was the largest of the three events at which the research team fielded intercept surveys. When we last conducted intercepts at a ride-and-drive event in November 2019, four vehicles were available to drive, 47 people attended, and 30 test drove vehicles. At this event, 10 vehicles were available, 252 people attended, and 136 test drove vehicles.

Table 3. Summary of Ride-and-Drive Participants and Dispositions – August 2022 Event

Disposition	Count
Number of attendees	252
Number of individuals who test drove a vehicle	136
Completed surveys with those who test drove a vehicle	**37[a]**

[a] We asked 39 attendees to complete the survey and two declined to provide feedback.

2.2.3 TNC Driver Focus Group

The team hosted a second focus group with TNC drivers who were PGE customers, recently or actively drove for a TNC company, and owned or leased an EV or PHEV.[7] The online focus group was held in August 2022, and the discussion explored participants' experiences as a TNC driver or on-demand delivery driver, and their experiences using EVs and PGE's EA charging sites. The team hosted the first focus group in July 2020 with TNC drivers who were PGE customers that either recently or actively drove an internal combustion engine (ICE) vehicle for a TNC company, and who were considering purchasing or leasing an EV or PHEV for their next vehicle.

[4] Results from the first and second rounds of ride-and-drive intercept surveys can be found in the 2019 Annual Report.
[5] PGE targeted this group because prior research had shown that higher-income households are most likely to purchase EVs. PGE continues to offer and develop programs that can bring EV ownership/leasing to moderate- and lower-income customers. In particular, PGE's Drive Change Fund provides grants for a range of transportation electrification options for lower-income and environmental justice communities. PGE has sponsored additional ride-and-drive events that have been open to all income levels, including the Milwaukie EA grand opening event in April 2019, a National Drive Electric Week event in September 2019, and a rideshare community event and information session in Downtown Portland in November 2019.
[6] Not all individuals who test drove a vehicle were surveyed due to the event being spread across a large event space and attendees leaving the area prior to being surveyed.
[7] The research team conducted a focus group with TNC drivers who were PGE customers who were considering purchasing an EV or PHEV in 2020. Results from the focus group can be found in the 2020 Annual Report.

The team recruited TNC drivers from a list of 153 EA subscribers provided by PGE. Emails were sent to all 153 EA subscribers requesting they fill out a short screening survey. The survey confirmed PGE was their electric service provider, they owned an EV, and they could participate in a focus group at the specified time and date. After EA subscribers responded to the screening survey, the team called interested respondents and confirmed that they were either current or recently retired TNC or on-demand delivery drivers.[8] The team recruited 12 participants, eight of whom attended the online focus group.

2.2.4 EA Site User Survey

The research team fielded in-person intercept surveys at six of PGE's seven EA sites in May 2022.[9] To supplement data collected at EA sites, the team also conducted a web survey in September 2022 with EA users. The key objectives of the EA surveys are to understand:

- The demographic and household characteristics of EA users;
- Charging practices of EA users; and,
- User satisfaction with PGE's EAs and desired changes.

Due to a lower than anticipated intercept survey response, web surveys were conducted in September 2022 with additional EA users. For the web survey sample, PGE provided a list of monthly EA subscribers and those who pay per hour for EA use ("non-subscribers"). The web survey included two screening questions that confirmed respondents were not PGE employees and had charged at an EA site. A total of 159 surveys were completed, 124 via web and 35 via intercept (Table 4).

Table 4. Summary of EA Site User Respondents and Disposition by Survey Type

Disposition	Intercept Survey	Web Survey	Total
Screen-outs	0	12	12
Refusals	4	0	4
Completes	**35**	**124**	**159**

Table 5 summarizes the responses received from each EA location and survey type. Intercept survey respondents were asked to focus on the EA where they had been charging at the time of the survey while web survey respondents were asked to think of the EA that they most often use. The Downtown Portland location near the World Trade Center was the EA with the most responses, followed by the East Portland and Beaverton locations.

[8] "Retired drivers" reported working for a TNC company in the last year but are not currently driving for a TNC company.
[9] The research team did not field intercept surveys at PGE's Salem EA site because the site was offline due to construction at the Oregon State Capital building where the EA is located.

Table 5. EA Site User Respondent Completes by Location and Survey Type

Location	Intercept Survey	Web Survey	Total
Downtown Portland	9	63	72
East Portland	9	19	28
Beaverton	7	17	24
Milwaukie	6	12	18
Wilsonville	2	8	10
Hillsboro	2	6	8
Total	**35**	**125**	**160**

2.2.5 Impact Analysis

EA Pilot

The EA impact analysis focused on the charging load at each EA site and how it impacted PGE's bulk and distribution systems. In addition to evaluating the system impact, the team investigated the charging load shapes and utilization at each site to draw high-level insights on users' charging preferences and site utilization. The team also looked at charging behavior differences across varying charger types, user groups, and seasons. The analysis was conducted using the charging data measured at the chargers at each EA site from March 2019 to October 2022 ("the analysis period"). The Salem EA site was only in use between 2019 and 2020 and is excluded from the analysis. More information about the Salem EA site can be found in Appendix A. The Downtown Portland site pre-existed the pilot program but is included in the analysis. Some figures have Downtown Portland removed to provide more clarity on trends from the pilot sites.

Electric Mass Transit 2.0 (TriMet) Pilot

The TriMet impact analysis presents the characteristics of the buses' charging load and discusses its impact on PGE's system. The analysis also summarizes the energy consumption and charging session duration at Merlo Garage and the Sunset Transit Center, quantifies the charging load factors and impact on PGE's system peak, investigates the impact of major service and maintenance events on monthly load, and summarizes typical errors with the Sunset Transit Center pantograph. Most analyses focus on the charging load impacts at Merlo Garage and Sunset Transit Center associated with the five short-range buses that were initially purchased by TriMet as part of the pilot. The team also presents analysis of the charging load impacts of six long-range electric buses recently purchased by TriMet that also utilize the PGE-maintained depot chargers. These long-range buses are outside the scope of the pilot; however, results are included to provide additional insights into the impacts of mass transit electrification.

The team primarily conducted these analyses using TriMet charging data measured at the meters and session data measured at the charger. Metering data at Merlo Garage could not be used for the analysis as pilot buses and non-pilot buses shared charging equipment interchangeably at the depot. Thus, analyses that required time series charging data relied upon a time series reconstructed from session data. Metering data for Sunset Transit Center was available throughout the study period and was used for time series analyses. No charging session data was available for Sunset Transit Center from September 2020 to September 2021.

3. OPUC Learnings

PGE provides the Oregon Public Utilities Commission (OPUC) with learnings associated with each pilot as part of the effort to monitor the progress of the pilots.[10] Table 6 through Table 8 (below) provide findings associated with the OPUC learnings by pilot. Note that the key findings are derived from the 2019, 2020, 2021, and 2022 evaluation activities and details for some findings are presented in the 2019, 2020, and 2021 evaluation reports. Also note that data collection activities related to some OPUC learnings are in progress or have not yet been initiated, as noted in the tables.

3.1 Outreach, Education, and Technical Assistance Pilot

Table 6. Outreach, Education, and Technical Assistance Pilot OPUC Learnings Key Findings

OPUC Learning	Key Findings
1.The impact of outreach efforts (e.g., ride-and-drive events, education) and marketing (e.g., ads), if available, on;	▪ Ride-and-drive events at dealerships were of mixed success and could be improved with additional promotional support from PGE for future ride-and-drive events. ▪ The partnership between PGE's ride-and-drive implementer and PGE can be leveraged further to increase attendance at non-dealership ride-and-drive events in the future. ▪ Ride-and-drive events appear to be increasing in popularity. The 2022 event was the largest of the three events at which the research team fielded intercept surveys. At the first surveyed event in November 2019, four vehicles were available to drive, 47 people attended, and 30 test drove vehicles. At the 2022 event, 10 vehicles were available, 252 people attended, and 136 test drove vehicles. ▪ The Portland International Auto Show has been an effective venue in educating people who are interested in EVs, and more cost-effective than ride-and-drives.
1a. PGE customer awareness of EVs in the service area as measured through PGE customer surveys, focus groups, one-on-one interviews, program data, etc.;	▪ In 2021, four-fifths of customers reported being familiar with EVs (80%) or PHEVs (80%). The familiarly with EVs in 2021 increased since the 2019 Wave 1 and 2018 Baseline surveys (80%, up from 73% of Wave 1 and 76% of Baseline), while familiarity with PHEVs has remained consistent (80% of Wave 2, 78% of both Wave 1 and Baseline).
1b. The consideration of an EV for new car shoppers; and,	▪ Dealers say that EV educational kiosks help to explain EVs to new-car shoppers and alleviate their concerns regarding range and where and how to charge. ▪ In 2021, few (15%) EV owners reported being shown an EV educational kiosk while visiting a PGE partner dealer. ▪ Customer consideration of EVs and PHEVs for their next vehicle has increased. More customers in 2021 who are likely to purchase a vehicle during the next five years would "definitely" or "probably" consider purchasing an EV (52%, up from 39% of Wave 1 and 38% of Baseline) or PHEV (42%, up from 33% of Wave 1) compared to customers surveyed in 2019.
1c. Overall sales and leases of EVs in	Results pending Wave 2 of the EV Owner Survey in 2023. Results will be

[10] Report on Finalized Learnings for PGE's Transportation Electrification Programs (2018): *https://apps.puc.state.or.us/orders/2018ords/18-124.pdf*

OPUC Learning	Key Findings
the service area as measured through the evaluation of recent EV purchasers/lessees.	derived from the Wave 1 and 2 of the EV Owner Survey, the EA Site User Survey, Ride-and-Drive Surveys, and EV registration data.
2. The impact of technical assistance programs and marketing on the installation of workplace EV chargers.	Results from all three waves of the surveys suggest technical assistance from PGE was influential in the decision to install workplace charging (64% of respondents indicated PGE's technical assistance was at least moderately influential).
2a. Number of recipients of technical assistance that result in charger installations.	Three-fifths of technical assistance survey respondents (60%) who provide on-site parking have installed chargers or outlets for charging since receiving assistance. In the follow-up survey, five respondents indicated they had installed additional workplace chargers since completing the initial survey.
3. The change to participation rates in TOU rate schedules by EV owners.	A TOU rate specifically for EV owners was envisioned as part of the OE&TA pilot but has not been adopted by PGE. Other PGE evaluations of time-varying rates, for *all* residential customers, will analyze impacts on EV owners and other customer segments.
4. The change in EV charging load characteristics, influenced by education efforts.	
5. The major challenges business customers face when planning for and siting EV charging infrastructure.	Business customers noted a variety of challenges, including the installation taking more time to complete than expected, stations not working as intended, and permitting taking longer than expected.
5a. Evaluate the efficacy of outreach effort including challenges; and,	Customers had positive feedback about their consultations. PGE could improve their ability to evaluate the efficacy of their outreach by systematically tracking data on the customers' experience, including whether they have purchased EVs or installed charging equipment as a result of the consultation.[a]
5b. Adjustments to outreach efforts to increase effectiveness and response to barriers.	Most customers reached out to PGE about their consultation needs. A PGE contact indicated that outreach efforts could be improved by tracking data about customers' needs and knowledge of EVs to improve future outreach efforts.
6. Gather data on customer awareness of EVs and their exposure to PGE's EV marketing campaigns.	▪ The well-attended Portland International Auto Show has engaged customers and is likely more effective in educating people who are interested in EVs compared to ride-and-drives. ▪ Similar to the 2019 Wave 1 survey, about one-fifth (22%) of 2021 Wave 2 survey of likely vehicle purchasers reported seeing at least one PGE EV resource, campaign, or discount. ▪ TNC drivers primarily learned about PGE's EAs by driving past an EA site or using an EA charger. Drivers mentioned that EA charging sites and subscription services should be more widely marketed to drivers to increase awareness and participation.
7. Develop and implement a plan to gather sample information from a variety of populations in PGE's service territory, including those listed below:	Evaluation meets this requirement
7a. General sample of PGE customers;	Evaluation meets this requirement
7b. Recent EV purchasers;	Evaluation meets this requirement
7c. Recent technical assistance customers;	Evaluation meets this requirement
7d. Recent non-EV purchasers;	Evaluation meets this requirement

OPUC Learning	Key Findings
7e. Trade allies (e.g., dealers, manufacturers); and,	Evaluation meets this requirement
7f. Key stakeholders (e.g., ride-and-drive implementer, transportation authorities, program staff).	Evaluation meets this requirement

[a] Since initiation of the OE&TA pilot, PGE has launched the Fleet Partner pilot, which systematically tracks customer progress through the planning and building phases of fleet electrification projects.

3.2 EA Pilot

Table 7. EA Pilot OPUC Learnings Key Findings

OPUC Learning	Key Findings
1. Effect of EV charging on PGE's system to determine how EVs can be used to create a system benefit	EV charging has a minimal impact on PGE's bulk and distribution systems due to customer responsiveness to peak pricing periods. At full capacity, each charging site would only increase the feeder load by 1% to 2%, which is not enough to trigger distribution system capacity studies.
2. The impact of the presence of visible, reliable, and accessible charging infrastructure on:	
2a. Customers' willingness to purchase an EV; and,	▪ More customers in the 2021 Wave 2 survey reported their next vehicle will be an EV compared to the 2018 Baseline and 2019 Wave 1 surveys (19%, up from 14% of Wave 1 and 7% of Baseline). Additionally, in 2021, customers were equally likely to report they intend to purchase an EV (19%) or PHEV (15%) as a gasoline-fueled vehicle in the next five years (34% compared to 36%, respectively). ▪ TNC drivers who live in multi-family buildings without charging are less likely to purchase another EV due to lack of charging infrastructure. Further, TNC drivers had concerns about charger availability and range, and therefore said they were less likely to purchase another EV in the future. ▪ The availability of PGE's EAs had a moderate influence on EA users' decision to purchase or lease EVs. About half (52%) of users who were aware of PGE's EAs prior to purchasing their EV indicated PGE's EAs were either "somewhat" or "very" influential in their decision to purchase or lease their vehicles.
2b. Customers' willingness to take longer trips in an EV.	Even with improved charging infrastructure, customer expectations for vehicle battery range have increased over time. In 2021, over half (57%) of customers mentioned "minor" or "major" concerns with vehicle range, and would need a battery range of over 250 miles to alleviate range concerns. In the 2019 Wave 1 survey just under a half (47%) of customers had "minor" or "major" concerns about vehicle range.
3. To the extent possible, learning who the predominant users of the charging infrastructure are:	Although there has been a 324% increase in EA non-subscribers between 2020 and 2022, EA subscribers consumed more energy over the analysis period (894 MWh) compared to non-subscribers (565 MWh). On a per customer basis, subscribers use 2-3 times more energy per month compared to non-subscribers, potentially because they are more likely to live in multi-family homes compared to non-subscribers (per EA survey responses) and rely more heavily on public charging.
3a. Whether there are distinct use	▪ Over the analysis period, the charging load profile of EA monthly

OPUC Learning	Key Findings
cases with predictable load profiles;	subscribers peaked just before peak pricing began (around 3:00 p.m.) and exhibited a rebound peak just after peak pricing ended (around 8:00 p.m.). ▪ This behavior was not observed in the non-subscriber charging profile, which peaked during mid-day and did not have a rebound after peak pricing ended. This behavior was also not observed by any user group on weekends when peak pricing is not in place.
3b. Whether the chargers are regularly utilized by non-PGE customers; and	EA sites are primarily utilized by PGE customers, with over three-quarters (76%) of EA User Survey respondents indicating they are PGE customers.
3c. If possible, use by and effects of TNCs.	▪ One TNC company offered its drivers a discounted subscription pricing plan for EA charging, which ended in September 2020. In 2020, PGE reported that the Downtown Portland and East Portland EA sites were popular with TNC drivers, suggesting that drivers are utilizing the pricing plan and the EA network. The 2020 EA impact analysis confirmed the East Portland EA was most popular with TNC drivers; however, user group data was unavailable for the Downtown Portland EA. These sites are likely popular due to their central location and relative proximity to the airport. ▪ TNC drivers aggregately consumed an average of 1,879 kWh per month, which was approximately 19% of total EA charging between March 2019 and October 2020.
4. Utilization and/or demand for quick chargers versus L2 chargers, including the time of day and pricing information.	▪ Interviews with PGE staff revealed that customer demand for L2 chargers still exists among EA users though charging and utilization data suggests that customers prefer DCFC chargers. During the analysis period, DCFCs served 94% of energy delivered by EA chargers. In addition, the DCFC utilization rate when excluding Downtown Portland was 7.2%, nearly twice that of L2 chargers. ▪ The daily usage patterns of L2 and DCFC chargers exhibit differences: the daily average DCFC load profile exhibits two peaks with a dip between 3:00 p.m. and 8:00 p.m., during peak pricing, while the L2 average charging profile only peaks once around noon. The impact of peak pricing is not observable in the L2 average charging profile. ▪ The two types of chargers are not equally used by all user groups. EA non-subscribers use 7.5% of total energy at L2 chargers while subscribers only use 4.1% of total energy at L2 chargers. ▪ TNC drivers want to see additional fast chargers at the Downtown Portland and Beaverton EA sites. Drivers most commonly charge at these locations and would like to see more charging ports to allow for increased EV charging turnover.
5. To the extent possible, learning who is not using the charging infrastructure and why.	▪ Multi-family building owners, managers, and tenants have limited awareness of EAs and do not currently have large demand for charging capabilities. ▪ Lack of awareness is a major barrier to using the charging infrastructure. Customer awareness of PGE's EAs, while still higher than the 2018 Baseline survey, significantly decreased in 2021. About one-quarter (25%) of respondents reported they have seen at least one EA (down from 33% in Wave 1), and about two-fifths (38%) of EV owners have reported using at least one Electric Avenue location to charge their vehicle. ▪ EA sites are disproportionately used by multi-family residents. Surveyed EA users were considerably less likely to report living in

OPUC Learning	Key Findings
	single-family homes compared to EV owners in PGE's service territory (64% compared to 92%).
6. Network load profiles and the impacts on PGE's distribution system, including coincident and noncoincident peak loads of DCFCs and power quality in the vicinity of the chargers.	▪ Over the analysis period, charging load at six EA sites had minimal impact on PGE's distribution system.[a] None of the feeders at the EA sites were at risk of overloading even when all chargers are used at the same time. ▪ EA charging load is not observed to be highly coincident with PGE's system peak. For all EA sites combined, the non-coincident peak (NCP) ranged from 194-501 kW month by month after all charging stations were online, which is about 15%-19% of the total charging capability. As for the coincident peak, on average, 48 kW of charging happens during the top 3% of PGE load hours, which is approximately 4% of the total charging capability.
6a. Gathering of information to assist with analysis of impacts to PGE' s system, including how many users are charging off-peak and how that affects the system.	▪ Over the analysis period, 29% of charging occurred during the off-peak period, 53% occurred during the mid-peak period, and 19% occurred during the peak period.[b] ▪ Most (71%) surveyed EA users indicated charging outside of EA peak hours and nearly two-thirds (60%) reported being aware of the $0.19/kWh peak charge.
7. A comparison of customer use of charging infrastructure under time-variant rates versus free charging.	The $0.19/kWh peak charge from 3:00 p.m. to 8:00 p.m. on weekdays has an observable impact on the charging load shape and has helped shift the charging away from the system peak period. Over the analysis period, an estimated 62.2 MWh of peak period charging for the Beaverton, East Portland, Hillsboro, Milwaukie, and Wilsonville EAs was shifted to off-peak hours or approximately 66.4 kWh/day.
7a. Gathering of information to assist with analysis of whether price signals change charging behavior and why or why not.	A depressed on-peak charging pattern was observed across all EA sites. On average, 16% of charging occurs during the peak pricing period. EA subscribers are even more responsive to peak pricing and only use 12% of total energy charged during the peak pricing period, as opposed to 22% of total energy charged by non-subscribers.
8. Impact of, and customer interest in, unlimited monthly charging versus other pricing options (e.g., single use, who uses, behavior).	▪ Although still minor in scope, the unlimited monthly charging pricing plan may have an adverse effect on popular EA sites where congestion occurs because drivers have no incentive to unplug and move on once charging is complete. If the adverse effect persists, an alternative pricing structure may be warranted. The impact analysis found that more than three chargers were in simultaneous use 16% of the time between 8 a.m. and 8 p.m. at the Downtown Portland site, indicating that the most popular sites may experience some congestion. ▪ PGE staff reported potentially adjusting the EA subscription model as EV customers become more accustomed to per minute or per kWh charging. Some customers have complained that the current pricing structure is restrictive and expensive, especially for those who are not consistent EA users or are only charging for a short time. ▪ EA monthly subscribers show observable responses to peak pricing, which is not observed in the charging profile of non-subscribers. ▪ Surveyed EA users provided mixed opinions on preferred EA pricing options. Nearly equal numbers of survey respondents reported they would prefer to pay for just the amount of energy they used (37%) as prefer a monthly subscription (35%). The remaining respondents prefer flat rate charging (28%). Nearly all (85%) survey respondents who preferred to pay for the amount of energy they used currently pay

OPUC Learning	Key Findings
	a flat rate for EA charging. About two-thirds (61%) of EA users reported they would like to have the option to pay for EA charging on their home electric bill.
9. The additional PGE infrastructure, if any, needed to support and ensure highly reliable public charging infrastructure and associated costs.	▪ In 2021, staff noted EA charger downtime continued to be an issue; however, increased communication between vendors and PGE has improved service across sites. PGE developed a new service level agreement (SLA) with their charger vendor that includes a performance improvement plan to improve the reliability of charging networks. ▪ TNC drivers indicated that they have noticed that uptime has generally improved over the past year, however, they would like to see greater consistency across charging sites. Drivers mentioned that real-time input on apps such as PlugShare and Shell Recharge would be helpful so that PGE can quickly identify and resolve issues. ▪ TNC drivers also reported that additional charging ports are needed at current EA sites such as Downtown Portland and Beaverton and additional EA sites are needed in the Tigard and Lake Oswego areas. Drivers would like to increase their driving range and therefore need additional charging stations across Portland and in adjacent areas. ▪ Responses from surveyed EA users suggest a need for improved charger reliability, ability to reserve a charger, additional amenities (e.g., shelter from the elements, lighting, restrooms nearby), and additional chargers in the Portland metropolitan area.

[a] Six EA sites include Beaverton, East Portland, Hillsboro, Milwaukie, Salem, and Wilsonville.

[b] Off-peak, mid-peak, and on-peak periods are defined based on PGE's residential TOU tariffs: https://portlandgeneral.com/energy-choices/energy-choices-home/time-of-use-pricing-home.

3.3 Electric Mass Transit 2.0 (TriMet) Pilot

Table 8. Electric Mass Transit 2.0 (TriMet) Pilot OPUC Learnings Key Findings

OPUC Learning	Key Findings
1. Pilot design elements, including an exploration of:	
1a. Program implementation (pricing and suppliers);	▪ An electric bus manufacturer supplied five short-range buses to TriMet for $930,000 each (including warranties and upfitting). ▪ A transit-charging vendor supplied the charging systems for a total cost of $789,000 for equipment. ▪ TriMet estimated the total make-ready cost (installation, engineering, design, and permits) for both charging systems was $787,670.
1b. PGE physical infrastructure and cost (line extension, line drop, and distribution equipment requirements); and,	▪ At Merlo Garage, transformer pads and primary power connections were designed to ensure larger transformers and additional secondary runs could be accommodated in the future. ▪ The Sunset Transit Center has capacity for a second 450 kW charger.
1c. Customer service and technical assistance needs.	▪ TriMet trained its drivers on bus operation and charging, and trained its dispatchers so their advice to operators matched their bus. ▪ PGE and TriMet determined the scope of operations and maintenance (O&M) to include routine maintenance, emergency repair, on site spare parts on site, and monitoring services. ▪ PGE monitored charger operation and informed TriMet and, if needed,

OPUC Learning	Key Findings
	the charging vendor of any problems. ▪ PGE advised TriMet on the build-out of its Powell Garage chargers. ▪ In 2020, PGE reported needing greater communication and more timely responses when contacting the charging vendor with questions related to the charging dashboard. ▪ Driver shortages and ridership declines due to COVID-19 hindered bus service.
2. Actual impacts of bus charging load on system infrastructure: 2a. Additional infrastructure and cost, if any, needed to support and ensure reliable bus charging infrastructure	No feeder or substation upgrades were required for the Merlo Garage and Sunset Transit Center charging stations.
3. Actual impacts of bus charging load on the distribution system loading:	▪ Neither the Sunset Transit Center nor the Merlo Garage feeders are at risk of overloading despite the use of high-powered chargers. ▪ In 2022, loading in the summer on the feeders serving Merlo Garage and Sunset Transit Center was 59% and 45%, respectively, of its rated capacity, which is below the threshold that would trigger a capacity study by PGE.
3a. Total load and non-coincident peak (NCP) load compared to feeder loading; and,	▪ Over the study period, the NCP load at the Sunset Transit Center ranged from 185 kW to 421 kW. The NCP load at Merlo Garage was typically around 150-300 kW in months where the buses were operating. ▪ The charging capacity (450 kW) of the Sunset Transit Center represents about 2.5% of the feeder's capacity, and the charging capacity (300 kW) at Merlo Garage represents about 1.7% of the feeder's capacity, showing that bus charging contributes very little to feeder loading.
3b. Coincident peak demand, summer and winter of combined depot chargers.	Charging demand during bulk system peak hours is generally low compared to the capacity of chargers. Over the study period, charging load during the top 3% of system peak hours ranged from 17-23% (126 – 179 kW) in summer and 10-19% (51 -140 kW) in winter across the analysis period.[a] ▪ Coincident peak load on the distribution system was generally low. The Merlo Garage charging load averaged less than 16 kW, or 5% of the chargers' capacity, in the top 3% of feeder load hours. Sunset Transit Center's average load during summer peak hours was 118 kW, or 26% of the en route charger's capacity. During winter, the average load during peak hours was 67 kW.
4. Actual impacts to the bus fleet and fleet facility, of which TriMet will provide some information.	▪ As of 2021, all pilot buses had performance issues affecting reliability and availability. One bus in particular experienced battery and wiring issues, which caused it to be out of service throughout 2021. In 2021, all five short-range buses were in operation for less than 10% of the year. ▪ COVID-19 heavily impacted ridership and bus driver availability. Due to these impacts, TriMet staff expected at least a 10% decrease in service. ▪ TriMet staff reported that replacement of bus components and repairs are more common with electric compared to diesel buses. TriMet staff are still trying to understand the cadence at which components need to be replaced based on use and age. ▪ Between 2019 and 2020, buses were occasionally grounded due to

OPUC Learning	Key Findings
	issues connecting to the en route charger: a bolt in a mechanical component fell out causing connection issues. The en route charger has since been rebuilt by the charging equipment vendor. Significant maintenance events on the en route charger have continued to lead to periods of reduced service by the buses. ▪ Analysis of the most frequent errors that occurred with the en route charger indicated that misalignment of the bus and the pantograph and interlock failure were the two most common errors.
4a. How does the integration of chargers impact the internal logistics of route planning? (Benefits and costs to operations).	TriMet is currently piloting several long-range buses that only require depot charging to limit the use of unreliable en route charging.
4b. How does their optimal schedule for charging align with system load?	The charging load did not contribute significantly to PGE's system peak during the study period; however, the team observed high variation of average peak demand during the system peak hours due to the variation of buses arrival time at Sunset Transit Center. Given that, higher than normal demands in power charging at the Sunset Transit Center could occur by chance during PGE's peak hours in the future.
4c. How flexible is their charging need such that it could better align with system loading?	Charging flexibility for electric buses is based on battery capacity (short vs long-range) and route length. There is little flexibility to shift charging to off-peak times given the use of short-range buses and the route configuration.
4d. TriMet staff feedback on operations and charging compared to existing fleet resources	In 2020, TriMet staff noted operators enjoyed the buses because of their performance and quietness.
4e. Total combined costs from PGE and TriMet, including charging infrastructure installation, operation, and maintenance costs	See 1a above for charging and infrastructure costs.
5. PGE's initial deployment with TriMet will include TOU rates with demand charges (through Schedule 85-P). PGE intends to study system impacts on peak days, evaluate the bus charging use case, and assess the customer's needs.	Over three-quarters (78%) of charging occurred during the on-peak period of Schedule 85, the tariff the Sunset Transit Center and Merlo Garage are on. Eighty-two percent of charging at Sunset Transit Center occurred during the peak period, which is defined as 6 a.m. to 10 a.m. Mondays through Saturdays. This is largely unavoidable, as those are the typical hours in which the buses are operating and making frequent stops at the en route charger. Less on-peak charging occurred at the Merlo Garage, however. Fifty-four percent of charging load occurred during the on-peak period.

[a] Excludes summer 2020 and winter 2020-2021 when buses were out of service for long periods of time.

4. Outreach, Education, and Technical Assistance Pilot

4.1 Pilot Performance Metrics

The following section provides a summary of OE&TA Pilot activities completed since the beginning of the pilot in late 2018:

- **Installing EV educational kiosks:** A total of nine educational kiosks have been installed at partner dealerships: two BMW dealerships (2019 and 2021), a dealership for pre-owned EVs (2019), an Audi dealership (2021), a Chevrolet dealership (first installed in 2018 and moved to a different dealership in 2021), a Ford dealership (2021), a Hyundai dealership (2021), a Volkswagen dealership (2021), and a Volvo dealership (2021).
- **Partnering with dealerships to offer financial incentives for EVs and chargers to PGE customers:** Partnership incentives have included a $3,500 rebate on the Nissan Leaf (87 rebates issued in 2019[11]), a $500 rebate on the Chevrolet Bolt or a free L2 home charger at a Chevrolet dealership (12 Chevrolet Bolt rebates issued in 2019), and $5,000 in a raffle towards an EV for 2019 National Drive Electric Week.[12]
- **Sponsoring ride-and-drive events:** Portland International Auto Show (January 2019), at a Chevrolet dealership (February 2019), EA grand openings (April, May, and October 2019), The Electric Car Guest Drive (June 2019 and October 2022), National Drive Electric Week (September 2019), and for drivers of a TNC (November 2019).
- **Online total cost of ownership (TCO) tool:** In 2022, PGE launched an online TCO tool on the PGE website to help customers better understand the costs of owning EVs as compared to gasoline-fueled vehicles. The TCO tool was recommended in Opinion Dynamics' 2021 Annual Evaluation Report based in part on findings from the General Population Residential Customer survey and is funded by Clean Fuels Credits. Since the launch of the TCO tool, over 13,000 unique website visitors have used the tool. Since July of 2022, PGE has been conducting an online intercept survey with TCO tool users. Responses from 82 survey respondents suggest the tool is providing useful information to users.
  - A large majority of survey respondents were definitely (44%) or strongly (36%) considering purchasing an EV for their next vehicle.
  - Over half (53%) of respondents indicated they were more likely to purchase an EV after using the TCO tool.
  - Two-thirds (66%) of users indicated the TCO tool was "very easy" to use (provided "5" on a five-point scale from "not easy at all" to "very easy").
  - Two-thirds (66%) of users reported they would recommend the TCO tool to others who are considering an EV purchase.
- **EA exhibit at Portland International Auto Show:** PGE along with other stakeholders sponsored an EA exhibit at the 2020 and 2022 Portland International Auto Shows. Exhibits included EVs, a vehicle

[11] Due to changes to the dealership database, the team was unable to determine the number of Nissan Leaf rebates issued after 2019.

[12] Rebates for the Nissan Leaf were discontinued in 2021 due to supply chain issues. As of December 2020, there are no OEM rebates being offered to customers in partnership with PGE.

display wall showcasing readily available EVs and PHEVs in Oregon, an information booth with staff available to answer questions from attendees, EV educational kiosks similar to those placed in participating dealerships, touch screens showcasing PGE's TCO tool, and demonstrations of L2 and DCFC charging stations. The 2020 exhibit generated approximately 230,000 impressions over the course of four days. Impression details for the 2022 auto show are unavailable.

- **TE social media activities:**
  - **2018–2019:** A total of 330 posts on Twitter, Facebook, and Instagram between 2018 and 2019 (97 in 2018 and 233 in 2019) resulting in 3,435 engagements (830 "likes," comments, and shares in 2018 and 2,605 in 2019) and a combined reach of 2.2 million impressions (394,000 in 2018 and 1.8 million in 2019).
  - **2020:** Due to COVID-19, PGE did not engage in any social media activity related to the OE&TA Pilot in 2020.
  - **2021:** Posts associated with PGE's Residential EV Charging Pilot on Facebook and Instagram resulted in 119,769 impressions and 1,596 clicks.[13] Additionally, a social media campaign associated with National Drive Electric Week on Facebook and Instagram resulted in approximately 2 million impressions and 98 clicks.[14]
  - **2022:** Social media posts on Twitter, Facebook, and Instagram resulted in 23,303 views and 319 engagements across PGE's social platforms. Published eight MyPGE stories to share PGE's National Drive Electric Week (NDEW) efforts with employees, focusing on sharing new partnerships and employee stories. Also received 14 pieces of positive coverage (7 from online articles and 7 from broadcast clips) of activities associated with PGE's Electric School Bus Fund, Drive Change Fund, and Fleet Partner Pilot.[15]
- **Nonresidential OE&TA:** Up until 2022, PGE provided technical assistance and education to customers interested in fleet electrification or workplace charging, as well as fleet electrification assessments. Fleet assessments and electrification offerings are now covered through PGE's Fleet Partner Pilot and workplace charging and other commercial charging offerings, now covered through PGE's Business EV Charging Rebates Pilot. The bullets below provide a summary of nonresidential OE&TA activities:
  - **Business technical assistance**: PGE staff provided workplace charging and fleet electrification technical assistance to commercial, industrial, and non-profit organizations as well as local governments and transit authorities. In total, 155 individuals consulted with PGE staff between 2018 and 2021 (34 in 2018, 89 in 2019, 25 in 2020, and 7 in 2021), representing 85 local organizations (18 in 2018, 42 in 2019, 18 in 2020, and 7 in 2021).
  - **Comprehensive fleet electrification assessments:** In addition to the business technical assistance consultations, PGE and a fleet electrification solution provider produced five comprehensive fleet electrification assessments in 2020. The five assessments found that 4,597 light-duty gasoline-powered fleet vehicles could be economically converted to EVs, resulting in a reduction of 17,642 metric tons of CO2 annually, a lifetime fuel savings of $49 million, and lifetime maintenance savings of $25 million.

[13] Note that while the Residential Charging EV Pilot is not funded through the TE pilots, it does have potential impact on customer adoption of EVs, which is an overarching goal of the TE pilots.
[14] Note that National Drive Electric Week social media activity was tracked through January 28, 2022.
[15] Note that all 2022 activities were funded either by Clean Fuels Credits or PGE's internal marketing budget.

- **Educational events webinars, classes, and conference sessions:** Two educational events co-sponsored by a builder training implementor for those interested in building EV-ready homes, two workplace charging webinars, two fleet electrification classes, an electrifying school transportation session at the 2018 Oregon Pupil Transportation Conference, and a workplace charging session at the 2019 Northwest Facilities Expo. In total, 92 individuals attended an educational, webinar, or class event since May 2018.

4.2 Business Technical Assistance and Training Recipient Surveys

The following sections provide key findings from the Business Technical Assistance and Training initial and follow-up surveys through March 2022 (no additional surveys are planned). Respondents include both business and governmental organizations who received technical assistance from PGE staff or attended either a PGE-sponsored training on fleet electrification or webinar on workplace charging where a PGE representative presented. See Appendix B for detailed findings.

4.2.1 Workplace Charging

Installation of Charging and PGE Influence

Nearly two-thirds of technical assistance recipients had installed chargers after working or interacting with PGE. Among those respondents who both received technical assistance and reported providing parking to their employees or customers (84% of all respondents), three-fifths (59%) indicated they had installed EV charging (Table 9).

Table 9. Number of Respondents Who Had Installed Chargers or Were Considering Future Charger Installation (n=42)

Installation Status	Count	Percent
Installed chargers	25	59%
Had not installed chargers but were considering	15	36%
Had not installed chargers and were not considering	2	5%
Total	**42**	**100%**

Note: Counts include initial survey and follow-up survey responses. Question asked only of respondents who reported their organization provides parking for employees or customers.

Of the 25 respondents who installed workplace chargers, Level 2 chargers were the most-frequently installed (Table 10).

Table 10. Workplace Charger Installations by Type (n=25; Multiple Responses Allowed)

Amount Installed	DCFC	Level 2 Chargers	Standard Outlets
Five or fewer	2	8	3
More than five	2	10	6

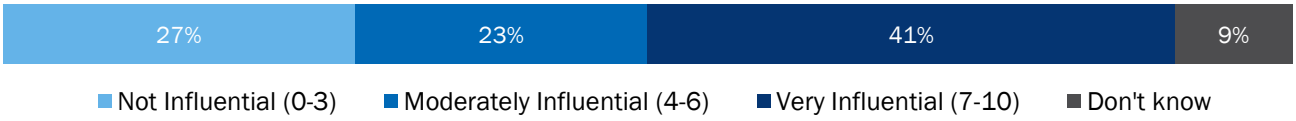
Note: Counts include initial survey and follow-up surveys. Five respondents could not provide any information about the types and number of chargers installed.

Most respondents who had not yet installed chargers were still considering installing chargers in the future. Among the 17 respondents who had not installed chargers but had parking for their employees or customers, over three-quarters (15 or 88%) indicated they were still considering installing charging in the future. The remaining respondents either indicated they were not considering installing charging or did not know. The most prevalent concerns among respondents who had not yet installed chargers were the costs

associated with purchasing and installing chargers (12 mentions), capital budget uncertainty (11 mentions), and lack of staff resources to devote to the project (five mentions; multiple mentions allowed).

A majority of surveyed technical assistance recipients indicated that the consultations they received from PGE were at least moderately influential in their decision to install chargers and without it, they would have scaled back their projects. Over one-thirds (41%) of respondents who reported installing chargers following their PGE consultation rated the consultation they received as very influential in their decision to install their charger(s), with an additional one-quarter (23%) of respondents reporting the consultation was moderately influential (Figure 1). When asked what they would have done if they had not had the PGE consultation, eight (of 25) respondents mentioned that they would have done the exact same installation(s). The remaining respondents indicated they would have done smaller scale installations (four mentions), postponed installing the charging equipment for two to three years (three mentions), done something else (two mentions), or did not know what they would have done (five mentions). One respondent who indicated they would have done something else mentioned that they would have "over-installed" charging if it had not been for PGE's consultation, with yet another mentioning they moved forward with their pre-consultation plans but the consult provided them with options for additional future installations.[16]

Figure 1. Influence of PGE Consultation on Respondents' Decision to Install Chargers (n=22)



Note: Three respondents who reported installing chargers at their workplace but did not know what type of chargers were installed were not asked this question.

Challenges and Barriers Associated with Workplace Charging

Most respondents who had not installed charging reported financial factors were preventing them from purchasing chargers. About three-quarters (76%) of respondents reported costs associated with chargers was a barrier, while over half (59%) of respondents reported capital budget uncertainty was a barrier. Though costs were the most reported reason for not installing charging, most (94%) respondents who had not installed workplace charging, or were unsure if they had, encountered other barriers (Table 11).

[16] Three respondents did not provide a response to the question about what they would have done had they not received a PGE consultation.

Table 11. Challenges Faced by Respondents Who Had Not Installed Charging (n=17; Multiple Responses Allowed)

Challenges Faced by Respondents	Count	Percent
Costs associated with chargers	12	76%
Capital budget uncertainty	11	59%
Lack of staff resources to devote to project	5	29%
Uncertainty in future operations, staffing, or customer traffic	4	24%
Benefits of adding charging not clear	2	12%
Concerns around third party owning property	2	12%
Staff and customers sharing access	2	12%
Reliability or uptime	1	6%
Unsure how to begin process	1	6%
Insufficient space for charger(s)	1	6%
Project stalled due to COVID-19	1	6%
Awaiting grant funding	1	6%
Cost of transformer and electrical panel upgrades	1	6%
Unsure how to find a contractor	1	6%
Not sure	1	6%

Note: Counts include combined, non-duplicate responses from initial and follow up survey.

Technical assistance recipients with capital budget uncertainty were asked whether they were more concerned about the costs of the chargers themselves or costs associated with site upgrades to do the installation. More respondents were concerned with the cost of the site upgrades (8 of 12) to install the chargers than the cost of the chargers themselves (3 of 12). The remaining respondents noted they were most concerned about the total project cost.

Likelihood of Future Charging Installation

About half of respondents who had not yet installed chargers reported they were likely to install charging in the next three years. Of the 17 respondents who reported providing off-street parking for their employees but had not yet installed EV charging, about half (47% or eight respondents) indicated they were very likely to install charging within the next three years and an additional five indicated that they were somewhat likely (Figure 2).

Figure 2. Likelihood of Charging Installation Within the Next Three Years (n=17)

4.2.2 Fleet Electrification

Purchase of EVs and PGE Influence

After receiving their consultation with PGE, about half (46%) of respondents whose organizations own fleet vehicles indicated that their organization purchased at least one EV. Respondents reported that they purchased a total of 148 EVs since receiving a consultation from PGE (Table 12). Types of EVs purchased by respondents included forklifts/lift trucks, passenger cars, vans, school buses, public transit buses, heavy-duty commercial trucks, and golf carts.

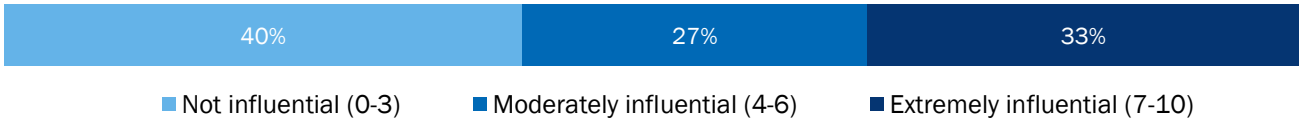
Table 12. EVs Purchased for Fleets After Consultations with PGE (n=15)

EV Type	Number Purchased
Passenger cars	88
Heavy-duty commercial trucks	36
Public transit buses	7
Forklifts/Lift Trucks	5
Vans	5
School buses	5
Golf carts	2
Total	**148**

Note: Counts include initial survey and follow-up surveys.

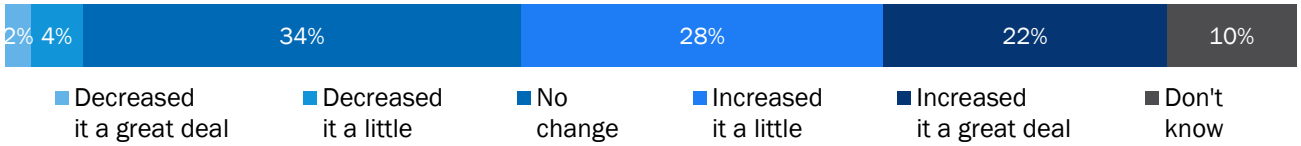
The influence of technical assistance on the decision to purchase EVs was mixed. One-third (33%) of respondents who purchased EV(s) for their fleet after receiving a consultation from PGE indicated that their consultation was very influential in their decision-making, with an additional one-quarter (27%) of respondents reporting the consultation was moderately influential (Figure 3).

Figure 3. Influence of PGE Consultation on Respondents' Decision to Purchase EVs (n=15)



Technical assistance and education had increased some respondents' likelihood of purchasing or leasing an EV for their fleet within the next three years, but not all. About one-quarter (22%) of respondents who received a consultation indicated that their PGE consultation increased their likelihood of purchasing or leasing an EV within the next three years "a great deal" (Figure 4).

Figure 4. Consultation Impact on Likelihood of Purchasing or Leasing an EV Within Three Years (n=50)



Likelihood of Future Fleet Electrification

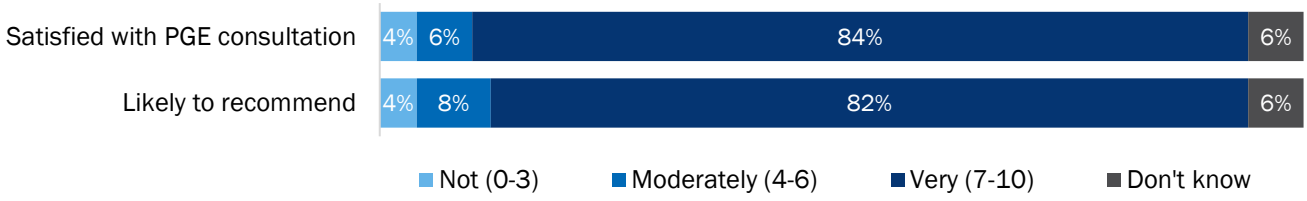
Nearly half (48%) of surveyed technical assistance recipients indicated they were very likely to purchase or lease an EV in the next three years and an additional 16% indicated they were somewhat likely (Figure 5).

Figure 5. Likelihood of Purchasing or Leasing an EV for Fleet Within the Next Three Years (n=50)

4.2.3 Satisfaction with Technical Assistance

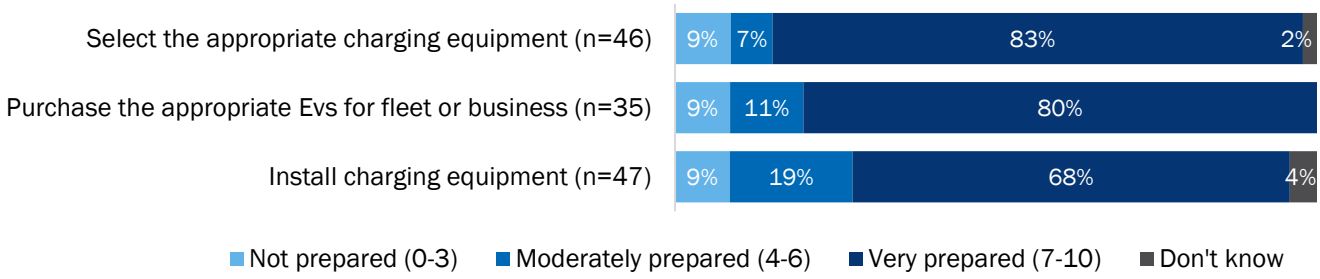
Recipient satisfaction with PGE's technical assistance was high and most recipients were likely to recommend PGE's consultation services to colleagues. Over three-quarters (84%) of respondents indicated being very satisfied with the technical assistance they received from PGE (Figure 6). About the same amount (82%) of respondents indicated they would be very likely to recommend the technical assistance they received from PGE to a colleague or other industry professional.

Figure 6. Respondents' Satisfaction with the Technical Assistance they Received from PGE and Likelihood to Recommend the Technical Assistance Received from PGE (n=50)



The technical assistance provided by PGE staff was effective in preparing businesses and organizations to electrify their fleets and install workplace charging. Respondents mostly indicated that after receiving a consultation from PGE staff, they were very prepared to select the appropriate charging equipment, install charging equipment, and purchase the appropriate EVs for their fleet or business (Figure 7).

Figure 7. Respondents' Level of Preparedness After Receiving a Consultation from PGE



Note: Analysis excludes respondents who provided "not applicable" responses.

4.3 Ride-and-Drive Survey

This section presents key findings from the third and final wave of ride-and-drive intercept surveys.[17] The research team fielded the surveys at the 2022 Electric Car Guest Drive and Electric Vehicle (EV) Charger Exhibit at Portland Community College's Sylvania campus. Detailed findings from the event can be found in Appendix C.

4.3.1 Respondent Characteristics

Respondents generally represented households with high annual income. Almost two-thirds (62%; 23 of 37) of those who provided their income reported household income of $125,000 or more, while only one respondent had a household income of less than $75,000.

Most respondents reported owning homes with off-street parking, making it easier to charge an EV at home. The vast majority (92%; 34 of 37) reported residing in a single-family detached house with a driveway, with the remaining respondents residing in a single-family attached home, a duplex with parking, or a mobile home (one mention each). Nearly all respondents (97%; 36 of 37) reported owning their homes. Given the parking situation of respondents, it is not surprising that all respondents reported that they would charge their new vehicle at home. About one-third (27%; 10 of 37) of respondents mentioned they would also charge at their workplace, and two mentioned that they would charge at a PGE Electric Avenue.

4.3.2 Awareness of Event and PGE EV Information and Resources

About half of ride-and-drive attendees confirmed receiving and engaging with some of PGE's EV marketing campaigns through email or social media, but generally were less aware of PGE's other EV resources or discounts. Over two-thirds (70%; 26 of 37) of respondents reported being aware at least one PGE EV resource, campaign, or discount prior to attending the event (Table 13). Respondents most commonly reported being aware of EV-related emails from PGE (49%; 18 of 37), PGE EV-related social media posts (41%; 15 of 37), PGE's $500 rebate for purchasing and installing a Level 2 home charger (35%; 13 of 37), and PGE's EA charging stations (22%; 8 of 37). Three respondents were aware of and had used PGE's online Total Cost of Ownership tool, all of whom found the calculator to be at least somewhat helpful in comparing EV costs and savings compared to gas vehicles.

[17] The research team conducted two ride-and-drive intercept surveys prior to this survey, one in April 2019 at the Milwaukie EA grand opening event and another in November 2019 at a rideshare community event and information session in Downtown Portland. The April event targeted the general public and the November event targeted TNC drivers. Results from these intercept surveys can be found in the 2019 Annual Report.

Table 13. PGE EV Resources, Campaigns, or Discounts Seen Before Attending the Event (n=37; Multiple Responses Allowed)

PGE Information and Resources	Count
Email from PGE	18
Social media information from PGE on EVs	15
PGE's $500 rebate for purchasing and installing a PGE-approved level 2 home charger	13
PGE's Electric Avenue charging stations	8
PGE's online TCO tool	3
PGE's Smart Charging Program	3
Interactive displays at dealerships with vehicle charging information	1
PGE's Electric Avenue at Portland International Auto Show	1
PGE's evPulse Program for Tesla vehicle owners	1
PGE's Electric Vehicles and Charging webpage	0
None	6
Don't know	5

4.3.3 Reasons for Attending

Respondents attended this ride-and-drive event primarily to test drive EVs. All but one of the 37 respondents reported attending the event to test drive an EV (Table 14). A little over one-third (38%; 14 of 37) of respondents wanted to learn more about EVs. Respondents also attended the event to learn about public charging availability (24%; 9 of 37), learn about EV rebates or discounts (22%; 8 of 37), and to learn about charging costs (14%; 5 of 37).

Table 14. Reason for Attending Ride-and-Drive Event (n=37; Multiple Responses Allowed)

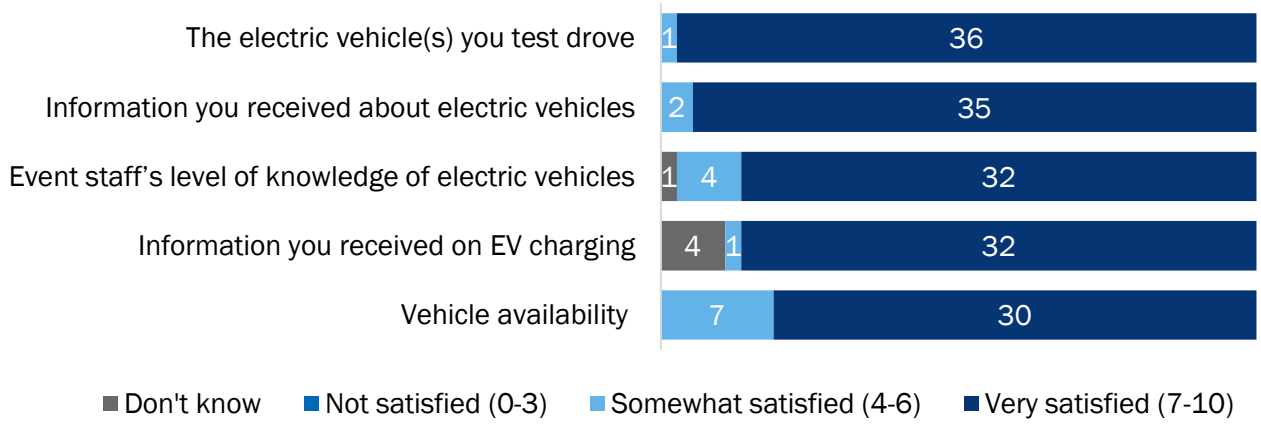
Reason for Attending	Count
To test drive EVs	36
To learn more about EVs	14
To learn about the types of charging available	9
To learn about EV rebates or discounts	8
To learn about charging costs	5

This ride-and-drive event attracted an audience that had some prior experience with EVs and is likely to purchase one. About one-third of respondents (32%; 12 of 37) already owned an EV or plug-in hybrid vehicle of their own. Of respondents who did not already own an EV, about two-thirds (62%; 16 of 25) had driven one. All respondents, including those that already owned an EV, confirmed that they were either very likely (95%; 35 of 37) or somewhat likely (5%; 2 of 37) to purchase or lease an EV within the next five years.

4.3.4 Event Feedback

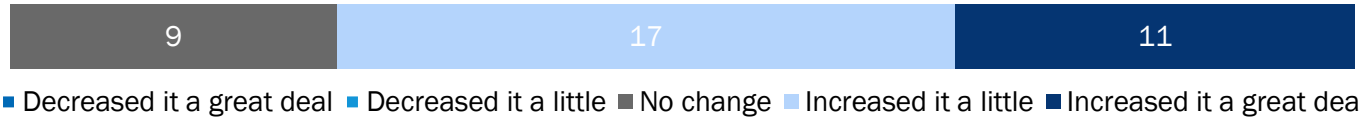
Survey respondents reported high levels of satisfaction with the event, especially regarding the EVs they test drove and the information they received (Figure 8). A minority of respondents (18%; 7 of 37) reported being less satisfied with vehicle availability. These respondents mentioned that the wait time to test drive some of the more popular EVs at the event was longer than they anticipated.

Figure 8. Respondent Satisfaction with the Event (n=37)



Most respondents indicated that the event increased their likelihood to buy or lease an EV. About one-third (30%; 11 of 37) of respondents indicated that the ride-and-drive event increased their likelihood of purchasing or leasing an EV "a great deal." About half (46%; 17 of 37) noted the event increased their likelihood by "a little." The remaining nine (24%) respondents did not feel that the event had changed their likelihood of purchasing a plug-in vehicle.

Figure 9. Effect of Ride and Drive Event on Likelihood of Purchasing or Leasing an EV (n=37)



After their test drives, respondents noted some concerns they had about purchasing or leasing an EV (Table 15). Respondents were primarily concerned about purchase price of the vehicle (70%; 26 of 37), while others were concerned with the lack of availability of EVs for purchase (35%; 13 of 37). Concerns with driving range were noted by a relatively small number of respondents (19%; 7 of 37). Other more technical issues, like safety, access to charging stations, and reliability were less concerning.

Table 15. Potential Barriers Preventing Respondents from Purchasing or Leasing a Plug-in Vehicle (n=37; Multiple Responses Allowed)

Purchasing or Leasing Barrier	Count
Purchase price of vehicle	26
Lack of available EVs for purchase or lease	13
Driving range (number of miles on a single charge)	7
Availability of public charging stations	4
Vehicle safety	4
Inability to charge at home	2
Inability to charge at work	2
Reliability	2
Time required to charge battery	2
Cost of charging the vehicle/Vehicle maintenance costs	2
Manufacturer/company reputation	1
Not applicable – already own or lease an EV	4
Don't know	2

4.4 TNC Driver Focus Group

This section presents key findings from an online focus group discussion Opinion Dynamics hosted with eight PGE customers who were either recent or current drivers for a TNC or an on-demand delivery company and had current ownership or lease of an EV or PHEV. All participants were PGE EA subscribers. Detailed findings from the focus group can be found in Appendix D.

4.4.1 Awareness of EV Resources

TNC drivers typically learned about EA and the EA subscription after physically using an EA charger (four mentions). Drivers reported they did not have knowledge about the EA subscription prior to using an EA charger. One respondent received an email from PGE after using an EA charger, notifying them about the subscription. Two drivers reported finding the EA subscription through independent research. One driver mentioned learning about the subscription through information provided by a local transportation electrification non-profit. Only one driver reported they knew about EA chargers prior to using a charger since EA was near their workplace.

Most drivers (5 of 8) conducted their own independent research to find information about EVs. A few drivers mentioned using YouTube (three mentions) or websites such as Reddit (two mentions), both of which allow individuals to post about their experiences. Two drivers reported visiting the PGE website to find information. After using an EA site to charge, one driver visited the PGE website where they learned about the EA subscription. Another driver stated that it was easy to navigate the PGE website and apply for a home charging incentive.

4.4.2 Charging Habits and Locations

All TNC drivers primarily use apps such as PlugShare and Shell Recharge to locate charging stations and primarily rely on EA sites for their charging needs. Table 16 summarizes each participant's charging habits between EA charging sites, non-EA charging sites, and home chargers. The median proportion of charging at EA sites was 70%. Three of the five drivers with home chargers predominantly utilize EA sites for their charging needs while the other two drivers split their charging time between home and EA or non-EA sites.

Table 16. Percent of TNC Drivers' Charging at PGE EA Sites, at Non-EA Public Sites, and at Home

Participant	EA Sites	Non-EA Public Sites	Home
Participant 2	95%	5%	N/A
Participant 1	90%	0%	10%
Participant 6	90%	10%	N/A
Participant 8	90%	0%	10%
Participant 3	50%	25%	25%
Participant 7	50%	0%	50%
Participant 4	45%	45%	10%[18]
Participant 5	20%	10%	70%
Median	**70%**	**8%**	**10%**

The research team combined information from the TNC drivers who completed mapping assignments prior to focus group participation, to identify the drivers' commonly used charging locations, routes they frequently drove, frequent pick up or drop off areas or locations, and places they frequently stopped for errands, food, or breaks. A "combined" map of this synthesized information is included in Appendix D, and shows commonly used EA and non-EA charging sites used across the Portland metropolitan area and suggested locations for new EA sites based on collected information.

TNC drivers would like to see more chargers at the current EA charging station locations, especially the Downtown Portland and Beaverton EA sites. Drivers most commonly charge at these locations and would like to see additional fast charging equipment installed to allow for increased EV charging turnover. TNC drivers also mentioned that additional charging ports are needed due to increased EV adoption in the area.

TNC drivers would like to see new charging stations in the Tigard and Lake Oswego areas. Drivers would like to increase their driving range and therefore need additional charging stations across Portland and adjacent areas.

TNC drivers who live in multi-family buildings without access to charging are less likely to purchase another EV due to lack of charging infrastructure. TNC drivers had concerns about charging availability and range and therefore said they were less likely to purchase another EV in the future.

[18] This driver did not have a dedicated home charger but reported using an extension cord from their apartment to the street to charge their vehicle.

4.4.3 Charging Experience and Amenities

TNC drivers are satisfied with EA chargers and have noticed that uptime has generally improved over the past year; however, they would like to see greater consistency across charging sites. One driver reported that lack of reliability among EA charging stations prompted them to purchase memberships for different charging platforms. Drivers also noted that chargers listed as online on EV charging apps are actually not online upon arrival. They mentioned that real-time user input on apps such as PlugShare and Shell Recharge would be helpful so that PGE can quickly identify issues and fix chargers.

TNC drivers reported that they chose chargers to use based on charger type and proximity to specific locations. Drivers reported choosing chargers based on the speed of charging (five mentions), the proximity to their location or destination (three mentions), or proximity to amenities such as stores, restrooms, or other conveniences (three mentions). Given the time that it takes them to charge their vehicle, TNC drivers will typically look for charging stations with amenities such as restaurants, grocery stores, and shopping malls.

Participants reported issues at the Downtown EA location including: EV drivers who park their vehicles in charging stations without charging, vehicles left overnight, and non-electric delivery vehicles blocking the station. This station was also reported as being one of the most heavily used by TNC drivers. Drivers felt additional accountability for illegal parking and charger idling is needed to make it easier to charge at this location. Other issues that TNC drivers reported included other EV drivers unplugging the charger from their vehicle and hitting the emergency stop button, in order to charge their own vehicle.

TNC drivers suggested that charging sites with amenities similar to those at gas stations would improve the charging experience, as would deploying charging sites close to stores, restaurants, and bathrooms. Drivers indicated that amenities such as trash cans, bathrooms, and vending machines would improve their charging experience. Additionally, drivers reported that shaded charging stations would prevent their cars from overheating while charging on hot days. Table 17 provides a list of charging location amenities suggested by participants.

Table 17. Amenities Mentioned by Participants (n=8)

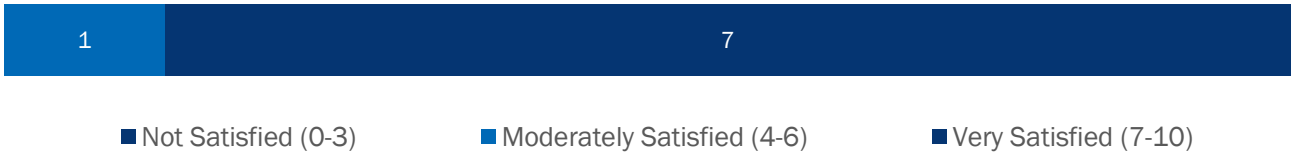
Amenity	Number of Mentions
Shade	3
Lighting at site	2
Security presence (e.g., security guard, cameras)	1
Trash cans	1
Bathrooms	1
Vending machine	1
Air for tires	1
Carwash	1
Vacuums	1
Squeegees	1

TNC drivers agreed that security is a concern at the Downtown Portland and Eastport Plaza sites. Three drivers felt the most unsafe while charging at these locations. One TNC driver noted they were on constant guard while charging because they were concerned about being robbed. Drivers also noted they would only charge at night at locations with lighting (two mentions) or a security guard (one mention).

4.4.4 Sentiments Towards EVs

Overall, TNC drivers expressed high levels of satisfaction with their EVs. Nearly all participants (7 of 8) rated their satisfaction with their EV as a seven or higher on an 11-point scale (Figure 10). Drivers reported that they preferred the feeling of driving an EV compared to an ICE vehicle (three mentions). Other benefits that drivers mentioned included the lower cost of ownership compared to an ICE vehicle (seven mentions) and increased profits driving an EV compared to an ICE vehicle (seven mentions). One participant who reported moderate satisfaction with their EV noted they have to stop to charge at least once a day for an hour. A couple of drivers also raised concerns about battery longevity (four mentions), limited vehicle range (two mentions), and the future cost of the battery replacement (one mention).

Figure 10. Driver Satisfaction with EV (n=8)



5. Electric Avenue Pilot

As described in the 2019 annual report, PGE developed the Electric Avenue (EA) pilot under its initial TE Plan to help increase the growth of EV adoption and support the growing network of EV charging infrastructure. PGE's first EA site in Downtown Portland was opened to the public in 2015. EA pilot activities in 2019 and 2020 included expanding the EA network to include six additional sites throughout PGE's service territory (Table 18). Users could charge their vehicles at EA sites for $3 per two-hour session using an L2 charger, $5 per two-hour session using a DCFC, or an unlimited charging plan for $25 per month.[19] To take peak time into account and shape demand, PGE charged an additional $0.19 per kWh when customers charge their EVs at the EA sites between 3:00 p.m. and 8:00 p.m.

Table 18. EA Network Site Information

Location	Site Description	Open Date	# L2 Chargers	# DCFCs
Downtown Portland[a]	Street parking in front of World Trade Center in Downtown Portland	2015	2	4
Milwaukie	Parking lot in Downtown Milwaukie	4/6/2019	2	4
Hillsboro	Shopping plaza	5/18/2019	2	4
East Portland	Shopping plaza	10/26/2019	2	4
Salem	Street parking in front of Oregon State Capital building	1/16/2020	2	2
Beaverton	Public parking lot across from shopping plaza	2/3/2020	2	4
Wilsonville	Library and shopping plaza	4/6/2020	2	4

[a] Also known as the World Trade Center EA. Note that the Downtown Portland EA was the first EA site PGE opened and is not included in the EA pilot evaluation.

5.1 EA Site User Survey

This section summarizes the results of the EA intercept and online web surveys. The research team fielded in-person intercept surveys at six of PGE's seven EA sites in May 2022.[20] To supplement data collected at EA sites, the team also conducted a web survey in September 2022 with EA users. Detailed findings from the event can be found in Appendix E.

5.1.1 EA User Characteristics

EA users are generally PGE customers who own their home, while a notable minority report living in multi-family homes. A majority (76%) of respondents reported PGE provides service at their homes. About two-thirds (64%) of respondents reported residing in single-family homes, with the remaining living in multi-family homes (34%) or manufactured homes (2%). Surveyed EA users were considerably less likely to report living in single-family homes compared to EV owners in PGE's service territory (64% compared to 92%).[21] Further, EA monthly subscribers were somewhat more likely to report living in multi-family homes compared to non-subscribers (41% compared to 32%). About two-thirds (61%) of respondents reported owning their homes.

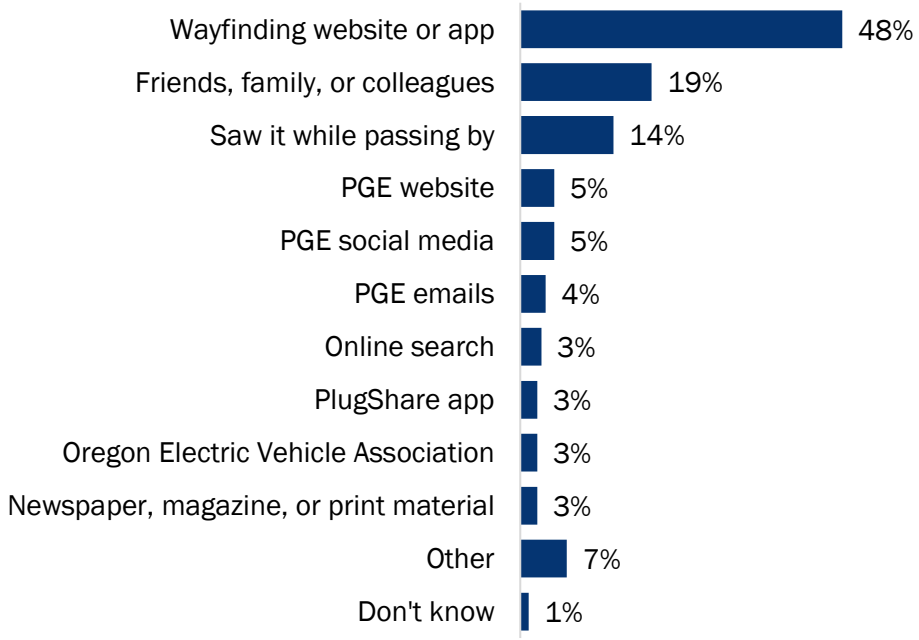
[19] The two-hour charging time limit is dictated by the parking signage installed at the EA sites, and not the tariff.
[20] The research team did not field intercept surveys at PGE's Salem EA site because the site was offline due to construction at the time.
[21] Based on 2021 survey of EV owners in PGE's service territory conducted by Opinion Dynamics. Survey results can be found in the 2021 Annual Report.

Nearly all (92%) respondents used their EVs for personal use, with some using their EVs for rideshare driving (10%), on-demand delivery driving (5%), or for other commercial purposes (6%). Slightly over one in ten (13%) respondents reported using their vehicles for both personal and commercial purposes.

5.1.2 Awareness of EAs and Payment Methods

Respondents generally learned about PGE's EAs through non-PGE sources. Nearly half (48%) of respondents reported learning about PGE's EAs through a wayfinding website or app, with about one-fifth (19%) learning about them from friends, family, or colleagues (Figure 11). Few respondents reported learning about EAs from the PGE website (5%), social media (5%), or emails (4%).

Figure 11. Source of Awareness of PGE's EAs (n=159; Multiple Responses Allowed)



Respondents are generally satisfied with EA pricing and the payment process. Three-quarters of respondents were very satisfied with both the cost of EA charging and the payment process (Figure 12). When asked for suggestions for payment process improvements, comments mainly focused on replacing flat-rate pricing with per-kWh pricing or issues with the Shell Recharge app.

Figure 12. Satisfaction with EA Pricing and Payment Process (n=159)

When asked about their preferred payment method, EA user opinions were mixed. Nearly equal numbers of respondents reported they would prefer to pay for just the amount of energy they used (37%) as prefer a monthly subscription (35%). The remaining respondents prefer flat rate charging (28%). Nearly all (85%) respondents who reported preferring to pay for just the amount of energy used, indicated they typically pay a flat rate when charging at PGE's EAs. Additionally, about two-thirds (61%) of PGE customers reported they would like to have the option to pay for EA charging on their home electric bill.

5.1.3 Reasons for using EAs and User Experiences

Reasons for using PGE's EAs differed between monthly subscribers and non-subscribers. When asked the main reason for charging at PGE's EAs, monthly subscribers were more likely to indicate that they live or work nearby, whereas non-subscribers were more likely to report passing through the area for errands when charging (Table 19).

Table 19. Main Reason for Charging at Surveyed EA

Reason	Subscribers (n=50)	Non-Subscribers (n=109)
Live nearby	38%	21%
Work nearby	26%	15%
Plan my trips so I can charge at this EA regularly	18%	14%
Have other errands to do in the area	8%	26%
Travelling through the area but do not regularly use this EA[a]	6%	13%
Needed fast charging	0%	3%
Another reason	4%	9%
Total	**100%**	**100%**

[a] Item only displayed to intercept survey respondents. Some web respondents mentioned in open ended comments that they were traveling through the area and do not regularly use PGE's EAs and were coded into this response option.

Monthly subscribers are more likely to be frequent users of PGE's EAs. Four-fifths (80%) of subscribers reported charging at an EA at least once a week, compared to just over one-quarter (28%) of non-subscribers (Table 20).

Table 20. Frequency of Charging at an EA

Frequency	Subscribers (n=50)	Non-Subscribers (n=109)
Several times per week	58%	8%
About once per week	22%	20%
2-3 times a month	6%	14%
About once per month	6%	20%
Rarely	6%	31%
Once	2%	6%
Total	**100%**	**100%**

Most respondents report charging their EVs at PGE's EAs outside of EA peak hours (3pm – 8pm) and a majority are aware of the peak surcharge (Table 21). Nearly three-quarters (71%) of respondents reported that they typically charged outside of the hours between 3pm and 8pm, when a surcharge of $0.19/kWh is assessed. About two-thirds (60%) of respondents reported they were aware of the peak surcharge, with subscribers being slightly more likely to report being aware compared to non-subscribers (56% compared to 49%, respectively). Among those who were aware of the surcharge, about one-quarter (24%) reported charging during peak hours compared to one-third (33%) of those who were not aware of the surcharge.

Table 21. Typical Charging Times (n=159)

Charging Hours	Percent
Before 9am	6%
Between 9am and 3pm	52%
Between 3pm and 8pm	30%
After 8pm	13%
Total	**100%**

5.1.4 Influence of EAs on EV Purchase

The availability of PGE's EAs is moderately influential in respondents' decision to purchase or lease EVs. Over half (57%) of respondents were aware of PGE's EAs prior purchasing their EV. Among those who were aware of EAs prior to purchasing their EV, about half (52%) indicated PGE's EAs were either somewhat or very influential in their decision to purchase or lease their vehicles (Figure 13).

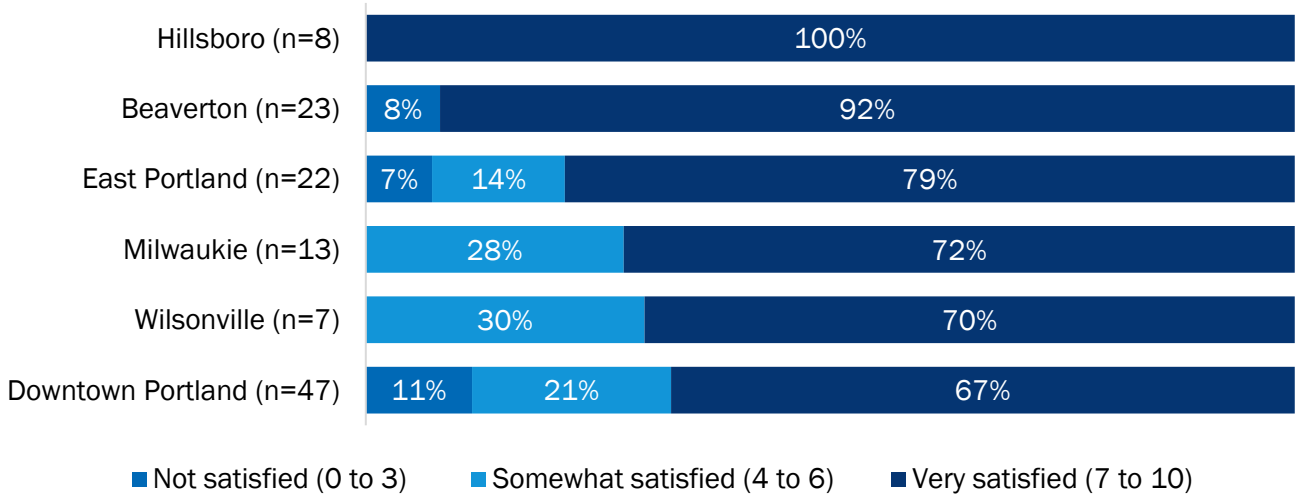
Figure 13. Influence of Availability of EAs on Purchase Decisions Among Those Aware of EAs Prior to Purchase (n=90)

5.1.5 Satisfaction and Recommendations for Improvements

We asked respondents to rate their satisfaction of specific aspects of the EA they typically charged at or, for intercept survey respondents, the site where the survey was conducted. We broke results down by EA site to gauge the differences in user experience by site.

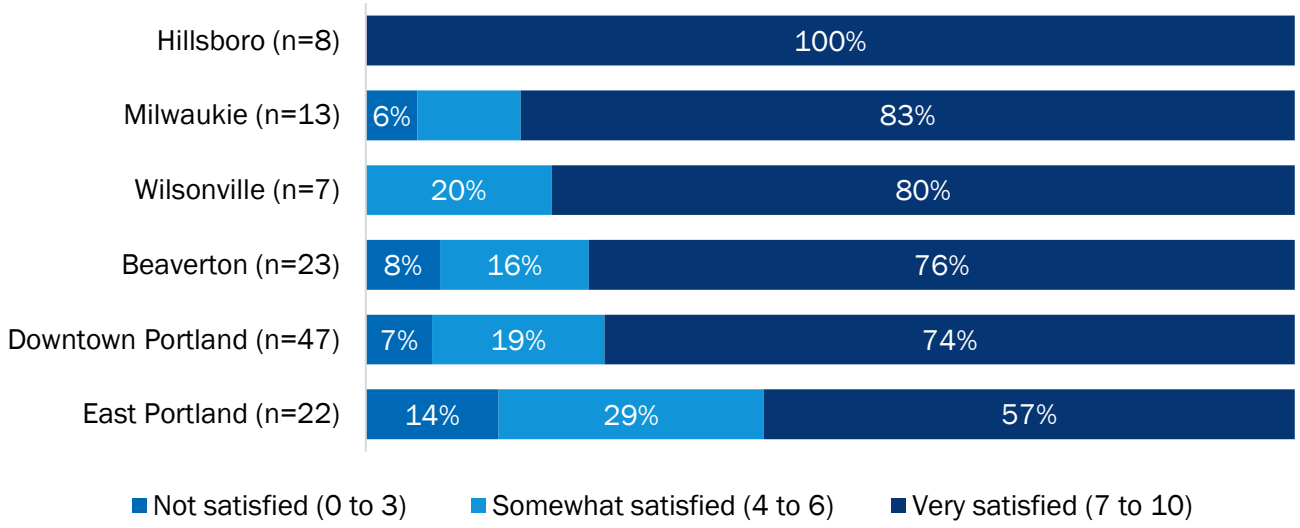
While respondents are generally satisfied with charger availability, those who typically use the Downtown Portland site are least satisfied. About one-third (32%) of respondents indicated some dissatisfaction with charger availability at the Downtown Portland EA (Figure 14). The site usage analysis that we conducted for the 2020 Annual Report found that the Downtown Portland EA site was the highest utilized EA, which is likely leading to congested charger availability. Further, during a 2022 focus group with TNC and on-demand delivery drivers, participants mentioned issues at the Downtown Portland EA including: EV drivers parking vehicles in charging stations without charging, vehicles left overnight, and non-electric delivery vehicles blocking the station. This station was also reported as being one of the most heavily used by TNC and on-demand delivery drivers. In open ended comments, 13 respondents who typically use the Downtown Portland EA location mentioned that they would like to see additional chargers at this location.

Figure 14. Satisfaction with Availability of EA Open Charging Stations



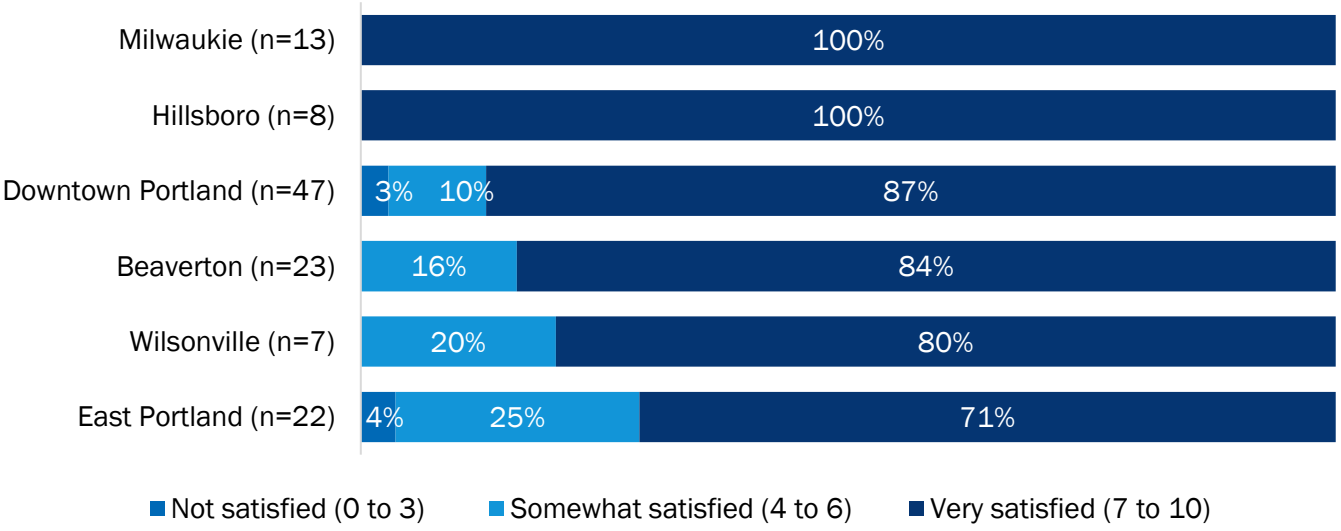
Respondents have concerns about charger reliability at some EA sites. While satisfaction with charger reliability was moderate to high for most sites, a few respondents who typically use the East Portland, Downtown Portland, and Beaverton EA sites expressed dissatisfaction (Figure 15).

Figure 15. Satisfaction with Charger Reliability at EA Site



Nearly all respondents were at least somewhat satisfied with the location of each EA. Respondents who were "very satisfied" ranged from 71% for East Portland to 100% for the Hillsboro and Milwaukie EAs (Figure 16).

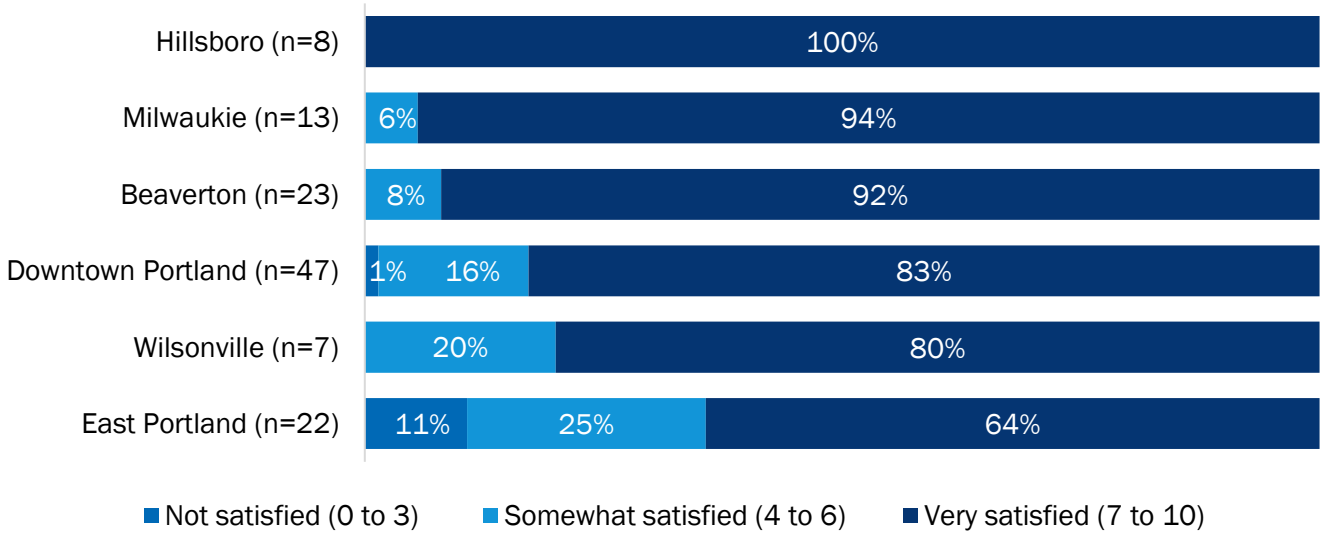
Figure 16. Satisfaction with Convenience of Location of EA Sites



Respondents were generally satisfied with their on-site experience at PGE's EAs, with somewhat lower satisfaction with the East Portland EA site. Those respondents who were very satisfied ranged from 64% for East Portland EA users to 100% for respondents who used the Hillsboro EA (Figure 17). When asked to suggest improvements, one respondent who charged at the East Portland EA felt that the chargers should be, "[placed] closer to a business I want to frequent while I wait. [Being in] the middle of a huge parking lot means a long unsheltered walk anywhere." Other suggested improvements to PGE's EA sites mentioned by

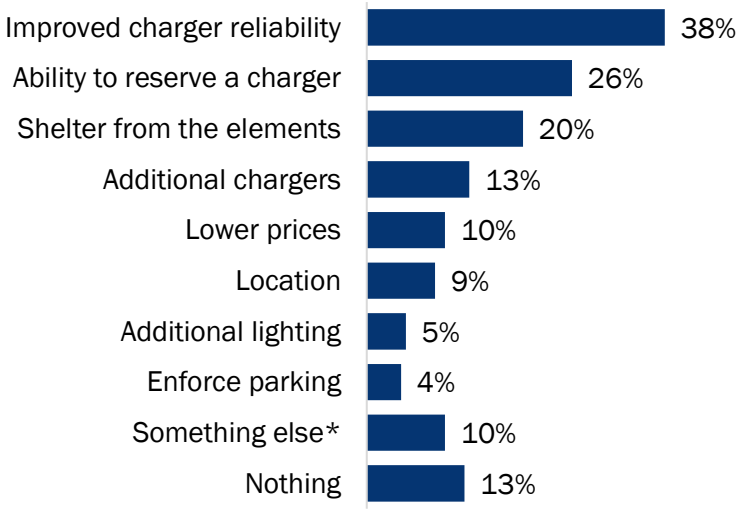
more than one respondent included having restrooms nearby (4 users), adding trash cans to EA locations (3 users), and better lighting at night (3 users).

Figure 17. Satisfaction with EA Site Experience



After using EAs, respondents were generally satisfied with various aspects of the charging experience. However, when asked what would encourage them to increase their EA use, nearly 90% suggested at least one area for improvement (Figure 18). The most mentioned area of improvement was to improve charger reliability (38%), with about half (49%) of Downtown Portland EA users reporting a need for improved charger reliability.

Figure 18. Suggestions to Encourage Frequent Usage of EA (n=159; Multiple Responses Allowed)



Note: Includes response suggestions such as safety concerns, public restrooms nearby, and longer charger cords.

5.2 Impact Analysis

The following sections provide results from the team's analyses of EA charger utilization data. We analyzed charging data measured at each charger at each EA charging station site from April 2019 to October 2022. The Downtown Portland EA is not part of the EA pilot but is PGE's most established and utilized EA site; we included Downtown Portland in some analyses for comparison to other EA sites. We note the results that do not include the Downtown Portland EA. We excluded PGE employees using the Downtown Portland EA from all analyses. The Salem EA was removed from service during the data capture period due to construction at the Oregon State Capital building. Charging load impacts from Salem were excluded from the analysis presented in this section but are explored in Appendix A.

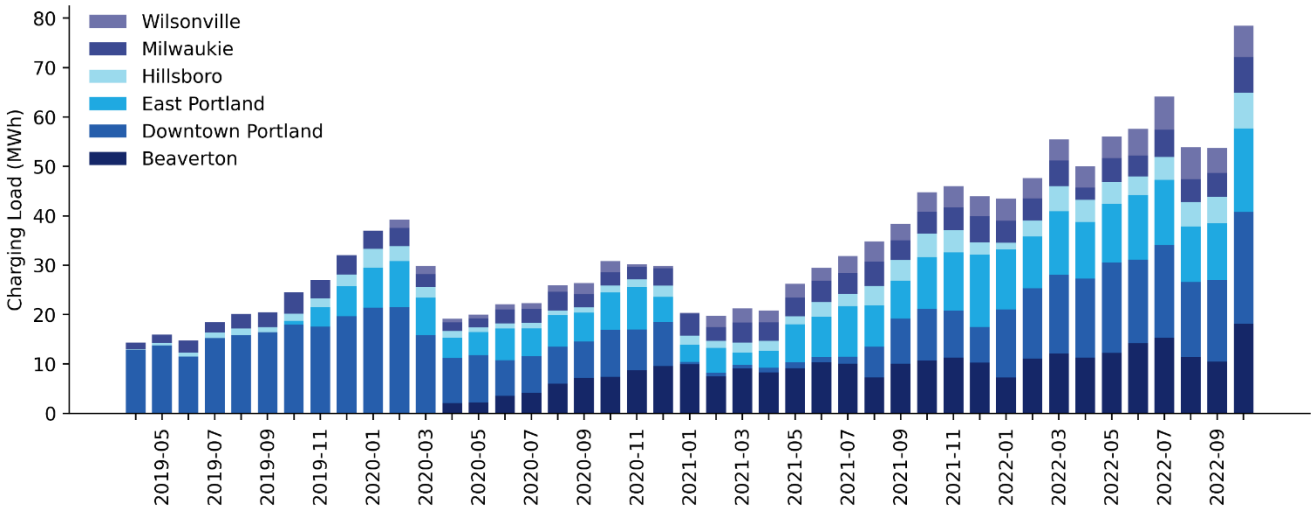
5.2.1 Change to Consumption and Charging Patterns

Aggregated monthly energy consumption increased from April 2019 through October 2022 (the end of the analysis period), reaching 79 MWh per month in October 2022 (Figure 19).[22] After all sites were operational, the total monthly charging load ranged from 19 - 79 MWh and the load factor ranged from 10% to 24%. The monthly charging load varied significantly between all the EA sites. In most months, the Downtown Portland EA had the highest usage and the greatest monthly energy consumption at 11 MWh on average. Higher charging load at the Downtown Portland EA is likely attributed to its central location in Downtown Portland, near many amenities and businesses. The Beaverton EA site had the second highest usage at 8.7 MWh on average since its opening in February of 2020. The Hillsboro and Wilsonville EAs had the lowest charging loads with an average monthly consumption of 2.6 and 3.0 MWh, respectively.

Early in the pilot, a significant decline in charging loads occurred at all EA sites following February 2020 due to the initial impacts of COVID-19. Charging loads increased from April 2020 through the end of that year, in part due to the opening of the final EA site in Beaverton. Another charging load decline occurred in January 2021, driven by a decrease in charging at the Downtown Portland EA site. PGE staff noted that the chargers installed in the Downtown Portland location experienced significant operational issues in colder weather, which could partially contribute to the observed decline in charging load. The charging equipment was replaced in the summer of 2021, which could explain why a similarly large drop in charging load was not observed in the winter of 2022. Charging load has increased, on average, 6.3% per month since February 2021, peaking in October 2022 at 79 MWh. Since the first month that all six sites were open (February 2020), monthly charging load has approximately doubled from 39 MWh to 79 MWh.

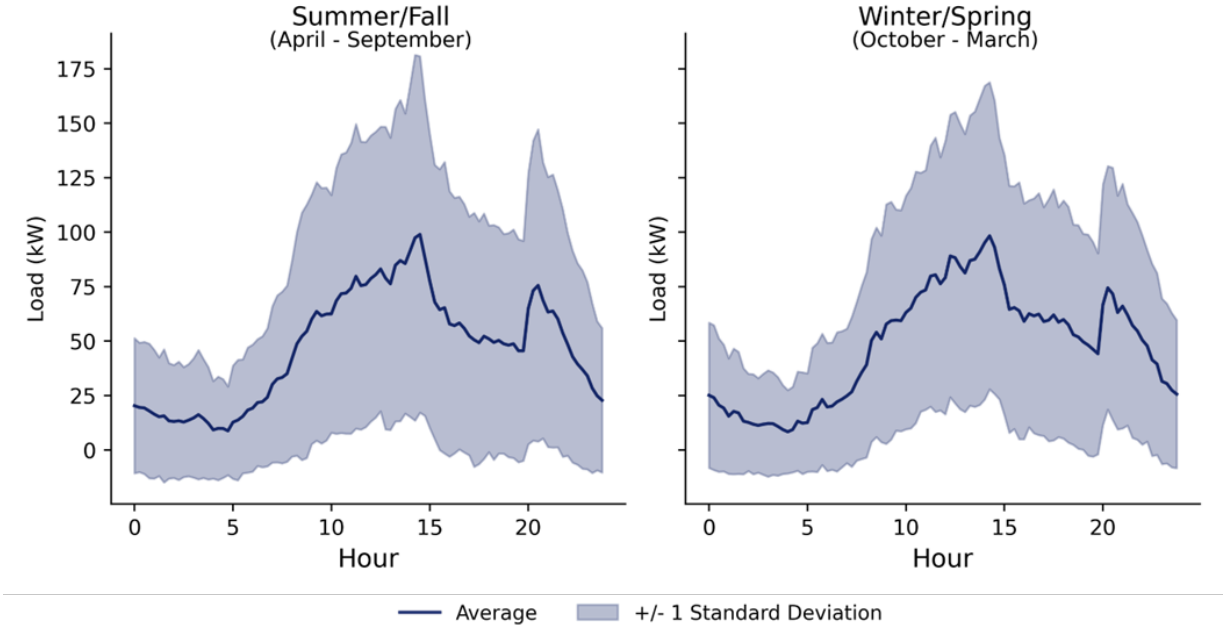
[22] The analysis calculates charging load impacts based on the energy delivered to vehicles and does not include losses due to charger efficiency. The demand on the grid from charging load would include losses due to charging efficiency.

Figure 19. Monthly Charging Loads at PGE EA Sites Over Time



The average charging load for all EA sites combined is plotted in Figure 20 with one standard deviation from the average shaded. The average load profile started to ramp up around 6:00 a.m. and peaked in the afternoon. The peak was around 2:00 p.m. in both winter/spring and summer/fall.[23] Charging load decreased after 3:00 p.m. due to the peak pricing surcharge (weekdays, 3:00 p.m. to 8:00 p.m.). A secondary peak occurred around 8:00 p.m. in both winter and summer and can likely be attributed to the end of the peak pricing hours at EA sites. Significant seasonal differences in charging behavior were not observed.

Figure 20. Average and Standard Deviation (shaded) Seasonal Load Profile for all EA Charging Load

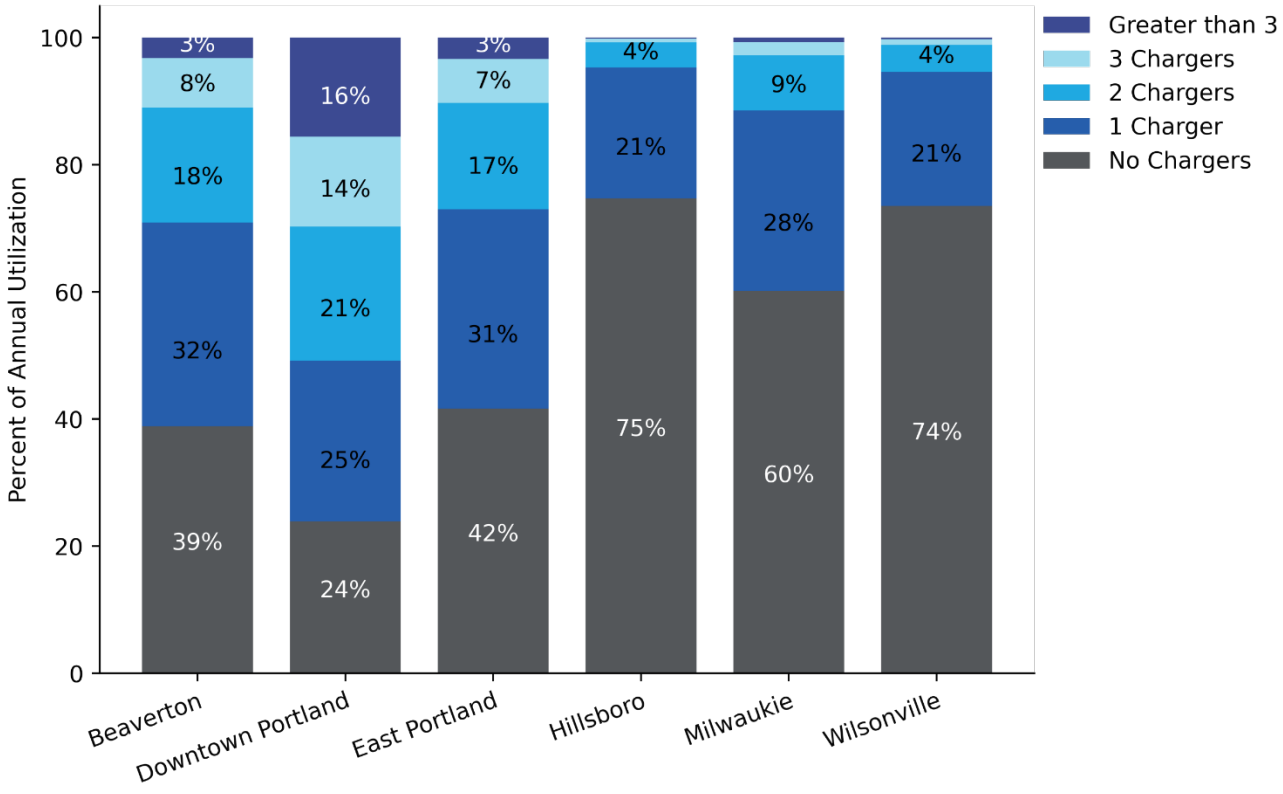


[23] Summer/Fall is defined as April through September, and winter/spring is October through March.

Peak pricing surcharges appear to be influencing charger usage. Analysis shows that charging load patterns varied slightly between EA sites. (See Figure 45 in Appendix A for average charging load shapes by weekday and weekend for each EA site.) On weekdays across all EA charging locations, lower load was observed from 3:00 p.m. to 8:00 p.m. followed by a load spike at the end of this period. This pattern is most noticeable at the East Portland and Beaverton EAs and likely reflects the effects of peak pricing surcharges that are applied during that time on weekdays. However, on weekends when peak pricing surcharges are not applied, depressed load from 3:00 p.m. to 8:00 p.m. is not observed at any site, suggesting that peak pricing surcharges are influencing charging patterns. Downtown Portland is the only EA site that exhibits a weekday morning peak. All sites generally experienced lower loads from midnight to 5:00 a.m. Average weekend load was not signficantly lower than weekday load at any site.

The EA site with the highest utilization rate was Downtown Portland followed by East Portland, and then Beaverton (Figure 21).[24] At least one charger was in use between 21% to 32% of daytime hours (8 a.m. to 8 p.m.) at all sites. Hillsboro had the lowest utilization rate of 25%. More than three chargers were in simultaneous use at a site less than 4% of the time at all sites except Downtown Portland, suggesting that customers usually do not need to wait for charging at EA sites.

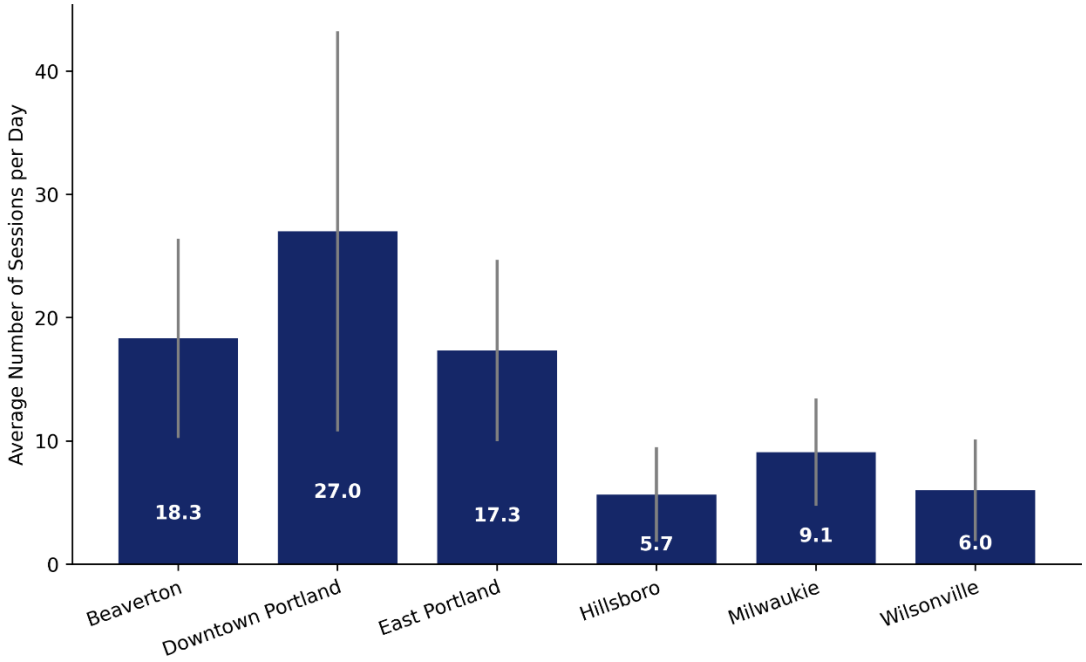
Figure 21. Annual Charger Utilization at EA Sites



[24] The site utilization rate was calculated for each EA site as the percentage of time between 8 a.m. and 8 p.m. a given number of chargers were in simultaneous use since the site became operational. Note that site utilization measures whether any chargers are in use while the other commonly reported metric, charger utilization, measures whether a particular charger is in use.

The average number of EA charging sessions ranged between 5.7 at Hillsboro and 27 per day at Downtown Portland (Figure 22).

Figure 22. Average Number of Charging Sessions per Day at EA Sites

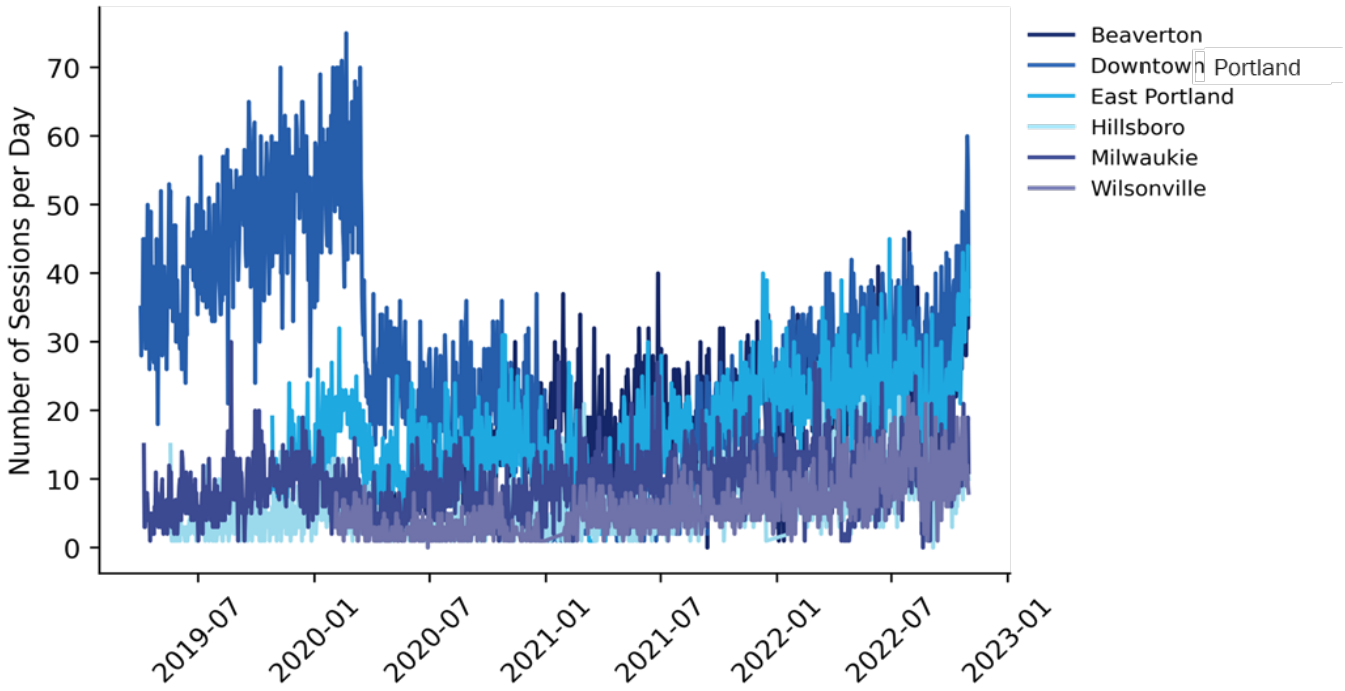


Note: Average shown in blue bars with standard deviation shown in grey lines.

The number of charging sessions per day generally increased over the analysis period at all sites, except for Downtown Portland. While the number of charging sessions fluctuated significantly from day to day as seen in Figure 23, the number of charging sessions per day generally increased at all locations over the analysis period. The exception to this trend is Downtown Portland, where daily charging sessions declined significantly in early 2020 around the beginning of the COVID-19 pandemic. Although charging load had recovered to pre-pandemic levels at Downtown Portland as seen in Figure 19, the number of charging sessions per day had not recovered, which suggests that pre-pandemic charging sessions were shorter and delivered less energy per session as compared to charging sessions in late 2022. Possible reasons for the changes to utilization of the Downtown Portland EA include:

- Lingering impacts of the COVID-19 pandemic on the number of workers and visitors traveling in Downtown Portland.
- Businesses closing or relocating due to prolonged protests in Downtown Portland during the Summer of 2020.
- The Downtown Portland EA was highly utilized by TNC drivers for short charging sessions prior to the pandemic and a persistent decline in post-pandemic TNC ridership could explain the lower number of charging sessions per day.
- A decline in parking restriction enforcement since the beginning of the pandemic could also have led to longer charging sessions delivering more energy per session, which could have also contributed the observed changes in how the site is utilized.

Figure 23. Number of Charging Sessions Per EA Site Per Day Over Time



5.2.2 Peak Impact

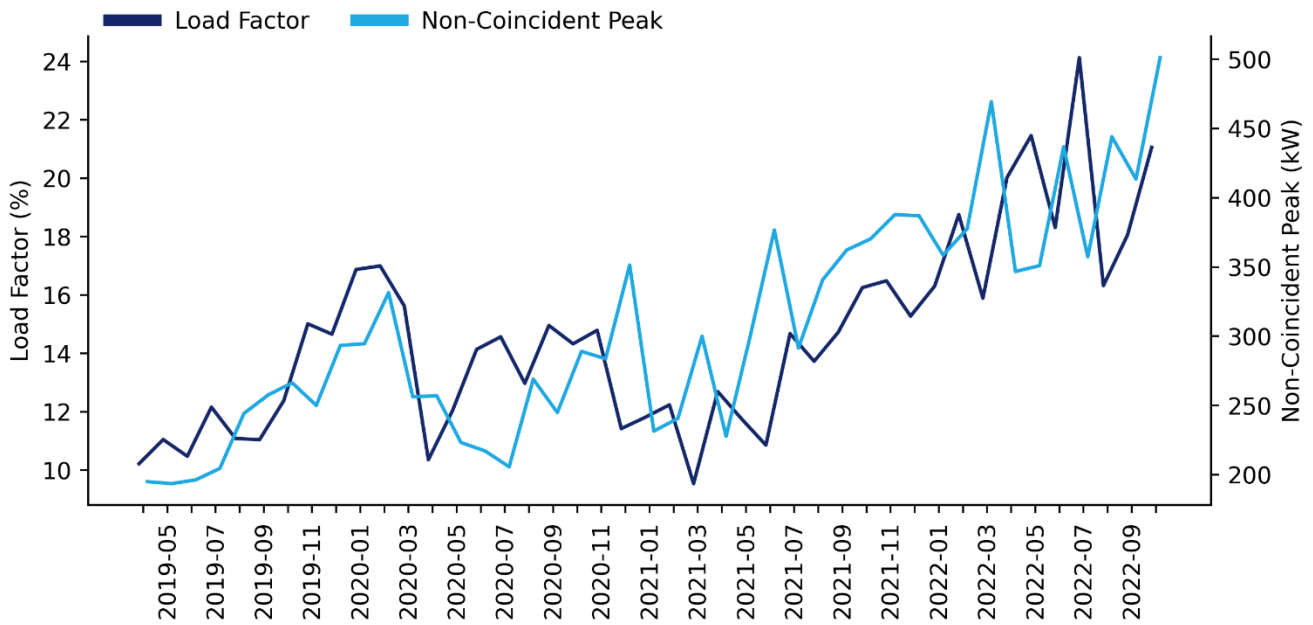
Throughout the study period, the non-coincident peak (NCP) load and the load factor of all EA charging generally increased (Figure 24). The increase in load factor can be attributed to the growing energy consumption during the study period, and the increase in NCP load is due to more chargers coming online as additional EA sites opened.[25] After all charging stations were online, the NCP load ranged from 194 - 501 kW.

PGE's EAs saw utilization that is in line with other utility territories with average load factors of approximately 15%. As show in Figure 24, load factors generally increased during the analysis period reaching 19% on average in 2022. Previous studies have found that load factors at "highly utilized" DCFC charging stations in California are 15% to 20%.[26]

[25] The load factor is defined as the ratio of average charging load and the maximum charging load over a given period of time. Here, the load factor is calculated as the average charging load of all EA stations divided by the NCP load for each month of the study period.

[26] Source: https://www.nrel.gov/docs/fy19osti/73303.pdf

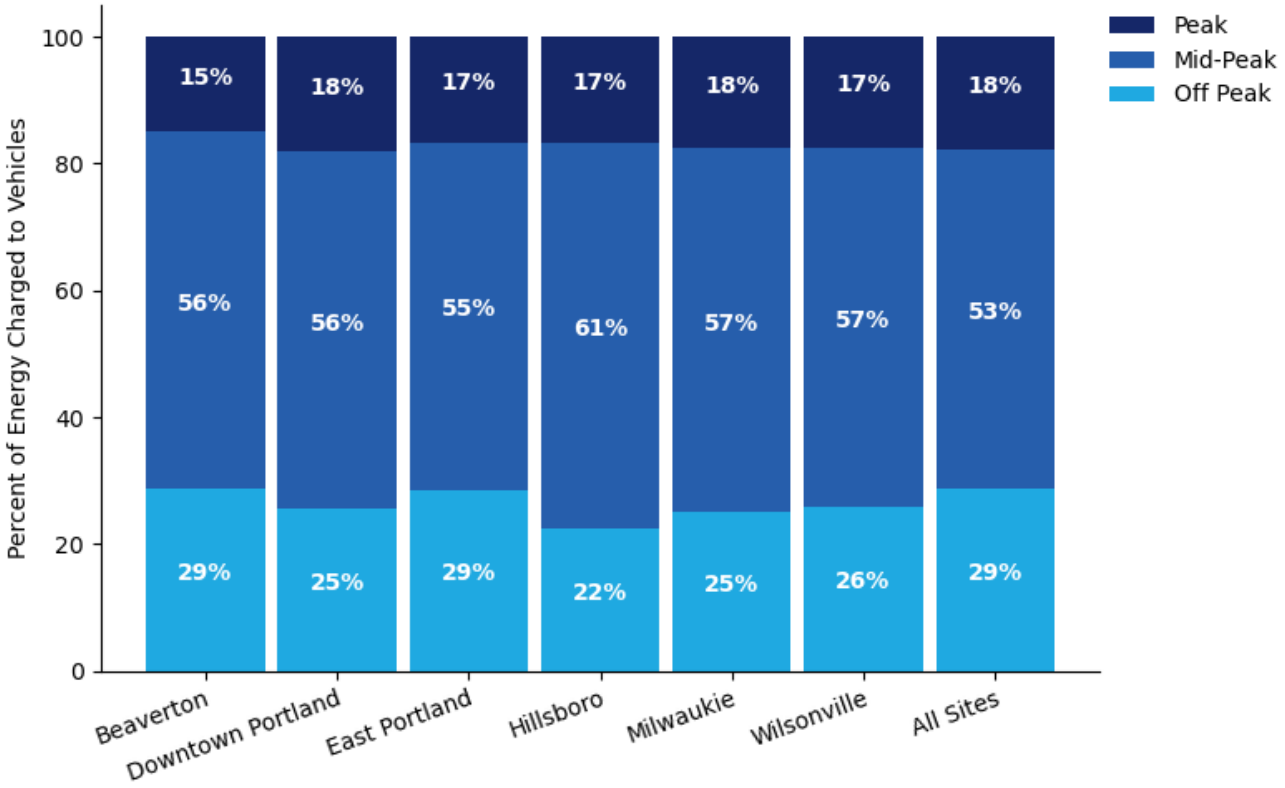
Figure 24. Monthly Non-Coincident Peak Load and Load Factors of all EA Charging Sites



The percentage of total energy consumption that occurred during the peak time periods (weekdays between 3:00 p.m. and 8:00 p.m.) ranged between 15% to 18% at EA sites, and the total on-peak TOU period energy consumption for all sites combined was 18% (Figure 25.).[27] The peak energy consumption was highest at the Downtown Portland EA, followed by the Milwaukie EA, and lowest at the Beaverton EA.

[27] The TOU period is defined based on PGE's residential TOU tariffs. We chose to use this tariff because the residential TOU period is potentially more in line with PGE's system load and provides a good proxy for estimating peak impact. These TOU periods define Winter/Spring as November – April and Spring/Summer as May – October, which is different from how seasons are defined in the rest of the analysis. https://portlandgeneral.com/energy-choices/energy-choices-home/time-of-use-pricing-home

Figure 25. Percentage of Energy Consumption According to Time-of-Use Period at EA Sites



Bulk System Peak Impact

In addition to NCP load, we also investigated the system-coincident peak, which represents the charging load peak contribution during PGE's system peak hours. Table 22 below summarizes charging load at each site during the top 3% of PGE's system load hours as a percentage of site capacity. At all sites and seasons during the analysis period, average charging load during peak hours was less than 25% of charging capacity at each site, which indicates that charging at the EA sites is not highly coincident with PGE system peak loads. Throughout the analysis period, the average charging load during the top load hours varied significantly between seasons, but load during the summer/fall was generally higher than in the winter/spring, particularly in 2021-2022.[28]

[28] Summer/fall is defined as April through September, and winter/spring is October through March.

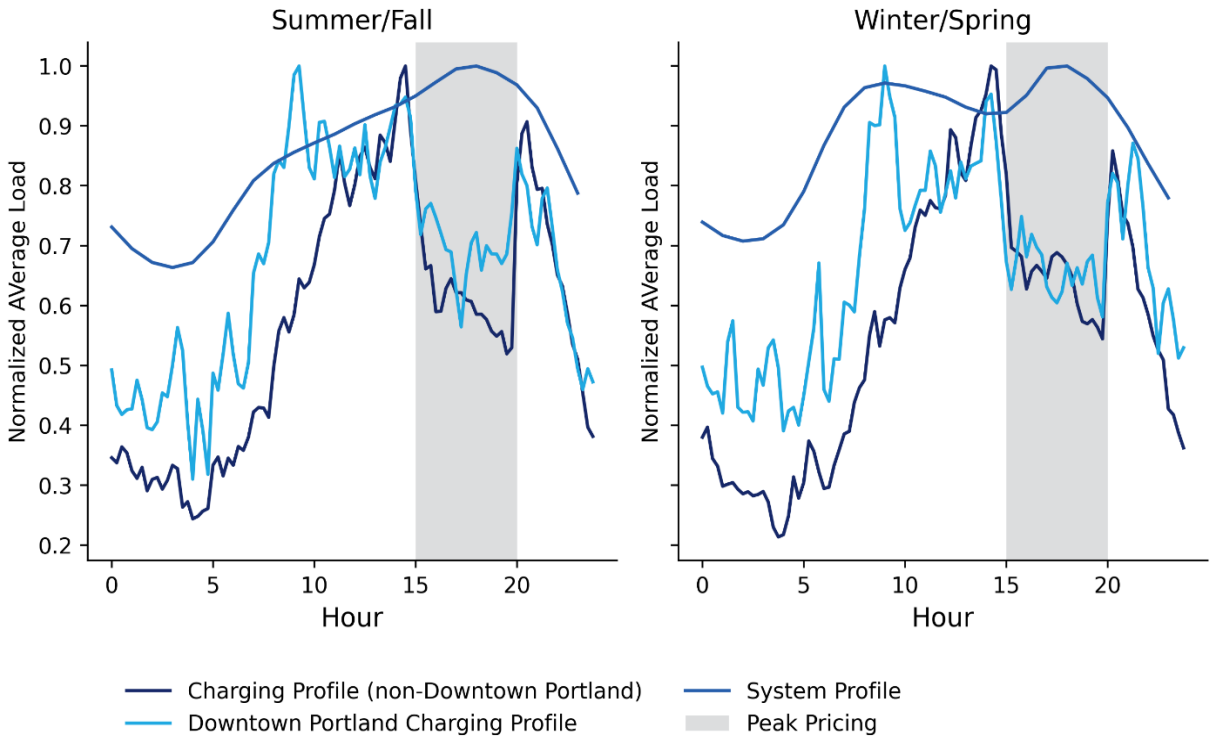
Table 22. Charging Load During Top 3% Peak Hours as a Percentage of Site Capacity

EA Site	Average charging load during feeder peak hours (% of site capacity)		
	Winter/Spring		Summer/Fall
	Morning	Evening	
Beaverton	11.2%	11.9%	17.1%
Downtown Portland	20.1%	15.4%	17.5%
East Portland	11.9%	14.8%	16.3%
Hillsboro	5.6%	4.7%	5.6%
Milwaukie	5.7%	8.6%	8.0%
Wilsonville	3.6%	3.9%	8.0%

Note: Summer/fall is defined as April through September, and winter/spring is October through March. Analysis considers period from the summer 2019 season through the summer 2022.

The peak pricing program appears to be highly effective in shifting charging loads away from system peak load periods. The normalized average system load in the summer peaked between 6:00 p.m.–7:00 p.m. when EV charging load is lowest during the peak pricing window (Figure 26). In the winter, neither morning nor evening system peak occurs when charging load is peaking. There is a greater coincidence of Downtown Portland EA charging load with the system winter morning peak compared to all other sites as charging load at the Downtown Portland EA ramped up faster.

Figure 26. Normalized System Load Shape verses the Normalized Charging Profile



Distribution System Peak Impact

We investigated the potential impact of each EA site on the distribution system based on feeder loads and ratings provided by PGE. To estimate the impact on potential future feeder upgrades, the team calculated the feeder loading with the historical EA charging load from 2022, which is the year with the highest charging load. In addition, the team estimated the contribution to feeder loading of EA stations in a worst-case scenario when all chargers are used at the same time.

None of the feeders at the EA sites are at risk of overloading. Currently, when a feeder's loading is above the 67% threshold, it triggers a capacity study by PGE. The maximum total load on feeders serving EA sites has historically been below 64% of rated capacity, indicating that they are not at risk of needing an upgrade (Table 23). Potential feeder loading increases range from 1.07% – 2.06% if all chargers are in simultaneous use, and there would be minimal impact on the distribution system. We considered if the capacity of EA's DCFC chargers were upgraded from 50 kW to 150 kW and found the potential feeder loading increases would range from 3.07% to 5.91% of the feeder's capacity. The charging station with the highest feeder loading is the Wilsonville EA. Feeder City R356, which serves the Wilsonville EA, peaked at 64.1% during summer 2022. Even with all chargers in simultaneous use during the feeder's peak, the loading percent would only reach 65.3%, which is below the 67% threshold instituted by PGE.

Table 23. Loading on Feeders Serving EA Sites

EA Site	Feeder % loading with historical EA charging load		Feeder loading % increase if all chargers are in use	
	Winter/Spring	Summer/Fall	Winter/Spring	Summer/Fall
Milwaukie	25.5%	37.5%	1.36%	2.06%
East Portland	29.0%	37.1%	1.07%	1.20%
Wilsonville	56.0%	64.1%	1.07%	1.17%
Beaverton	42.0%	55.1%	1.07%	1.20%
Hillsboro	20.4%	48.7%	1.07%	1.20%

Note: Downtown Portland EA site was not included in this analysis because data for this feeder was not available. Potential feeder loading % increase is calculated as maximum EA charging capacity (MW) / feeder seasonal rating provided by PGE for 2022.

Additionally, we examined the impact on distribution feeders by determining the average share of charging capacity in use during the top 3% of load hours on the feeder serving each site. As shown in Table 24, charging load was less than 20% of the capacity of the chargers during distribution peak load hours, suggesting that charging load had minimal impact on increasing distribution peak load.

Table 24 Charging Load During the Top 3% of Distribution System Peak Hours

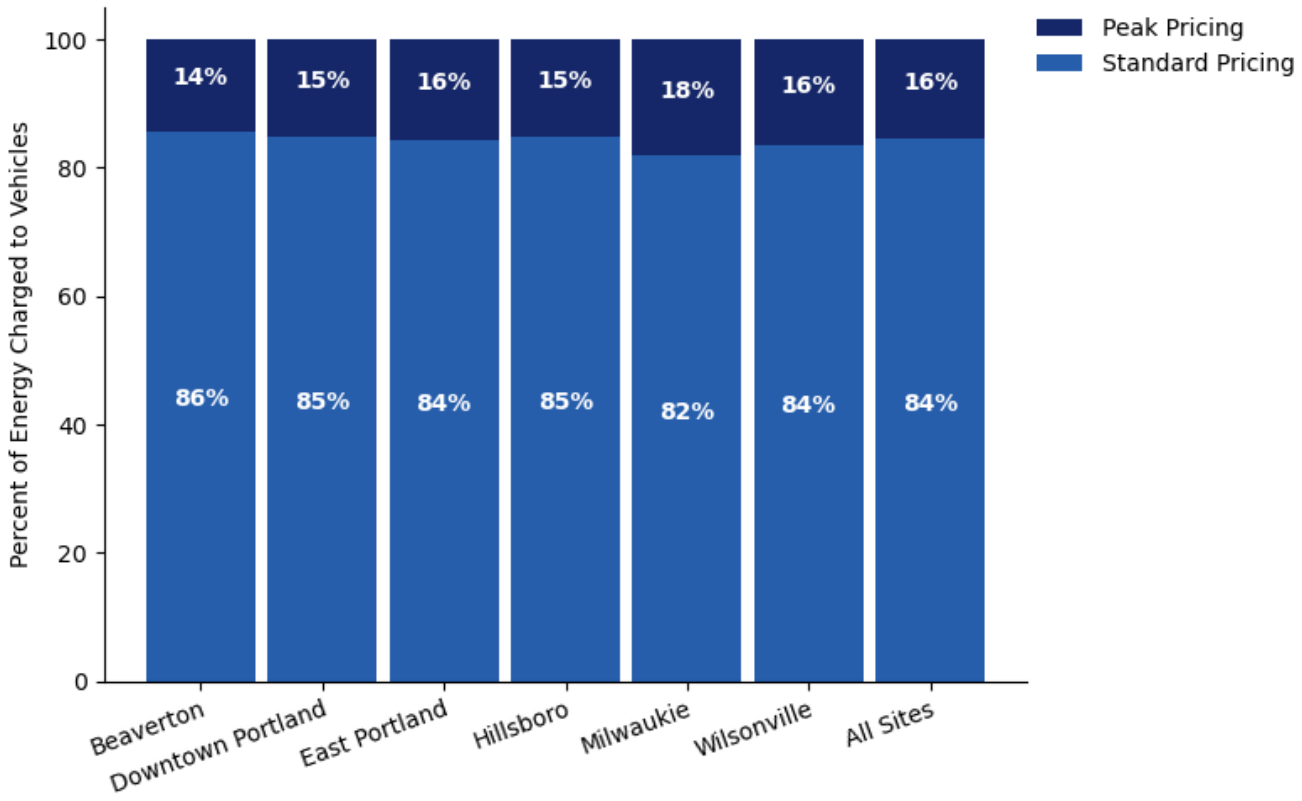
EA Site	Average charging load during feeder peak hours (% of site capacity)	
	Winter/Spring	Summer/Fall
Milwaukie	8.5%	8.8%
East Portland	16.4%	15.4%
Wilsonville	4.8%	7.7%
Beaverton	16.0%	12.3%
Hillsboro	7.6%	4.2%

Note: Downtown Portland EA site was not included in the analysis because data for this feeder was not available. Analysis considers from the summer 2019 season through the summer 2022 for all sites except Hillsboro which spans from the winter 2020-2021 season through summer 2022 due to data availability.

5.2.3 Peak Pricing Impact

During weekdays, EA users incur a $0.19/kWh peak charge between 3:00 p.m. and 8:00 p.m., which has helped shift charging away from the system peak period. Less than 19% of energy consumed at each EA site occurs when sites have peak pricing in effect (Figure 27).

Figure 27. Peak Pricing Period Energy Consumption at EA Sites



5.2.4 DCFCs vs L2 Chargers

EA sites offer both DCFC and L2 charging options. The following section provides a summary of how charging behavior and utilization differs between the two types of chargers.

The vast majority (94% or 1,376 MWh) of energy delivered by EA chargers was delivered by DCFCs. Given the higher capacity of DCFCs, greater energy delivery from DCFCs is expected; however, this finding suggests a customer preference for fast charging.

This preference for fast charging is also observable in relative utilization rates (the percentage of time the charger is in use) of DCFCs as compared to L2 chargers. Across all sites, the DCFC and L2 utilization rates are similar at approximately 8%. However, when Downtown Portland site data were excluded, the utilization rate of DCFC chargers was 7.4%, nearly twice that of L2 chargers (4%), which could be because L2 charging sessions require more time to deliver the same amount of energy or DCFC chargers are unavailable (Table 25). The EA sites' DCFC utilization rate is similar to the 4%–15% utilization rates observed at DCFC charging locations in California.[29] The average charging session duration on L2 chargers at PGE EA sites is 2.5 hours with a standard deviation of 4.3 hours. The average charging session duration on DCFC chargers at those same sites was shorter at 0.9 hours with a standard deviation of 0.7 hours, which is expected due to the higher power delivery of DCFC chargers.

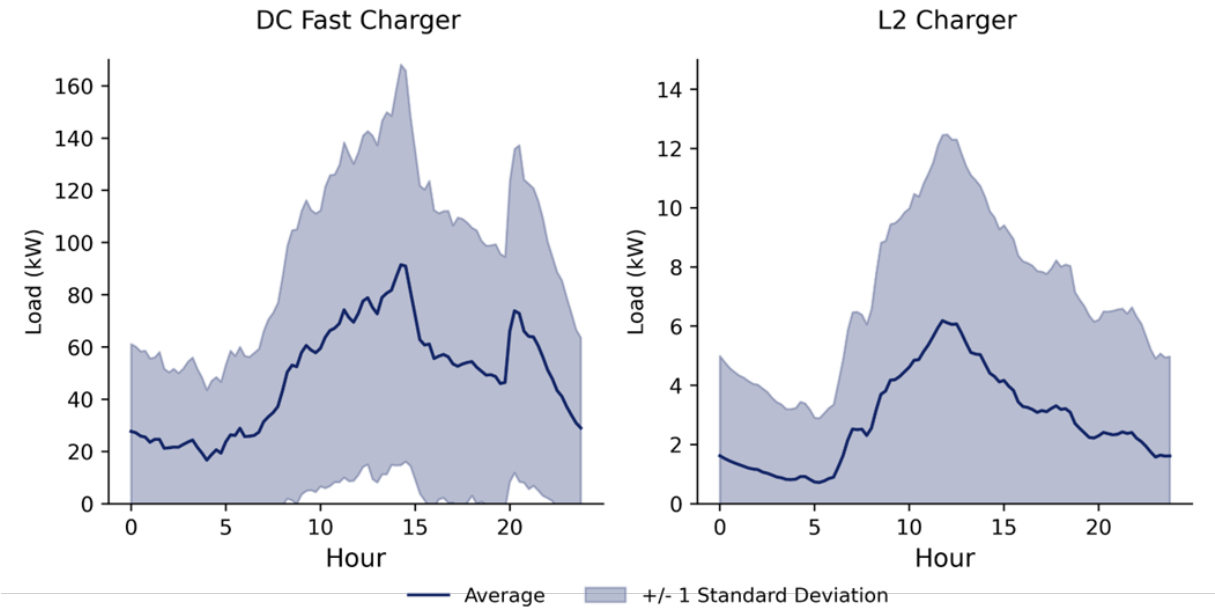
Table 25. DCFC and L2 Energy Utilization and Consumption at EA Sites

Charger Type	Utilization (%)		Energy Consumed (MWh)	
	All EA Sites	All EA Sites Except Downtown Portland	All EA Sites	All EA Sites Except Downtown Portland
DCFC	8.1%	7.4%	1,377	932.8
L2	8.4%	4.0%	81.2	33.9

The daily usage patterns of DCFC and L2 chargers exhibit significant differences (Figure 28). In the team's analysis, the daily average total DCFC load profile exhibits a dual peak pattern. The first occurs around 2:00 p.m. to 3:00 p.m. and the later peak occurs around the end of the peak pricing period (8:00 p.m.). The average daily L2 charging pattern does not exhibit a dual peak. Instead, the L2 daily average profile has a single peak that appears around noon. The usage variation between DCFCs and L2 chargers is likely because the peak price surcharge would be greater for a DCFC charging session the same length as L2 sessions during 3 p.m. to 8 p.m. window due to the higher charging power. If a driver needs to charge their vehicle during the peak period, it appears they are more likely to choose an L2 charger due to the lower cost.

[29] Fitzgerald and Nelder, 2017, "EVgo Fleet and Tariff Analysis: Phase 1: California," Rocky Mountain Institute, https://rmi.org/wp-content/uploads/2017/04/eLab_EVgo_Fleet_and_Tariff_Analysis_2017.pdf

Figure 28. Average Daily Load Profiles for DCFC and L2 Charging with +/- 1 Standard Deviation



5.2.5 Charging Behavior by User Groups

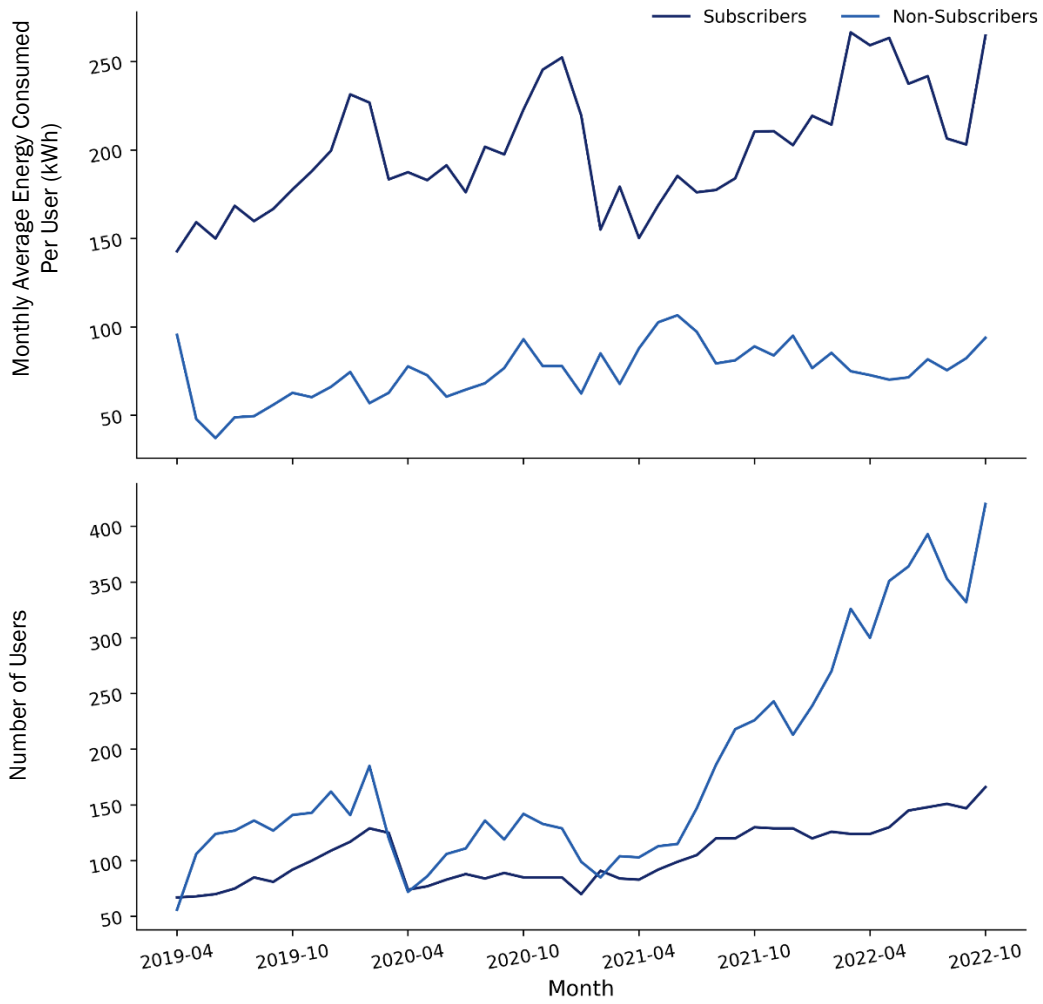
We categorized EA users into two user groups, subscribers and non-subscribers, and investigated the usage pattern differences between these two groups.[30] The subscriber user group included both EA Monthly Plan Subscribers and TNC EA Subscribers, which is a program for TNC drivers that phased out in September 2020.[31]

Subscribers consumed more energy on a per customer basis than non-subscribers. While subscribers make up the smaller share of users, they have higher per customer energy consumption in all months (Figure 29). This finding is consistent with the idea that customers who consume more energy per month have greater motivation to enroll in a subscription program or that customers with a monthly subscription plan are more likely to use the same charging network to fully utilize the subscription. During the initial period of the COVID-19 pandemic (March to May 2020), subscribers had a steep decrease in energy consumption per customer, while non-subscribers had a steep decrease in number of EA users. However, the monthly per customer energy consumption for both user groups fluctuated significantly over the study period. Between January 2021 and October 2022, the number of non-subscriber customers using EA sites per month increased 324% and increased much faster than the number of subscriber users per month (137% increase). Despite the greater number of non-subscribers, the subscriber group consumed more energy over the analysis period (894 MWh) compared to non-subscribers (565 MWh).

[30] The data used in the user group analysis is only a subset of the charging data because the dataset used in previous analyses did not contain user subscription information. The data used for this analysis is from May 2019 to August 2020 and does not include the Downtown Portland EA site.

[31] The 2020 Evaluation of PGE's TE pilots Annual Report analyzed the differences between TNC subscribers, general subscribers, and non-subscribers. The analysis found that TNC subscribers were the user group that consumed the most energy per customer per month and were more responsive to the peak period surcharge than non-subscribers.

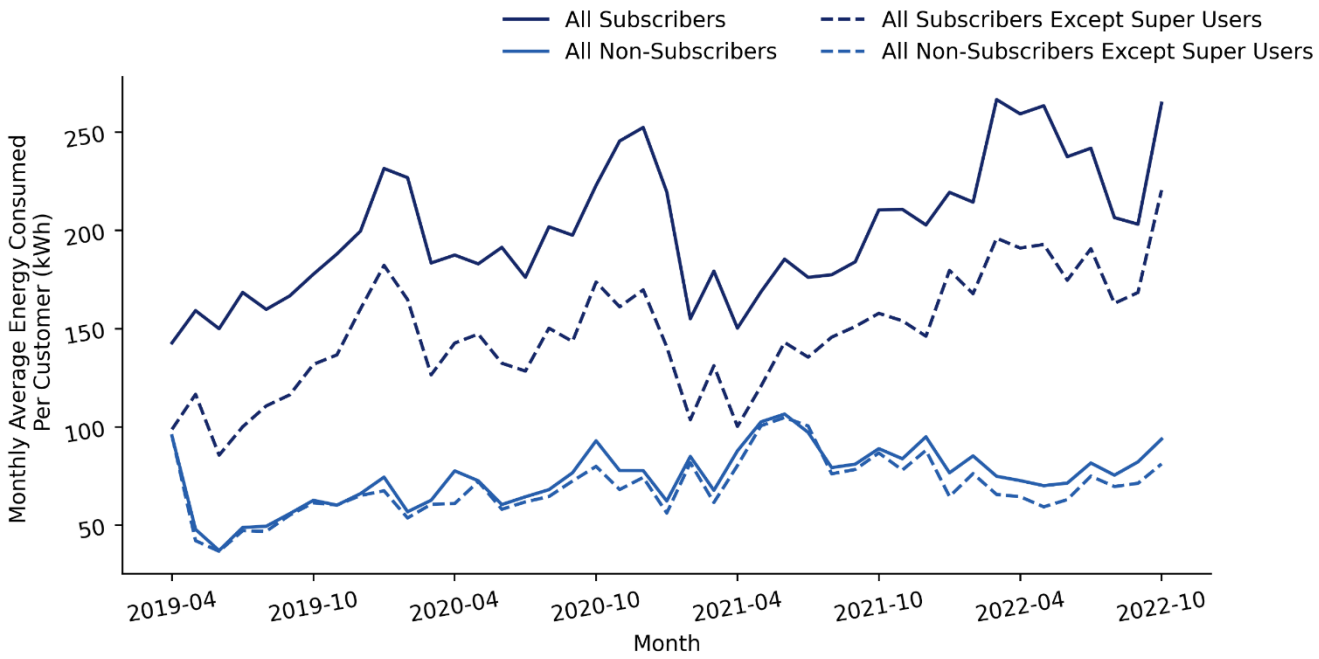
Figure 29. Average Per User Monthly Energy Consumption (top) and Number of Users (bottom) by Subscriber Type



We identified "super users" in each user group and analyzed their impact on average monthly charging consumption by comparing the monthly average energy consumption per customer with and without the super users in the population. The team identified 17 subscriber super users and 51 non-subscriber super users.[32] For non-subscribers, removing super users had minimal impact on average consumption per user, but removing super users from the subscriber group decreased the monthly per customer consumption between 20-75% (Figure 30). While these super users consumed significantly more energy than the average user in their group, excluding the super users from the analysis did not change any conclusion regarding differences in consumption patterns between the user groups.

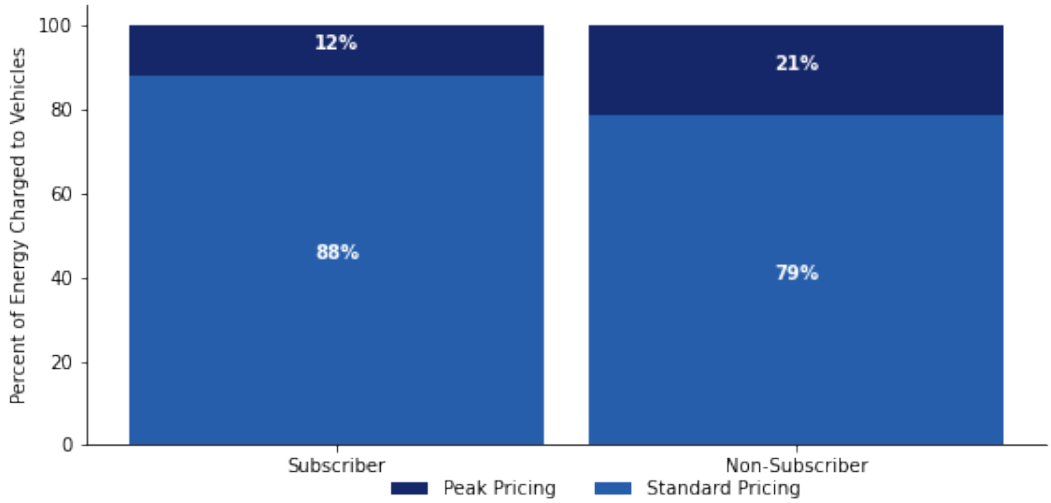
[32] The team defined "super users" as customers that consume more energy than three standard deviations above the average energy consumption for the user group. In addition to the 51 non-subscriber super users, a 52nd user ID was removed. This final user ID is not an individual super user, but the user ID that is recorded when the charger is offline and cannot log individual user IDs. This code was used over 14,000 times during the analysis period.

Figure 30. All Users Monthly Average Energy Consumption Excluding Super Users Over Time



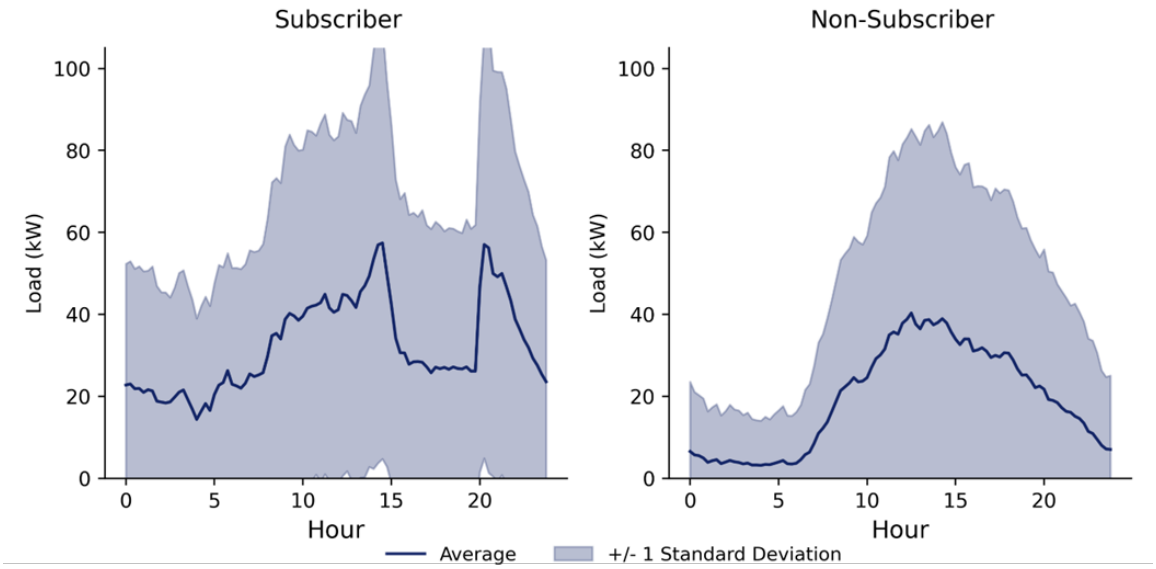
Charging behavior of EA subscribers was different from non-subscribers. EA non-subscribers charged almost twice as much during the peak pricing period than subscribers (Figure 31). The greater share of on peak charging among non-subscribers indicates that the peak period surcharge might be most effective in changing charging behavior if the driver is already on a subscription plan, likely due to subscribers consuming more energy per charge than non-subscribers.

Figure 31. Peak Pricing Energy Consumption by Subscriber and Non-Subscriber User Groups



EA subscribers showed a sensitivity to the peak pricing period in charging load profile that was not observed with non-subscribers. The charging profile of EA subscribers shows a peak in the early afternoon and a second peak at 8:00 p.m., with depressed load from 3:00 to 8:00 p.m. (Figure 32). Comparatively, non-subscriber charging peaks around noon and is lowest overnight.

Figure 32. Normalized Average Daily Load Profile for Each User Group



Subscribers received about 4% of their energy from L2 chargers, compared to almost 8% for non-subscribers (Table 26). Both user groups obtained more than 90% of their energy at DCFC chargers. Given the small difference in the share of energy consumed from DCFC charging sessions between user groups, it was difficult to conclude that subscribers have a significantly stronger preference for DCFC sessions compared to non-subscribers. Since an individual session at a DCFC charger costs more than an L2 session (on a $/minute basis), non-subscribers may have been more likely to choose the L2 charger if it satisfied their charging needs better than the DCFC charger. Subscribers do not pay more for using a DCFC charger and thus may be more likely to choose DCFC chargers because of the shorter charging time. However, there are other potential drivers of differences in charger type use. For example, DCFCs may not be as available when non-subscribers want to charge their vehicles compared to subscribers, or non-subscribers may drive older EV models that do not accept high power charging.

Table 26. Percentage of Energy Charged at DCFC and L2 Chargers by User Group

User Group	% of Energy Charged at DCFC	% of Energy Charged at L2
Subscriber	95.88%	4.12%
Non-Subscribers	92.53%	7.47%

6. Electric Mass Transit 2.0 (TriMet) Pilot

6.1 Impact Analysis

In early 2019, the Electric Mass Transit 2.0 Pilot included the installation and commissioning of two 150 kW chargers at Merlo Garage and one 450 kW overhead fast charger at Sunset Transit Center, all of which were intended to serve five short-range electric buses operating on Line 62. Since the installation of the pilot chargers and procurement of the short-range buses, TriMet has installed two additional chargers in the Merlo Garage, which the transit agency owns, and has purchased six long-range buses to serve other routes. The original chargers installed for the pilot at Merlo Garage and the additional chargers are currently used interchangeably to charge TriMet's short- and long-range buses, in addition to occasional use by diesel-to-electric conversion buses. This analysis primarily focuses on the charging load impact of the original five buses purchased for the pilot at Merlo Garage and Sunset Transit Center. Additional analyses present the charging load impacts of four non-Pilot long-range electric buses from the end of October 2021 to November 2022 to provide additional context for load impacts of short-range Pilot buses.

The first of five electric short-range buses went into service in April 2019. By October 2019, all five buses on Line 62 had been delivered by the electric bus manufacturer and were in service. In December 2020, all electric buses associated with the pilot on Line 62 were out of service due to equipment and software issues. TriMet returned electric short-range buses to service in February 2021, however, the buses continued to experience issues and were offline at times throughout the study period.

6.1.1 Overview

According to TriMet, during normal operation, short-range electric buses charged every time they stopped at Sunset Transit Center using a 450-kW overhead charger. Each bus has a 200-kWh battery, which could power one or two round trips. Electric long-range buses at the Merlo Garage charged overnight using 150 kW bus depot charging stations. More than 83% of charging occurred during daytime at the Sunset Transit Center (Figure 33). This was because of the buses limited battery capacity, which needed to be frequently re-charged during daytime to support daytime bus operations.

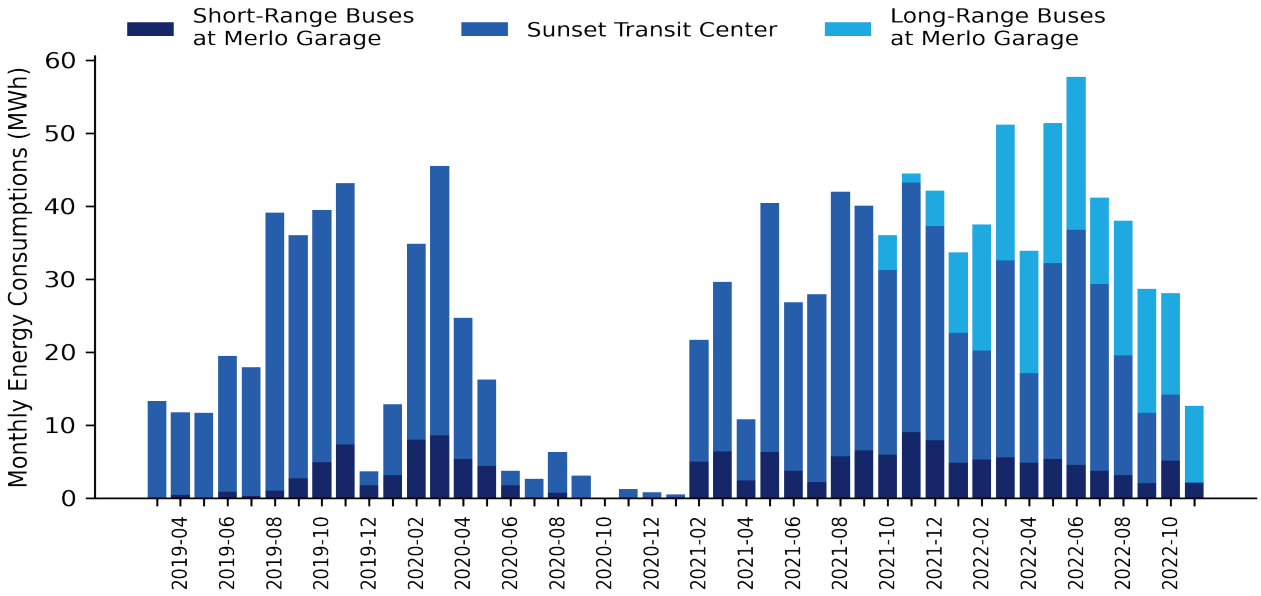
During the study period, charging load varied significantly between months and reflected periods of time when the buses were not in service or charger maintenance was being conducted (Figure 33). From early 2019 through October 2019, charging load steadily increased as buses were gradually added and put into service. In December of 2019, TriMet reported that all buses went out of service due to technical issues. Then in March 2020, TriMet reduced the bus frequency and lowered the number of buses in service due to COVID-19. Electric buses started experiencing technical issues related to software updates in April 2020 and were grounded until February 2021. Between February of 2021 and October of 2022, the average monthly energy consumption of the five short-range pilot buses at both the Merlo Garage and Sunset Transit Center charging locations was a combined total of 28 MWh, with a standard deviation of 10 MWh. Service logs dating from February 2021 to November 2022 provided insights into the wide fluctuations in monthly charging load. Months with decreased charging load and notable charger maintenance or technical issues are noted below:

- **April 2021:** Testing and repairs occurred on the Sunset Transit Center pantograph. During this time there were discussions about replacing contact rails.
- **June 2021:** Charger communication issues at Sunset Transit Center.
- **July 2021:** Pantograph contact rails were replaced at Sunset Transit Center.

- **January 2022:** Software update caused firmware errors and charging failures at Sunset Transit Center.
- **April 2022:** Planned maintenance occurred at both the Merlo Garage and Sunset Transit Center. Additional pantograph service due to mechanical issues.
- **October 2022:** Pantograph contact rails and power modules replaced at Sunset Transit Center.

The team also calculated the charging load of six long-range buses charging at Merlo Garage, which were commissioned into service by TriMet starting in October of 2021. The monthly charging load from the long-range buses was greatest in June 2022 at 21 MWh. In 2022, the monthly energy consumption of long-range buses was 2-8 times that of the short-range pilot buses at Merlo Garage. The short-range pilot buses, however, consumed more total energy than the long-range buses when including en route charging at Sunset Transit Center.

Figure 33. Monthly Energy Consumption for TriMet Electric Buses Over Time

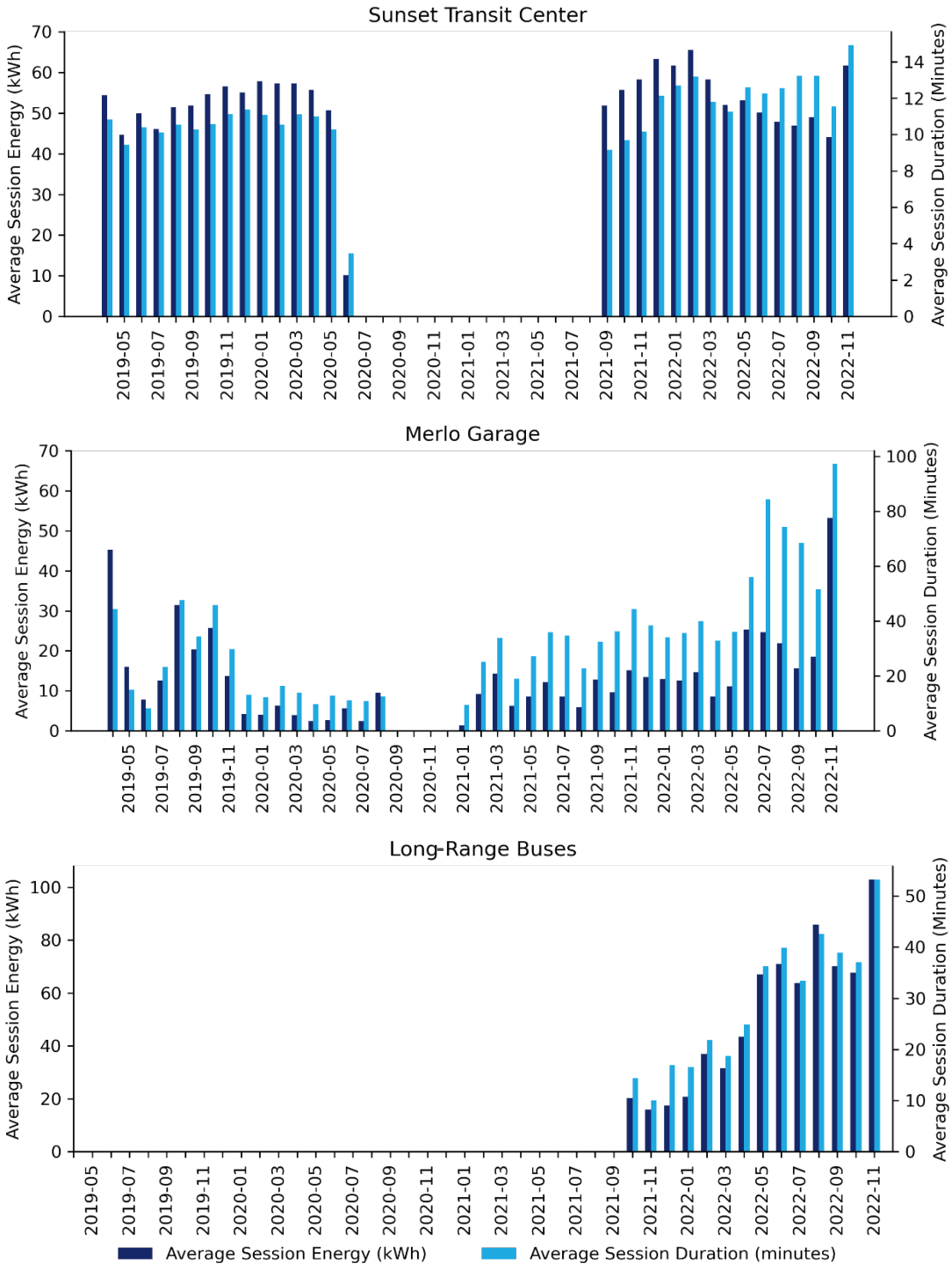


Note: Charging load impacts of the pilot buses and long-range buses charging at Merlo Garage do not account for charger losses and are based on the energy delivered to the buses. Charging load impacts at Sunset Transit Center includes losses from the charger.

Average charging session energy consumption and duration are generally consistent at the Sunset Transit Center during the study period[33], with average energy consumed of 52.4 kWh/session and charging duration of 11 minutes (Figure 34). In contrast, the average charging session duration at Merlo Garage was 33 minutes with a standard deviation of 21 minutes after removing outliers of sessions longer than the 95th percentile. The variance in charging session duration and energy consumption still exists after removing the outliers, suggesting that TriMet has not developed and maintained a set schedule for charging buses at Merlo Garage during the study period or that buses are regularly not put into service and are left plugged into the charger during the day. The long-range buses have a similar average charging session duration of 29 minutes and a large standard deviation of 13 minutes.

[33] This analysis relies upon charging session data. Charging session data was not available at the Sunset Transit Center from September 2020 to September 2021.

Figure 34. Average kWh Charged per Session and Average Session Duration at Pilot Sites Over Time

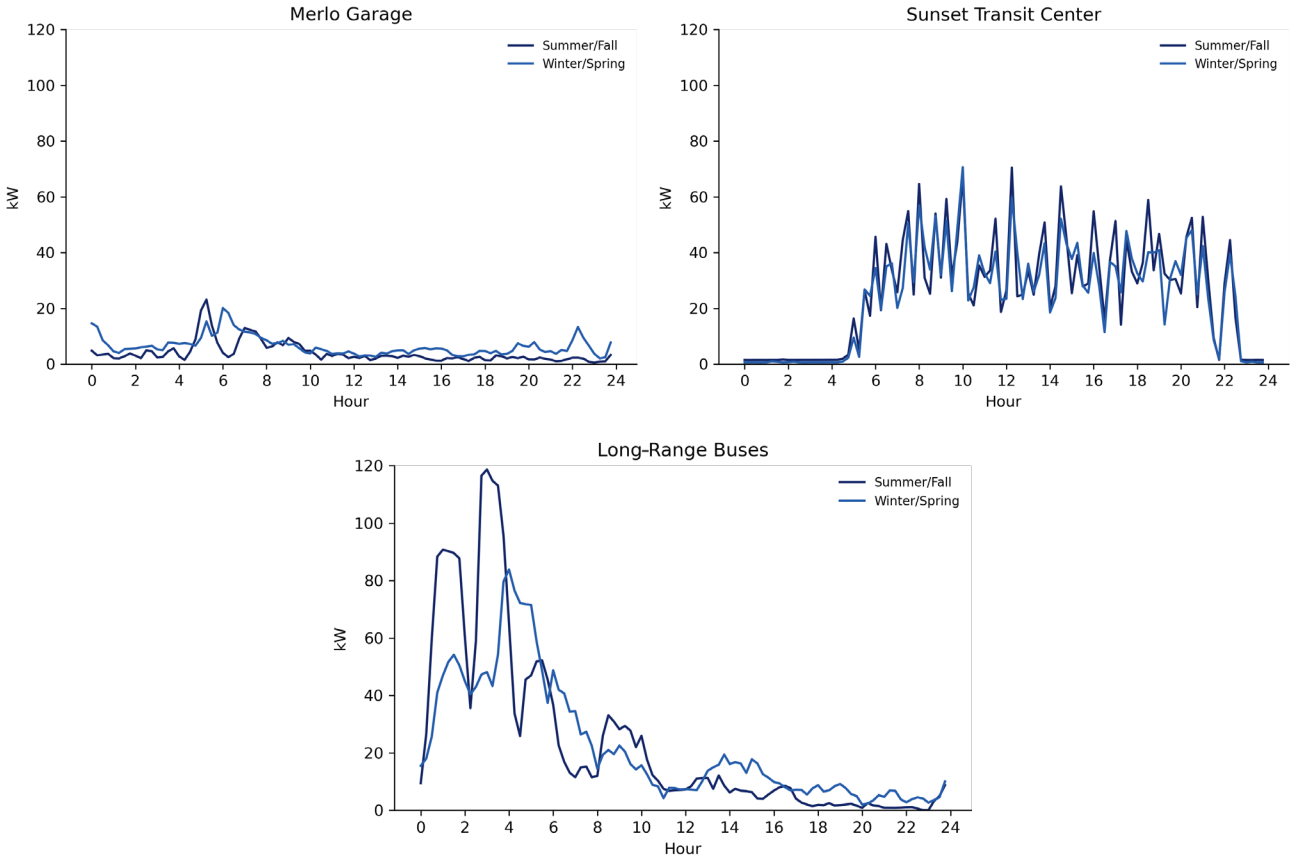


Note: Analysis excludes charging sessions with a duration greater than the 95th percentile duration due to some extreme outliers in charging session duration data.

6.1.2 Charging Profile and Load Factors

Charging profile data for Merlo Garage shows an early morning peak in charging load around 5 to 6 a.m. (Figure 35). Merlo Garage charging load appears to peak later in the morning for pilot buses compared to the long-range buses. Staffing requirements for maintenance and operations of the electric buses may impact when charging load peaks occur for short range buses at Merlo Garage and the long-range buses. As seen in Figure 35, Sunset Transit Center had no energy consumption at night or early morning as buses were not in operation during that time. The average charging load profile exhibits many short peaks in load when buses frequently make stops at the charger. The maximum charging load of the average daily profile at Sunset Transit Center was considerably lower than the capacity of the charger due to the variation in buses' actual arrival time and the effects of averaging. Charging occurred slightly more in the morning compared to the afternoon due to a slightly busier bus schedule. Differences in seasonal charging patterns were not observed for either charging location.

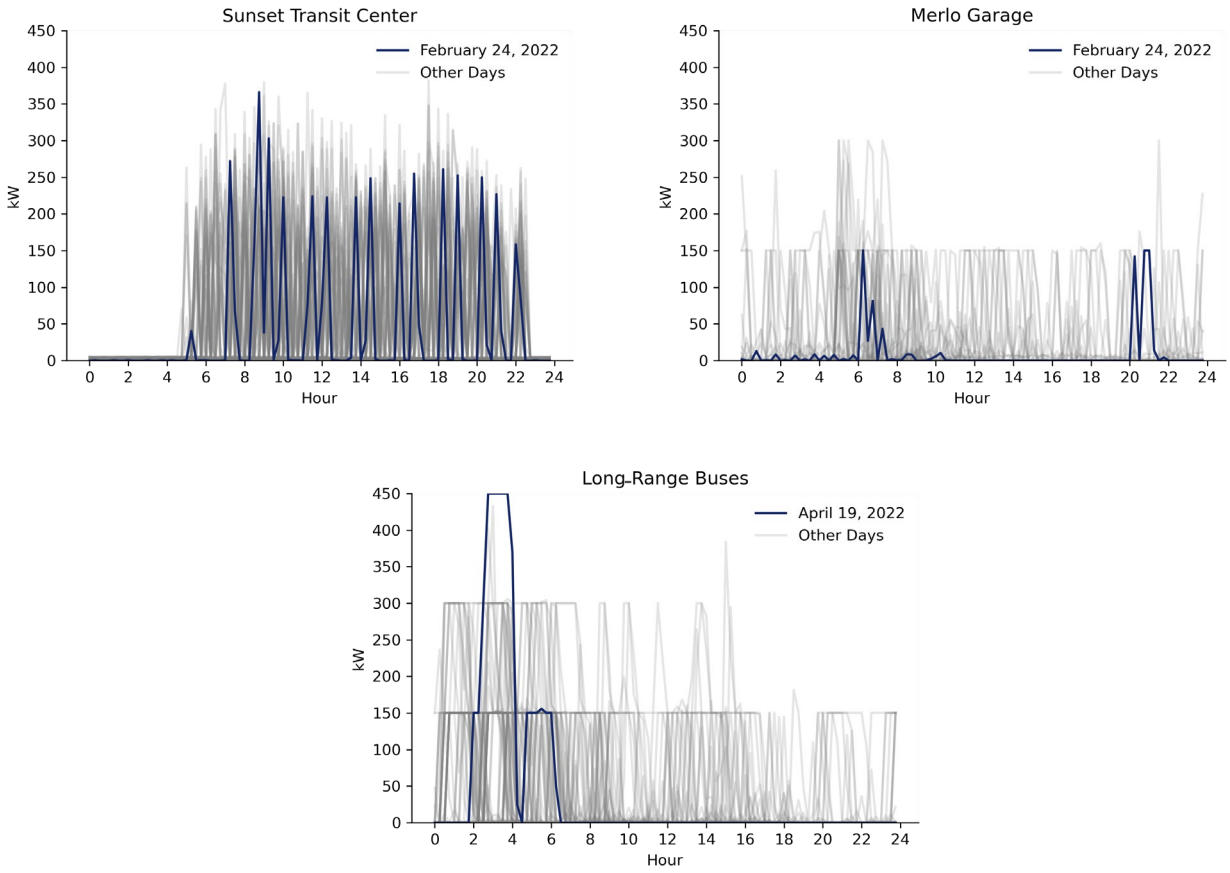
Figure 35. Average Daily Charging Load



Day-to-day charging load patterns at Sunset Transit Center were highly variable due to the short charging sessions which occurred when buses arrived and successfully connected with the en route charger (Figure 36). Given that high-powered chargers are used and buses charged for only short periods when en route, the load profiles exhibited many spikes of short duration, as illustrated in Figure 36. The en route charger can adjust the charging power given the state of the buses' batteries, which is why the charging power is not always at the maximum in the example day shown in Figure 36. Charging at Merlo Garage usually occurred

during the night or early morning, but as seen in the sample of example days below, there is significant daytime charging at Merlo Garage which could be attributed to testing or maintenance issues.

Figure 36. Example Day Load Profiles

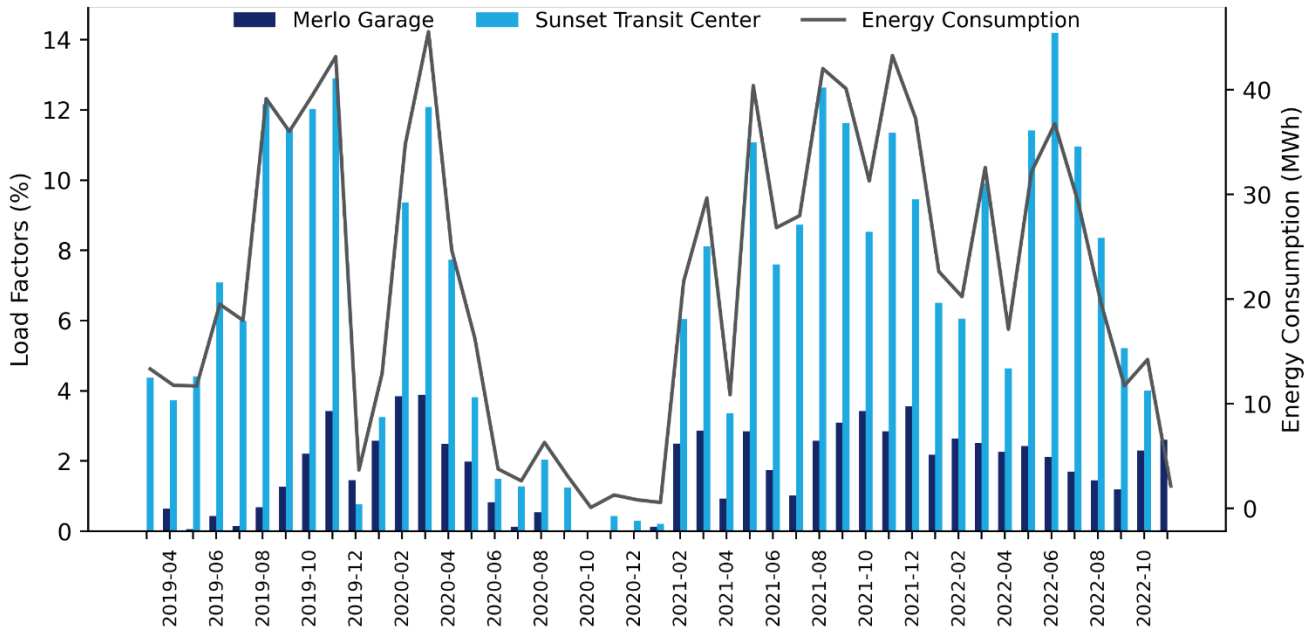


Note: Daily charging profiles for one example day are shown in dark blue with the daily charging profiles for a random sample of 100 days in the dataset plotted in gray in the background. The example day for each graph was selected as a day with high charging demand.

The load factors at both Merlo Garage and Sunset Transit Center were generally low and did not exceed 15% (Figure 37). Months in which more energy is consumed have higher load factors. Although charging at Merlo Garage occurred in longer sessions with a lower charging power than Sunset Transit Center, the monthly load factors at Merlo Garage were lower than those at Sunset Transit Center due to low utilization. While sessions were longer at Merlo Garage, the average energy delivered in those charging sessions was lower than sessions at the en route charger, which leads to very low average charging load across the month at Merlo Garage.[34] Load factors from long-range bus charging were generally higher than those of the pilot buses at Merlo Garage because they consumed more energy from the Merlo Garage chargers.

[34] Load factors at Sunset Transit Center were calculated using advanced metering infrastructure (AMI) data providing a 15-minute resolution timeseries of charging load. Load factors at Merlo Garage were calculated using a synthesized timeseries data derived from charging session data. The synthesized timeseries data tends to be peakier than what might be recorded with AMI data. This

Figure 37. Monthly Load Factors and Energy Consumption at Merlo Garage and Sunset Transit Center

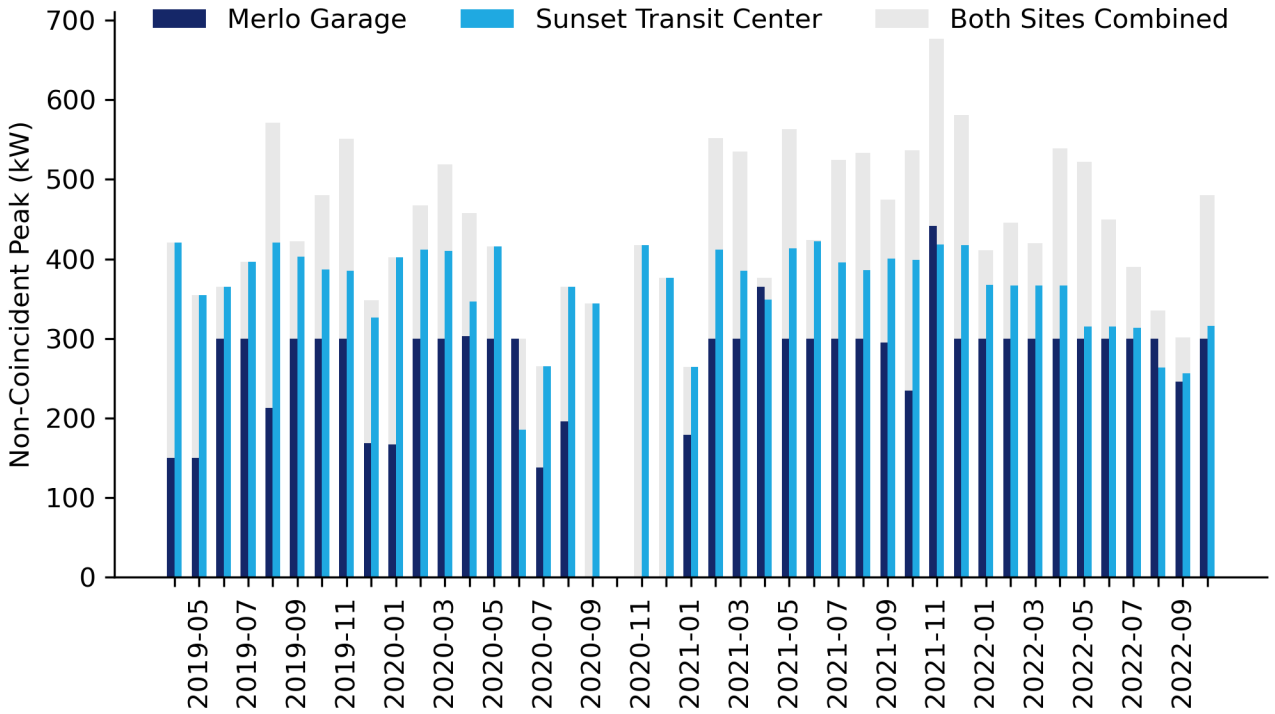


6.1.3 Peak Impact

The Sunset Transit Center had consistently higher charging load due to its higher-power charger, which primarily drove the combined non-coincident peak (NCP) (Figure 38). The NCP load at the Sunset Transit Center was between 185-422 kW, indicating that the full capacity of the en route charger was not used. In most months, the NCP at Merlo Garage was typically around between 150-300 kW, indicating that at most, two buses charged simultaneously. For two months, the NCP charging load from pilot buses was greater than 300 kW at Merlo Garage, indicating the additional chargers TriMet installed to complement the initial chargers for the pilot were used to support the buses.

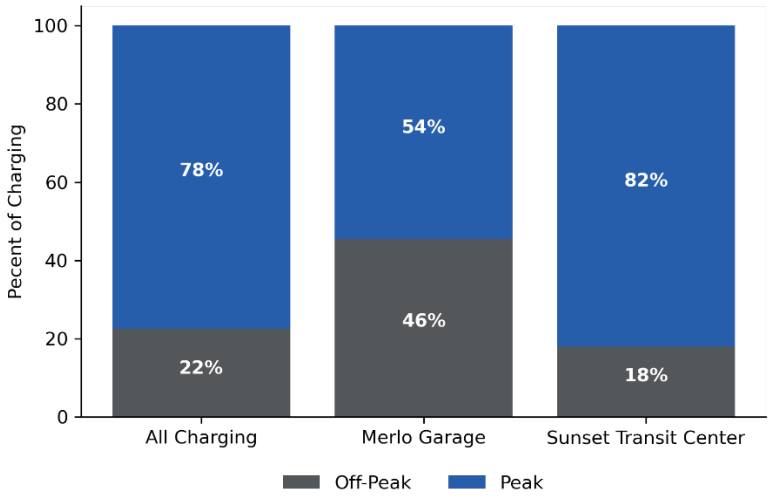
difference could also contribute to the lower load factors observed at Merlo Garage. Note that the 2020 Evaluation of PGE TE plots also used AMI data to calculate load factors for both Sunset Transit Center and Merlo Garage.

Figure 38. Non-Coincident Peak Load at Merlo Garage, Sunset Transit Center, and Both Locations



The majority of energy consumption at both Merlo Garage and Sunset Transit Center occurred during the on-peak period (Figure 40). The team examined the charging load occurring during the peak and off-peak periods as defined by the tariff Merlo Garage is on, Schedule 85. A large portion of charging load at Sunset Transit Center occurred during on-peak hours, defined as Monday through Saturday 6 a.m. to 10 p.m., which overlapped with operating hours when buses made frequent stops at the en route charger. More than half of Merlo Garage charging load occurred during on-peak hours. During normal operations, buses returned to Merlo Garage around 4 p.m. to 1 a.m. The large portion of charging load during on-peak hours suggests that buses did not wait until the off-peak period to begin to charge or that significant amounts of charging load occurred in early morning hours at the beginning of the peak period as shown in Figure 35 (above). As illustrated in Figure 36, above, significant amounts of charging load occurred during the day at Merlo Garage, which contributed to peak period energy consumption. Given that the buses were typically parked at Merlo Garage for most of the off-peak period, there may be opportunity for PGE and TriMet to develop an operating schedule that reduces peak period energy consumption, which could be explored in future research.

Figure 39. Energy Consumed by TOU Period of Schedule 85

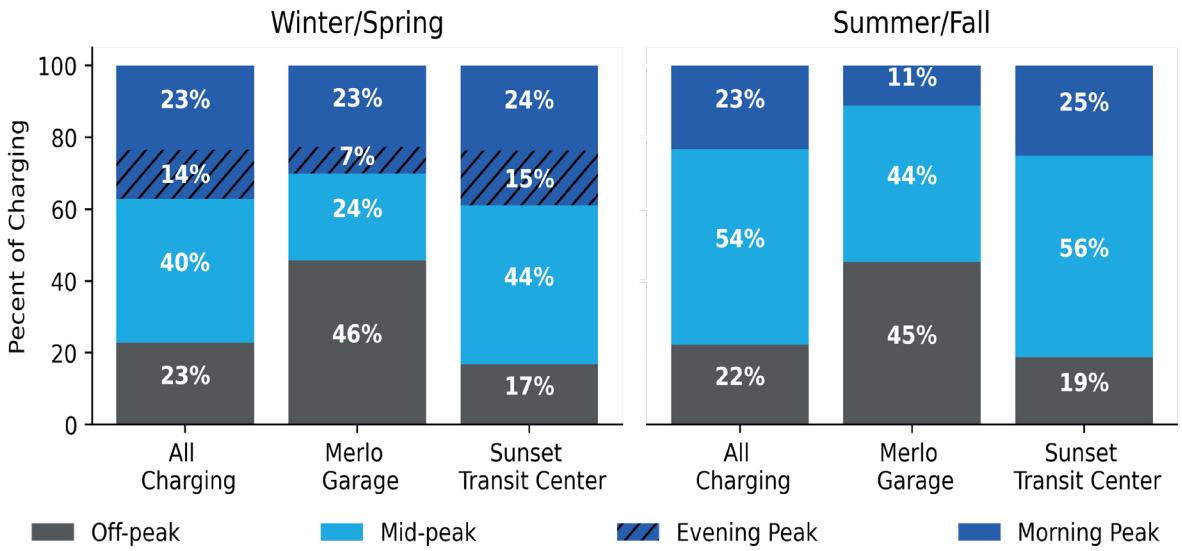


We also examined charging load by PGE's residential time-of-use rate peak period definitions (Figure 40).[35] In the summer and fall, 11% of charging at Merlo Garage occurred on-peak, while 25% of Sunset Transit Center charging occurred on-peak.[36] In the winter and spring, there was more charging load during the peak period as the charging load overlapped more with the morning peak. Among all on-peak charging, 62% occurred during the morning peak period. At both locations, the majority of on-peak energy consumption as defined by Schedule 85 occurred during the mid-peak period of the residential time-of-use rate.

[35] The TOU period is defined based on PGE's residential TOU tariffs: https://portlandgeneral.com/energy-choices/energy-choices-home/time-of-use-pricing-home

[36] Summer/fall is defined as May through October, and winter/spring is November through April.

Figure 40. Percentage of TriMet Energy Consumption by Time-of-Use Period



Bulk System Impact

Bus charging load did not contribute significantly to PGE's system peak during the study period (Table 27). The team investigated the charging load that occurred during PGE system peak hours or coincident peak. The average demand during system peak hours varied but was small compared to the capacity of the chargers installed for the pilot (450 kW + 150 kW × 2).

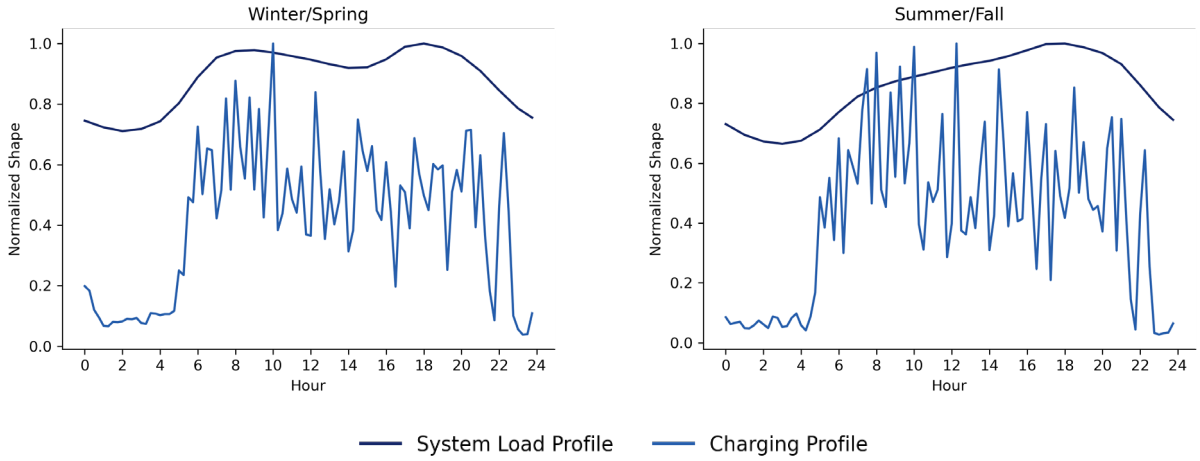
More charging occurred during system peak hours in summer 2019 than summer 2020 because the buses were not in operation due to technical issues. By summer 2021, the charging load in summer peak hours returned to similar levels observed in 2019. In winter 2019–2020 and 2021-2022 peak hours, more charging occurred during morning peak hours than evening peak hours. The average demand in the morning and evening peak hours in the winter was also low compared to the capacity of the chargers serving the buses.

Table 27. Pilot's Average Peak Demand During System Peak Hours

Season		Total Energy Consumed (kWh)	Average Demand (kW)
Summer 2019		8,608	171
Winter 2019-2020	Morning	2,949	121
	Evening	1,926	74
Summer 2020		665	13
Winter 2020-2021	Morning	870	51
	Evening	1,370	52
Summer 2021		9,071	179
Winter 2021-2022	Morning	3,127	140
	Evening	3,674	104
Summer 2022		6,668	126

The variation of average peak demand during the system peak hours was likely due to the highly variable nature of transit bus charging during daytime hours. To compare the charging load profile with the PGE system load profile, the team normalized the two shapes by their peaks and plotted them. The average daily charging load was highly variable during system peak hours. In the summer and fall, charging load during the system peak hours was generally lower than it was at other times of day (Figure 41). In the winter and spring, the normalized charging load profile was highest during the system morning peak hours but was lower during the evening winter peak. Given that the timing of charging load during the day was almost entirely determined by the timing of buses arrival, high-power charging at the Sunset Transit Center was likely to occur during PGE's peak hours.[37] If the peak period is relatively short, TriMet might be able to skip a charging session to help mitigate the system peak.

Figure 41. Normalized Average Daily Charging Load vs PGE System Load



PGE Distribution System Impact

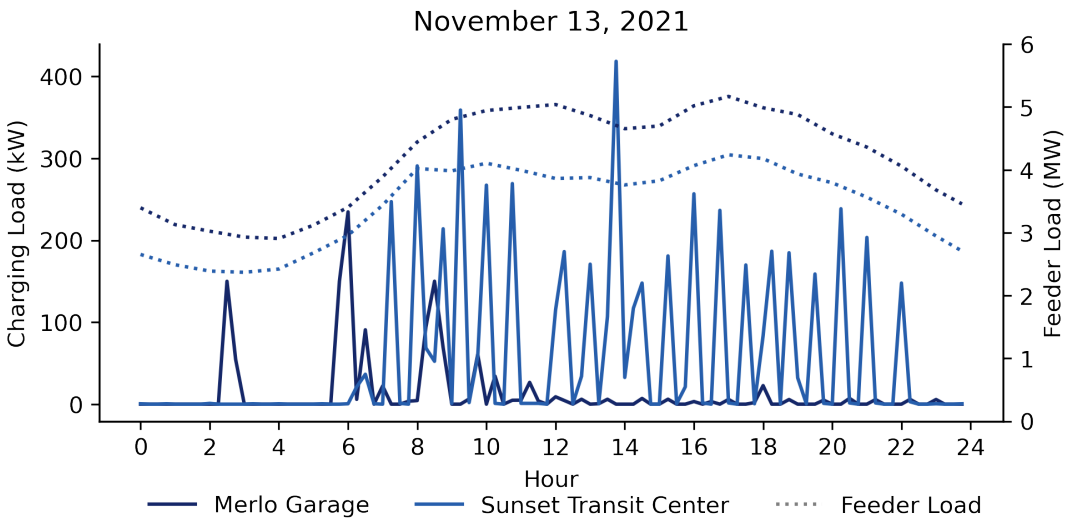
Neither the Sunset Transit Center nor the Merlo Garage feeders were at risk of overloading despite the use of high-powered chargers. The current loading in the summer on the feeders serving Merlo Garage and Sunset Transit Center is 59% and 45% of its rating, respectively, which is below the threshold that would trigger a capacity study by PGE. The charging capacity of the Sunset Transit Center represents about 2.5% of the feeder's capacity, and the charging capacity of the two 150-kW chargers at Merlo Garage represents about 1.7% of the feeder's capacity, showing that bus charging contributed very little to feeder loading. An example day (November 13, 2021) was analyzed for coincidence with feeder load (Figure 42). Charging load at Merlo Garage was low during the day when the load on the feeder was higher. As charging load occurred mostly during the day at Sunset Transit Center, there was significant charging load when feeder load was high. In the example day, charging load peaked around 2 p.m. when the feeder load had a midday decline.

TriMet charging data was also analyzed for coincidence with the top 3% of load hours on the feeders serving Merlo Garage and Sunset Transit Center in the summer/fall and winter/spring. In all seasons analyzed, the average load at Merlo Garage during the peak hours was less than 16 kW, or 5% of the charging capacity of the two pilot chargers, indicating that depot charging had little impact on peak distribution system load. At Sunset Transit Center, the average load during the peak hours of summer/fall was 118 kW, or 26% of the

[37] This issue might be mitigated by a communication of peak hours between PGE and TriMet through utility programs like Demand Response (DR) or managed charging.

capacity of the en route charger. In winter/spring, the average charging load at Sunset Transit Center during peak hours was lower at 67 kW, indicating that the high powered en route charging contributed very little to distribution system peak loads.

Figure 42. TriMet Charging Load and Feeder Load on Example Day



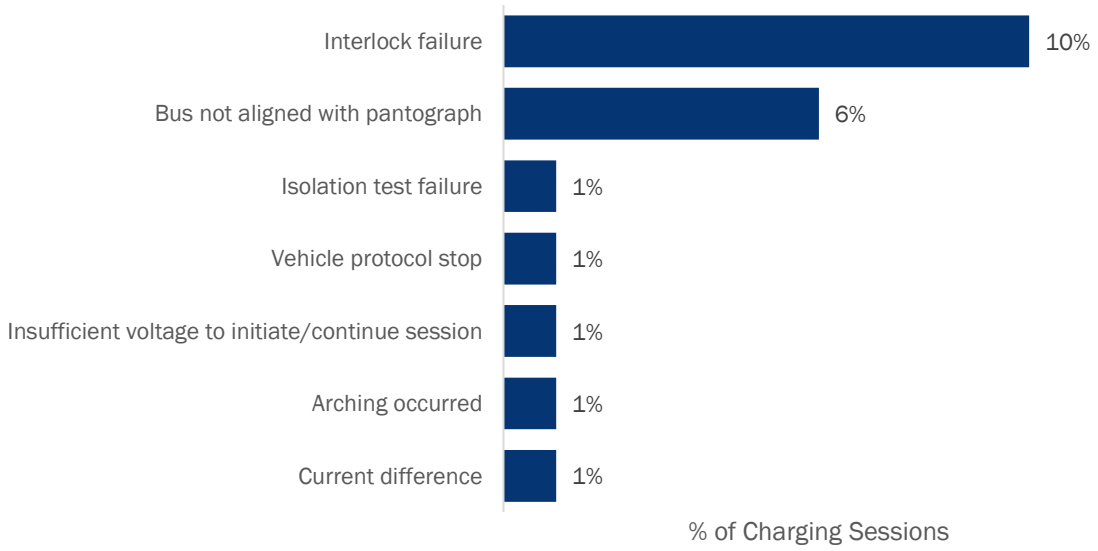
6.1.4 Sunset Transit Center Equipment Errors

The team examined attempted charging sessions at the Sunset Transit Center en route charger that resulted in errors. Data for this analysis was available for April 2019 to September 2020 and September 2021 to October 2022.

The most common error at the Sunset Transit Center en route charger was caused by interlock failure. About 10% of all charging sessions triggered an interlock failure, which can be caused by issues with the bus and triggered at the end of a charging session if the procedure to end the charging session is not perfectly executed (Figure 43). The second most common error occurred when buses did not properly align with the pantograph. The bus alignment error occurs when the pantograph lowers but does not land on the rails as expected.[38]

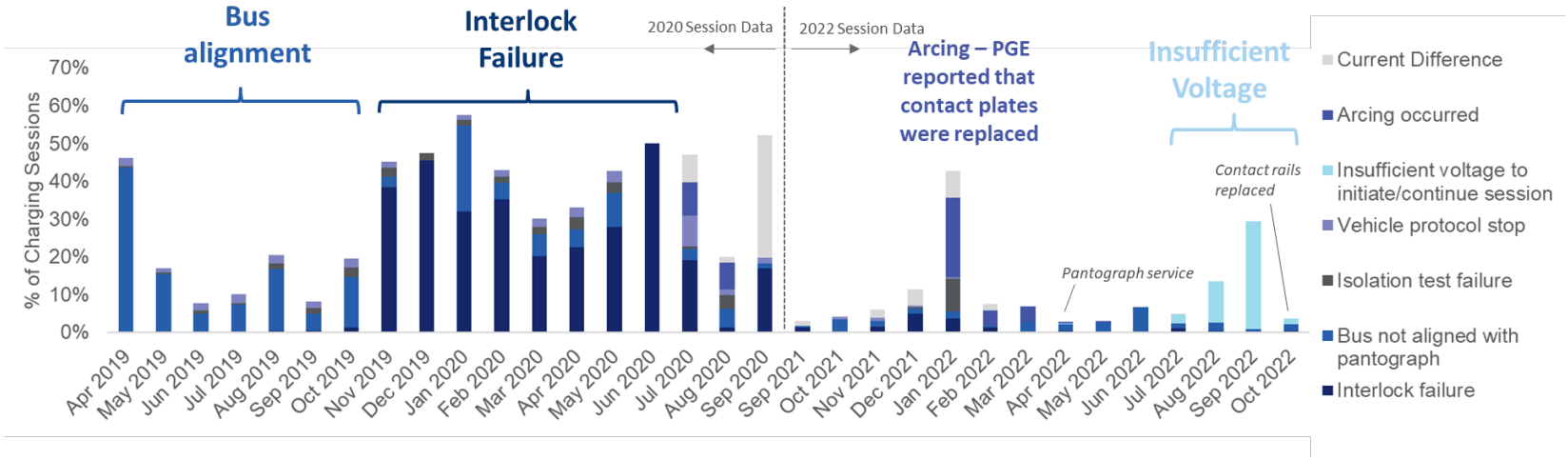
[38] Interlock error is a broad error code that could be triggered by multiple things and can be triggered at the end of a charging session if it does not end perfectly. Bus/pantograph alignment errors occur when the pantograph lowers but does not land on the bus rails as expected. Other common pantograph errors include:
Arcing errors, which occurs when connection points are not connected properly.
Insufficient voltage, which occurs when the expected voltage at the connector head is not met which can be caused by several reasons including failure to activate power modules, DC contactor damage, and ground faults at the DC power line level.
Current difference, which occurs when the expected current exceeds a specific deviation which can be caused by current leakage, a short, or by a signal from the bus to slow the charging rate or stop charging.

Figure 43. Share of Charging Sessions Resulting in an Error



During the analysis period, the share of sessions that resulted in errors ranged from 3% per month to 58% per month. The month in which the greatest share of sessions resulted in errors was January 2020 (Figure 44). In January 2022, the arcing error, which occurs when the connection points cannot connect properly, drove another spike in errors after a few months with very few errors. The contact plates on the pantograph and bus rails were cleaned to address these errors. In April 2022, the pantograph was serviced after which there were very few arcing errors. Insufficient voltage errors became common starting in July 2022 and peaking in September. The contact rails and power modules were replaced in October when voltage error frequency decreased.

Figure 44. Sunset Transit Center Charging Errors Over Time

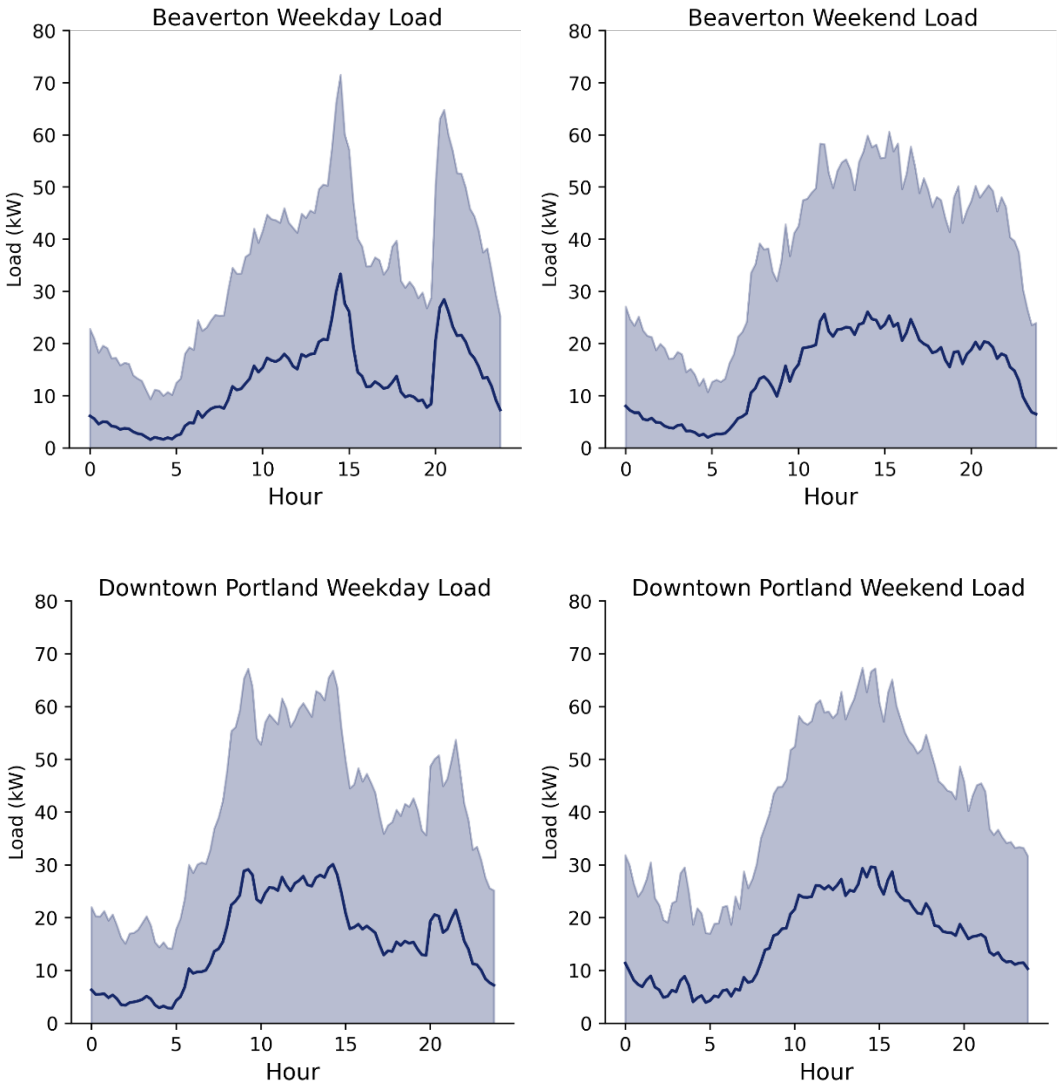


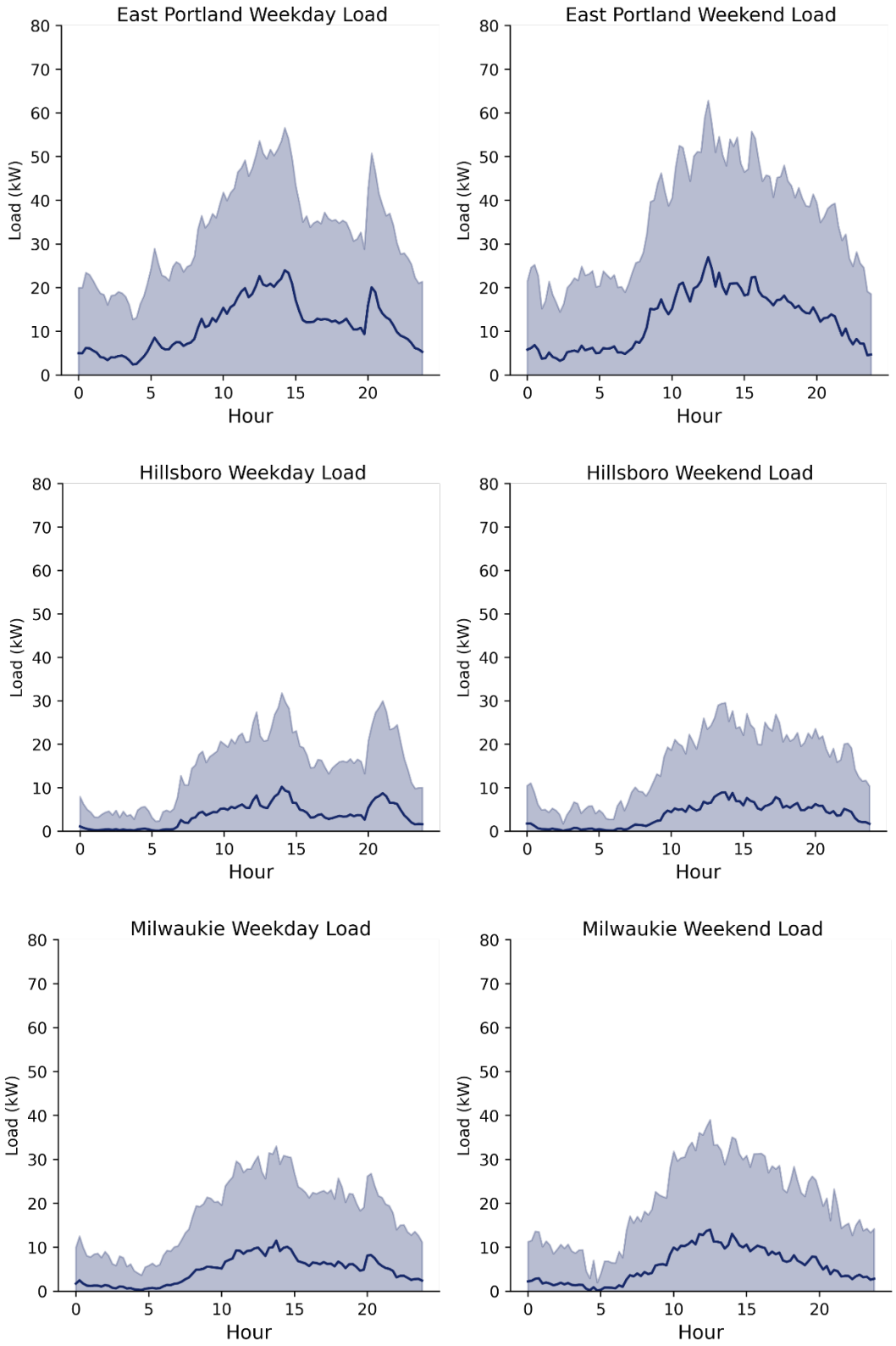
Appendix A. Additional EA Impact Analyses

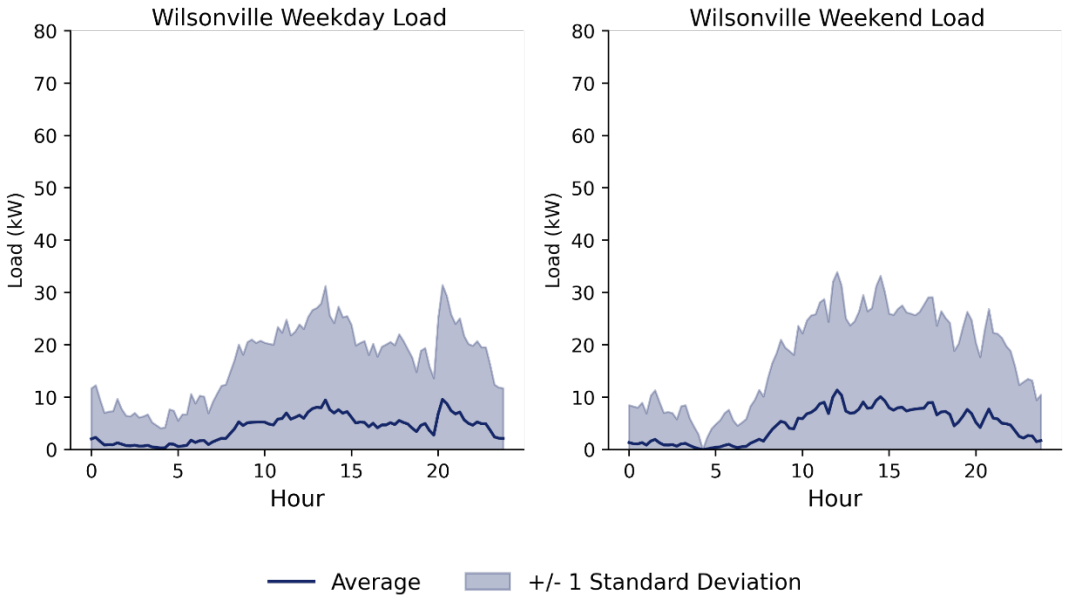
EA Charging Load Shapes

Figure 45 show the average charging load shape by weekday and weekend along with a shaded area showing how load levels range with plus and minus one standard deviation for each EA site.

Figure 45. Average and Standard Deviation (shaded) Weekday and Weekend Load at EA Sites




East Portland Weekday Load
East Portland Weekend Load
Hillsboro Weekday Load
Hillsboro Weekend Load
Milwaukie Weekday Load
Milwaukie Weekend Load
Load (kW)
Hour
0
10
20
30
40
50
60
70
80
0
5
10
15
20



Detailed Bulk System Peak Impacts

Table 28 provides a detailed summary of charging load as a percentage of site charging capacity during the top 3% of system peak hour through the analysis period.

Table 28. Detailed charging load during top 3% of system peak hours

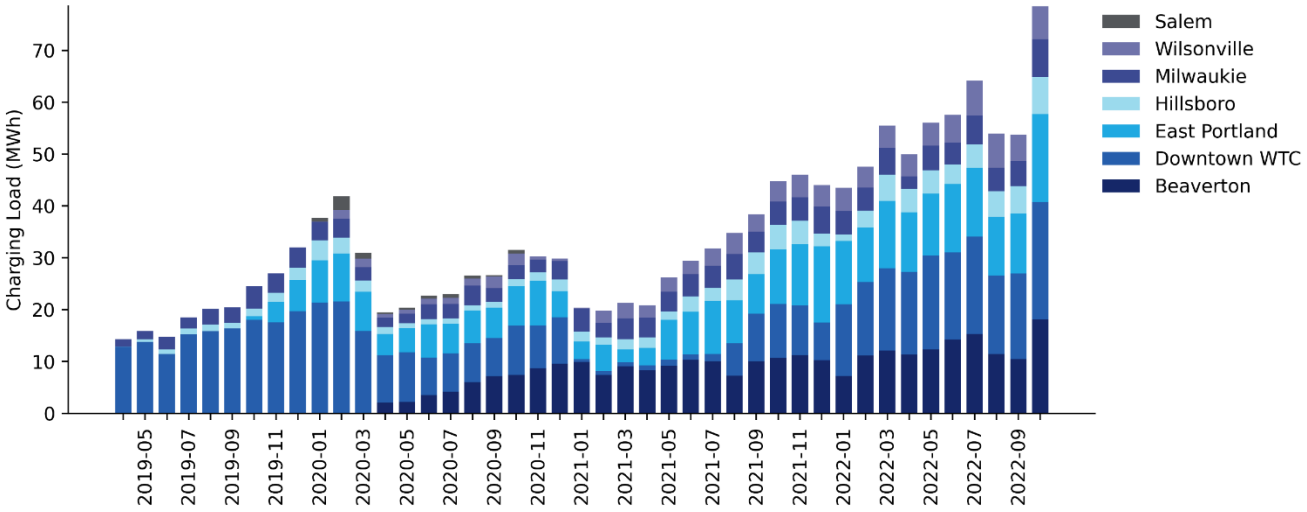
EA Site	Charging Load During Top 3% Peak Hour as a Percentage of Site Capacity									
	Summer/ Fall 2019	Winter/Spring 2019-2020		Summer/ Fall 2020	Winter/Spring 2020-2021		Summer/ Fall 2021	Winter/Spring 2021-2022		Summer/ Fall 2022
		Morning	Evening		Morning	Evening		Morning	Evening	
Beaverton	N/A	N/A	N/A	4.51%	9.1%	8.0%	9.38%	3.1%	0.89%	11.0%
Downtown Portland	11.7%	22.7%	15.1%	5.3%	2.1%	1.8%	2.7%	8.3%	9.53%	14.7%
East Portland	N/A	6.9%	4.5%	4.6%	3.5%	6.8%	8.4%	6.4%	11.12%	10.5%
Hillsboro	1.0%	4.3%	5.3%	0.6%	2.4%	1.6%	3.1%	1.1%	1.69%	5.4%
Milwaukie	1.9%	4.2%	2.8%	3.2%	3.2%	3.7%	4.3%	2.2%	3.10%	4.2%
Wilsonville	N/A	0.8%	0.0%	1.3%	0.1%	1.0%	3.0%	3.4%	2.04%	5.6%

Salem EA Impact Analysis

The Salem EA site opened in January 2020 and was temporarily closed in the Summer of 2021 due to construction at the State Capital Building. Since the site was not open for same amount of time as the other sites, it is not included in the main impact analysis of the EA Pilot. This section provides details about the Salem EA site in the context of the other analyses done in this report.

Figure 46 shows the Salem EA site's charging load in comparison with the other EA sites.

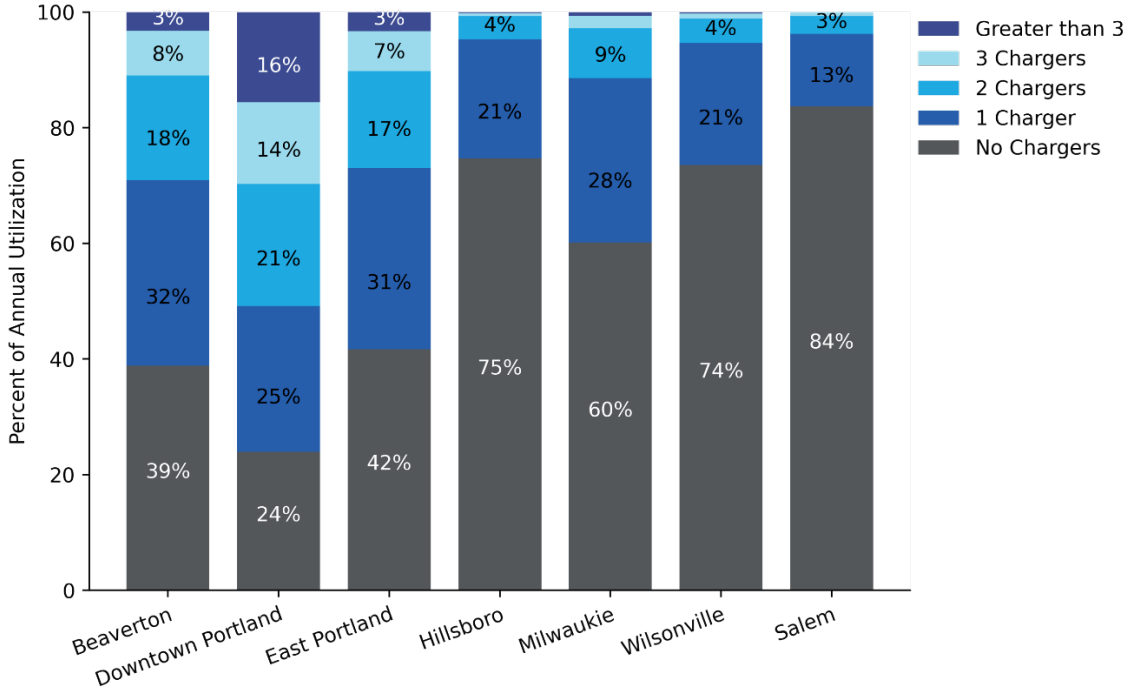
Figure 46. Monthly Charging Load at EA Sites



Despite having the third highest charging load of all EA sites in February 2020 with 5.4 MWh, Salem quickly became one of the least utilized EAs, accounting for between 0.28 and 2.3 MWh of load between March and October of 2020. Thus, the Salem EA has lower utilization rates compared to other EAs,[39] in part because of equipment malfunction (Figure 47).[40] Salem was in use only 7% of the time that it was online, compared to Hillsboro, the next least utilized site, with 18% utilization. For contrast, Downtown Portland was the highest utilized site with 60% utilization.

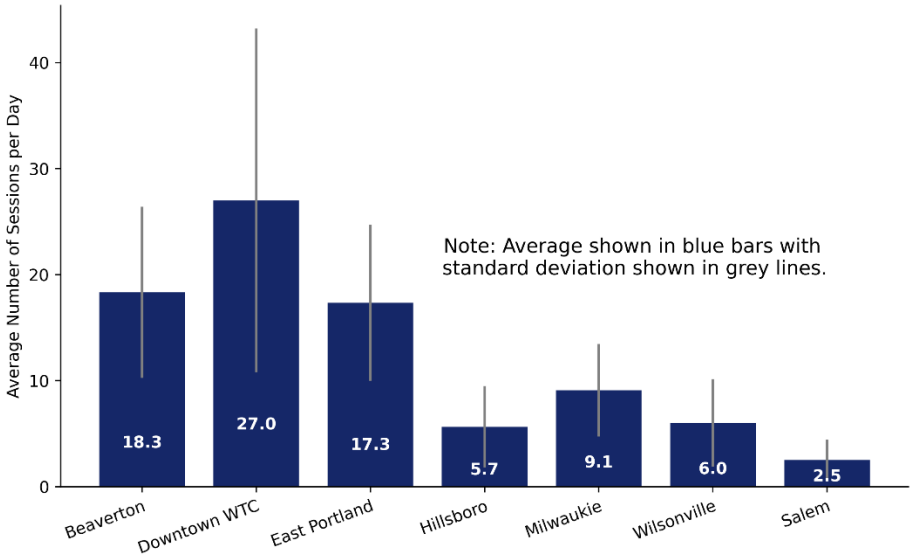
[39] Utilization is calculated for daytime hours between 8 a.m. and 8 p.m.
[40] The PGE 2020 Annual Report provides additional details as to why utilization was lower at the Salem EA.

Figure 47. Percent of Annual Charger Utilization at EA Sites Including Salem



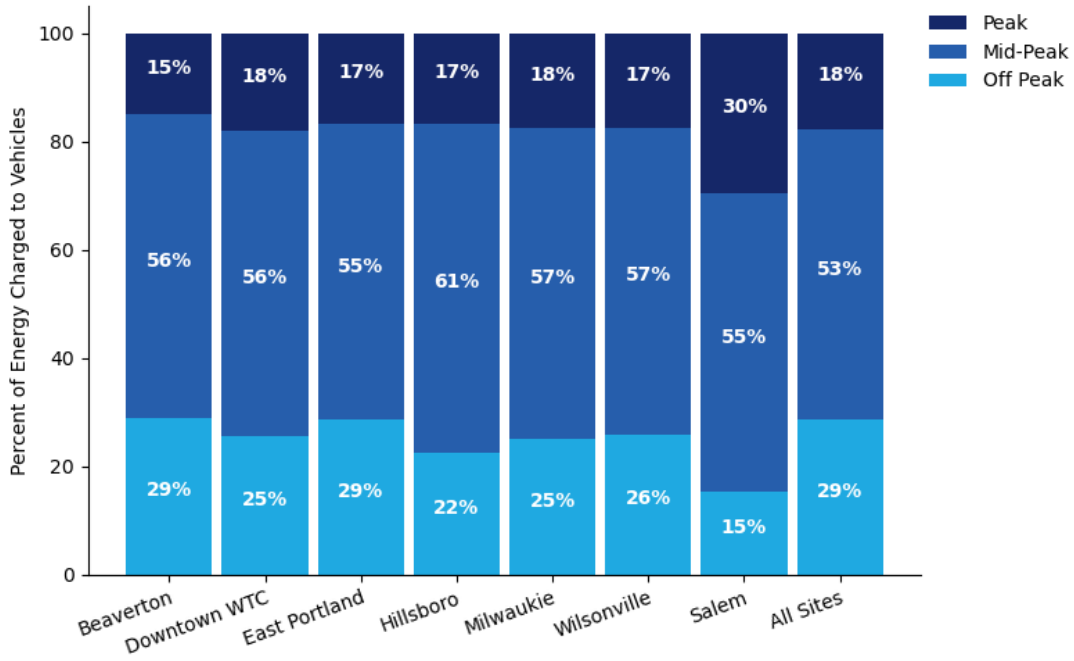
In addition to having fewer chargers in use, the Salem EA also had fewer average daily charging sessions, with 2.5 sessions per day (Figure 48). For comparison, Hillsboro had the second lowest average charging sessions with 5.7, while Downtown Portland had the most, with 27.0 sessions.

Figure 48. Average Number of Charging Sessions per Day at EA Sites Including Salem



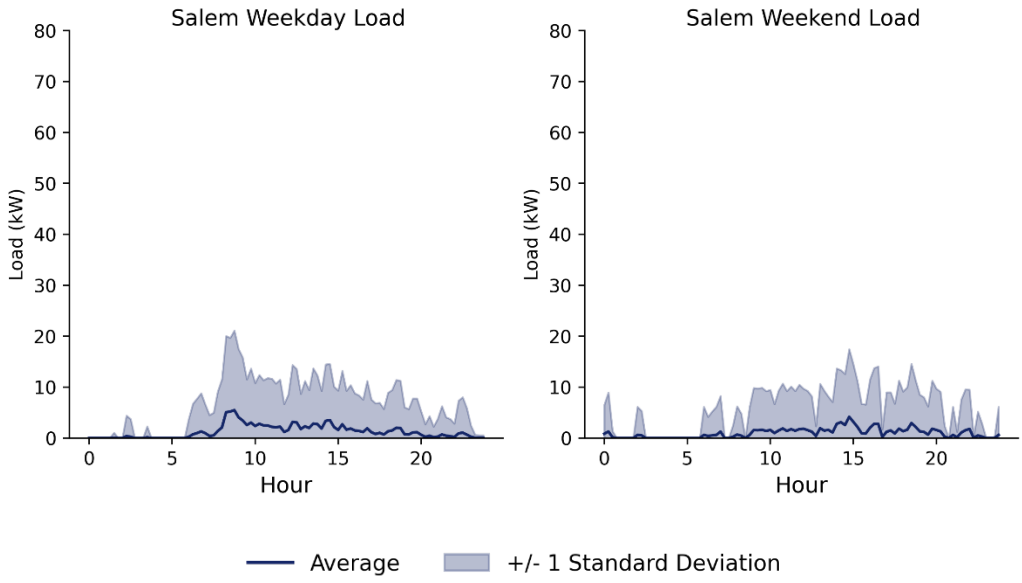
Users of the Salem EA were more likely to charge during system peak hours compared to users of other EA sites. Thirty percent of Salem EA site charging occurred during peak hours, compared to 13% to 18% at other EA sites (Figure 49). Some of this may be due to Salem EA's location near the Oregon State Capitol, creating a charging site that is frequently used in the morning as people show up to work. Much less charging occurs at Salem at night or midday, which constitutes much of the "off-peak" time. Additionally, 6:00 a.m. to 10:00 p.m. on Saturday falls into mid-peak, meaning that Sunday is the only day that is fully off-peak. Only 8.5% of Salem's sessions take place on Sundays, which might also contribute to the high incidence of peak and mid-peak usage at Salem EA.

Figure 49. Percent of Energy Consumption According to Time-of-Use Period at EA Sites Including Salem



The load shape for Salem EA was more irregular than the load shapes at other EA sites (Figure 50). This is likely because of the limited data from the site. Out of the 1,203 sessions recorded, only 242 of them occurred on the weekend. Of the weekend charging sessions, none occurred within the hours of 1:00 a.m., 3:00 a.m., or 4:00 a.m., leaving holes in the data. Similarly, weekday charging did not see any sessions at 4:00 a.m. or 5:00 a.m. Even on hours that saw more frequent charging, the lack of data led to the overall load shape not being as smooth as other sites.

Figure 50. Salem Weekday and Weekend Load Shapes



Appendix B. Business Technical Assistance and Training Recipient Survey Memo

PGE Business Technical Assistance

Appendix C. Ride-and-Drive Event Survey Memo

PGE TE Pilot
Program Wave 3 Ride

Appendix D. TNC Driver Focus Group Memo

Round 2 TNC Drivers Focus Group

Appendix E. EA Site User Survey Memo

PGE TE Pilot
Program Electric Ave

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Memorandum

To: John Boroski, Portland General Electric

From: Zac Hathaway and Allyson Dillehay, Opinion Dynamics

Date: June 9, 2022

Re: PGE UM 1811 Transportation Electrification Pilot – Business Technical Assistance Recipient Feedback

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This memo summarizes the results of three rounds of surveys with organizations who received technical assistance consultations from Portland General Electric (PGE) staff for installing workplace charging and/or fleet electrification. Opinion Dynamics attempted to survey each organization who received technical assistance twice; the first survey was shortly after receiving the technical assistance from PGE (the "initial survey") and the second survey was about six months later (the "follow-up survey") to better understand how their project(s) were progressing.

The key objectives of the Business Technical Assistance surveys were to understand:

- Recipient experience and satisfaction with the technical assistance received
- How recipient understanding of charger siting, maintenance, and costs changed because of the technical assistance
- The influence the technical assistance had on charger installations and/or electric vehicle (EV) fleet purchases.

Analysis of the Business Technical Assistance surveys revealed the following key findings:

- Nearly two-thirds (60%) of respondents whose organizations provide parking to their employees or customers have installed chargers after working or interacting with PGE. Over one-third (41%) of those who installed charging since receiving a consultation from PGE reported the consultation to be very influential in their decision-making, with an additional quarter (23%) of respondents reporting the consultation was moderately influential.
- Most (88%) respondents who have not installed chargers but have parking for their employees or customers indicated that they are still considering installing charging in the future, with about half (47%) reporting they are very likely to install charging within the next three years. When considering installing charging, respondents are more concerned about the cost of site upgrades than the cost of the chargers themselves.
- Nearly half (46%) of respondents whose organizations own fleet vehicles indicated that their organization electrified at least a portion of their fleet after interacting with PGE. One-third (33%) of respondents who purchased EV(s) for their fleet after receiving a consultation from PGE indicated that the consultation was very influential in their decision- making, with an additional quarter (27%) of respondents reporting the consultation was moderately influential.

- About one-quarter (22%) of respondents who received a consultation indicated that their consultation increased their organizations' likelihood of purchasing or leasing an EV within the next three years a great deal. Further, about half (48%) of respondents indicated that their organization is very likely to purchase or lease an EV in the next three years.
- Respondents are highly satisfied with the technical assistance they received from PGE, with 84% indicating they were "very satisfied" with the consultations. Similarly, over three-quarters (82%) of respondents indicated they would be very likely to recommend PGE technical assistance consultations to a colleague or other industry professional. After receiving a consultation from PGE staff, most respondents indicated that they are very prepared to select the appropriate charging equipment (76%), install charging equipment (64%), and purchase the appropriate EVs for their fleet or business (56%).

1. Methodology and Survey Disposition

Opinion Dynamics completed three waves of surveys between 2019 and 2021 with organizations who received technical assistance consultations from PGE staff. We conducted initial surveys with 50 organizations between five and twelve months (typically six months) following receipt of the technical assistance (Table 1). We also completed 29 follow-up surveys with organizations who had received technical assistance consultations and completed the initial survey. We fielded this survey between seven and eight months after the initial survey to learn how the organizations were progressing toward electrification. We report the combined results from the initial and the follow-up surveys below.

Table 1. Business Technical Assistance Survey Dispositions

Survey Wave	Number of Attendees Invited	Initial Surveys Completed	Follow-up Surveys Completed	Total Surveys Completed
1	76	14	8	**22**
2	43	17	11	**28**
3	32	19	10	**29**
Total	**225**	**50**	**29**	**79**

2. Respondent Characteristics

Survey respondents represent a variety of organizations, including cities, hospitals, universities, research centers, state services, a port district that oversees aviation and marine activity, non-profits, apartments, a school district, a park, a zoo, a water district, a nature conservation center, transit operators, and businesses including a real estate firm, vehicle manufacturer, dealership, auto repair shop, air filtration business, construction companies, designing and architectural business, and trucking companies.

About one-third (34%) of respondents indicated their organization has between 101 and 1,000 employees working for their organization, and about one-quarter (24%) reported their organization has more than 1,000 employees (Table 2).

Table 2. Number of Employees in Respondents' Organizations (n=50)

Number of Employees	Count	Percent
Fewer than 10	8	16%
10 – 50	6	12%
51 – 100	4	8%
101 – 500	14	28%
501 – 1,000	3	6%
More than 1,000	12	24%
Don't know	3	6%
Total	**50**	**100%**

3. Survey Results

3.1 Reasons for Technical Assistance and Recipient Feedback

Nearly all respondents received technical assistance for charging infrastructure. The majority of surveyed technical assistance recipients indicated receiving information on charging infrastructure during their consultation, while almost half (48%) reported receiving technical assistance for fleet electrification. Over a third of respondents (42%) reported receiving assistance on both topics during their consultation.

Most respondents were in the middle stages of deciding about EV options or charging investments when they had their consultation with PGE staff. Many were further along in the process at the time of the follow up survey. Among respondents of the initial survey, most indicated that they were either considering or planning their investment (48%; Table 3). At follow-up, most respondents indicated they were still considering or planning their investment (28%) or in the design or purchase/installation process (31%).

Table 3. Decision Stage for Respondents at Time of Initial Survey and Follow-up Survey (Multiple Responses Allowed)

Decision Stage		Initial Survey (n=50)		Follow-up Survey (n=29)	
		Count	Percent	Count	Percent
Early ↓ Late	Still seeking out information	18	36%	2	7%
	Considering or planning investment	24	48%	8	28%
	Actively evaluating plan	18	36%	1	3%
	In design or purchase/installation process	16	32%	9	31%
	Already designed or purchased equipment	7	14%	6	21%
Unable to install charging after seeking out information		0	0%	1	3%
Project on hold due to budget or uncertainty		0	0%	4	14%

The main reasons respondents gave for signing up for technical assistance was to learn about EV incentives available (74%), understand costs associated with chargers (64%), and/or to learn about technical expertise and resources that are available (62%; Table 4).

Table 4. Reported Reasons for Receiving Technical Assistance (Multiple Responses Allowed; n=50)

Reason for Receiving Technical Assistance	Count	Percent
Learn about EV incentives available	37	74%
To understand costs associated with chargers	32	64%
Learn about technical expertise and resources available	31	62%
Learn about potential PGE distribution system upgrades needed	28	56%
To understand best location to place chargers	23	46%
Get help selecting chargers	19	38%
Learn the benefits of EVs for business or organization	8	16%

At follow-up, about one-third (31%) of respondents indicated that they still needed additional information to help them with their decisions including:

- Help comparing charger brands
- Information about reliability and durability of the chargers
- Charger siting recommendations
- Incentive offerings for charger installations

Additionally, four respondents mentioned they were waiting for permissions or requests for installation from other entities such as tenants and financial lenders. All other respondents indicated they did not need any additional information.

3.2 Workplace Charging

3.2.1 Installation of Charging and PGE Influence

Nearly two-thirds of technical assistance recipients have installed chargers after working or interacting with PGE. Among those respondents who reporting providing parking to their employees or customers (84% of all respondents), three-fifths (60%) indicated they installed EV charging (Table 5). Of those respondents who installed chargers, two indicated that their chargers are open to the public and four indicated they are open to employees and guests. At follow-up, five respondents indicated that they installed additional workplace chargers in addition to those that they had reported installing during the initial survey. Three respondents who had not previously installed workplace chargers at the time of the initial survey reported having installed workplace chargers in the follow-up survey.

Table 5. Number of Respondents Who Have Installed Chargers or Are Considering Future Charger Installation (n=42)

Installation Status	Count	Percent
Installed chargers	25	60%
Have not installed chargers but are considering	15	36%
Have not installed chargers and are not considering	2	5%
Total	**42**	**100%**

Note: Counts include initial survey and follow-up survey responses. Question asked only of respondents who reported their organization provides parking for employees or customers.

Of the 25 respondents who installed workplace chargers, Level 2 chargers were the most-frequently installed (Table 6).

Table 6. Workplace Charger Installations, by Type (n=25; Multiple Responses Allowed)

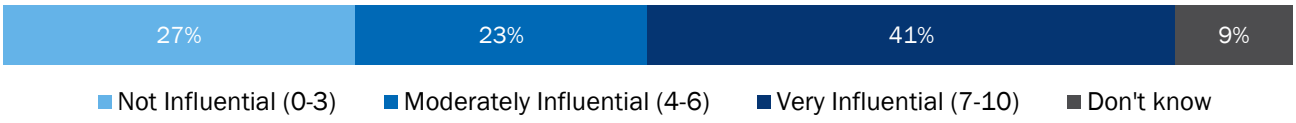
Amount Installed	Direct Current Fast Chargers (DCFC)	Level 2 Chargers	Standard Outlets
Five or fewer	2	8	3
More than five	2	10	6

Note: Counts include initial survey and follow-up surveys. Five respondents could not provide any information about the types and number of chargers installed.

Most respondents who have not yet installed chargers reported they are still considering installing chargers in the future. Among the 17 respondents who have not installed chargers but have parking for their employees or customers, over three-quarters (15 or 88%) indicated that they are still considering installing charging in the future. The remaining respondents either indicated that they are not considering installing charging or do not know. The most prevalent concerns among respondents who have not yet installed chargers were the costs associated with purchasing and installing chargers (12 mentions), capital budget uncertainty (11 mentions), and lack of staff resources to devote to the project (five mentions; multiple mentions allowed).

A majority of surveyed technical assistance recipients indicated that the consultations they received from PGE were at least moderately influential in their decision to install chargers and without it, they would have scaled back their projects. Over one-thirds (41%) of respondents who reported installing chargers following their consultation rated the consultation they received from PGE as very influential in their decision to install their charger(s), with an additional one-quarter (23%) of respondents reporting the consultation was moderately influential (Figure 1). When asked what they would have done if they had not had the PGE consultation, eight (of 25) respondents mentioned that they would have done the exact same installation(s). The remaining respondents indicated they would have done the installation but at a smaller scale (four mentions), postponed installing the charging equipment for two to three years (three mentions), done something else (two mentions), or did not know what they would have done (five mentions). One respondent who indicated they would have done something else mentioned that they would have "over-installed" charging if it had not been for PGE's consultation, and another mentioned they moved forward with their plans and the consult provided them with options for additional future installations.[1]

Figure 1. Influence of PGE Consultation on Respondents' Decision to Install Chargers (n=22)*



*Note: Three respondents who reported installing chargers at their workplace but did not know what type of chargers were installed were not asked this question.

[1] Note: three respondents did not provide a response to the question about what they would have done had they not received a PGE consultation.

3.2.2 Challenges and Barriers Associated with Workplace Charging

Technical assistance recipients were varied in terms of the consultation's impact on their likelihood to install charging in the next three years, suggesting there may be other factors driving their decision to install charging within the next three years. Three respondents (of 17 who did not install workplace charging or were unsure if they had) indicated that the consultation they received from PGE increased their likelihood of installing charging within the next three years "a great deal," while most respondents (seven mentions) indicated the consultation increased their likelihood "a little" (Figure 2**Error! Reference source not found.**).

Figure 2. Consultation Impact on Likelihood of Installing Charging within Three Years (n=17)

Fifteen (60%) of the twenty-five respondents who have installed workplace charging encountered challenges with purchasing, installing, or permitting their charger(s). The primary challenge reported by respondents included the installation taking more time to complete than expected (20%) or the stations not working as intended (16%; Table 7). Ten respondents reported experiencing no challenges, mentioning that the installation was on budget (three mentions) and the stations worked well from the beginning (eight mentions; multiple mentions allowed).

Table 7. Challenges Faced by Respondents Who Have Installed Charging (n=25; Multiple Responses Allowed)

Challenges Faced by Respondents	Count	Percent
Taking more time than expected	5	20%
Stations not working as intended	4	16%
Permitting taking longer than expected	3	12%
Stations not functioning properly	3	12%
Project has gone over budget	2	8%
No challenges	10	40%

Most respondents who have not installed charging reported financial factors are preventing them from purchasing chargers. About three-quarters (76%) of respondents reported costs associated with chargers as a barrier, while over half (59%) of respondents reported capital budget uncertainty as a barrier. Though costs were the most reported reasons for not installing charging, most (94%) respondents who did not install workplace charging, or were unsure if they had, encountered other barriers (Table 8).

Table 8. Challenges Faced by Respondents Who Have Not Installed Charging (n=17; Multiple Responses Allowed)

Challenges Faced by Respondents	Count	Percent
Costs associated with chargers	12	76%
Capital budget uncertainty	11	59%
Lack of staff resources to devote to project	5	29%
Uncertainty in future operations, staffing, or customer traffic	4	24%
Benefits of adding charging not clear	2	12%
Concerns around third party owning property	2	12%
Staff and customers sharing access	2	12%
Reliability or uptime	1	6%
Unsure how to begin process	1	6%
Insufficient space for charger(s)	1	6%
Project stalled due to COVID-19	1	6%
Awaiting grant funding	1	6%
Cost of transformer and electrical panel upgrades	1	6%
Unsure how to find a contractor	1	6%
Not sure	1	6%

Note: Counts include combined, non-duplicate responses from initial and follow up survey.

We asked technical assistance recipients with capital budget uncertainty whether they were more concerned about the costs of the chargers themselves or costs associated with site upgrades to do the installation. More respondents are concerned with the cost of the site upgrades (8 of 12) to install the chargers than the cost of the chargers themselves (3 of 12). The remaining respondent noted they were most concerned about the total project cost.

3.2.3 Likelihood of Future Charging Installation

About half of respondents who have not yet installed chargers reported they are likely to install charging in the next three years. Of the seventeen respondents who reported providing off-street parking for their employees but have not yet installed EV charging, about half (47% or eight respondents) indicated they are very likely to install charging within the next three years and an additional five indicated that they are somewhat likely (Figure 3).

Figure 3. Likelihood of Installing Charging within the Next Three Years (n=17)

3.3 Fleet Electrification

3.3.1 Purchase of EVs and PGE Influence

After receiving their consultation with PGE, about half (46%) of respondents whose organizations own fleet vehicles indicated that their organization purchased at least one EV. Respondents reported that they purchased 148 EVs since receiving a consultation from PGE (Table 9). EVs purchased by respondents included forklifts/lift trucks, passenger cars, vans, school buses, public transit buses, heavy-duty commercial trucks, and golf carts.

Table 9. EVs Purchased After Working or Interacting with PGE (n=15)

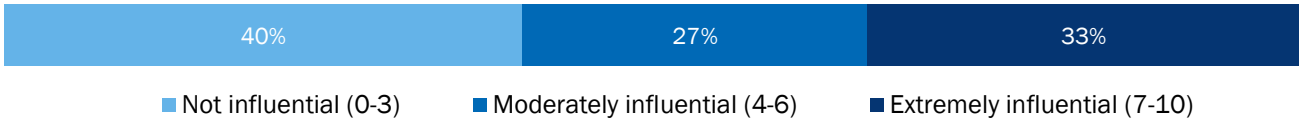
EV Type	Number Purchased
Passenger cars	88
Heavy-duty commercial trucks	36
Public transit buses	7
Forklifts/Lift Trucks	5
Vans	5
School buses	5
Golf carts	2
Total	**148**

Note: Counts include initial survey and follow-up surveys.

The most common barriers for respondents who had not purchased EVs for their fleet (n=23) include concerns about vehicle range (10 mentions), the cost being too high compared to gasoline or diesel models (10 mentions), and concerns about where to charge (nine mentions).

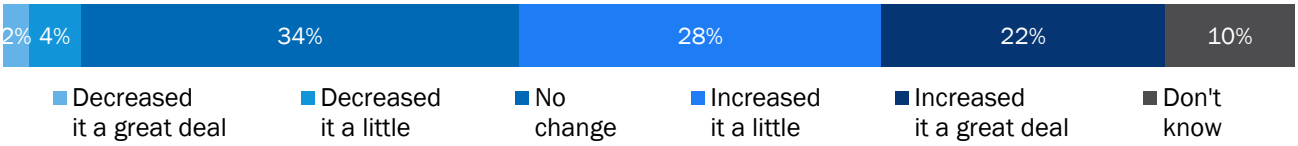
The influence of technical assistance on the decision to purchase EVs was mixed. One-third (33%) of respondents who purchased EV(s) for their fleet after receiving a consultation from PGE indicated that their consultation was very influential in their decision-making, with an additional one-quarter (27%) of respondents reporting the consultation was moderately influential (Figure 4).

Figure 4. Influence of PGE Consultation on Respondents' Decision to Purchase EVs (n=15)



Technical assistance and education have increased some respondents' likelihood of purchasing or leasing an EV within the next three years, but not all. About one-quarter (22%) of respondents who received a consultation indicated that their consultation increased their likelihood of purchasing or leasing an EV within the next three years "a great deal" (Figure 5).

Figure 5. Consultation Impact on Likelihood of Purchasing or Leasing an EV within Three Years (n=50)



3.3.2 Challenges and Barriers Associated with Fleet Electrification

The most commonly reported barrier preventing respondents from purchasing additional EVs for their organization's EV fleet was the cost of EVs in comparison to gas or diesel models. Nearly two-thirds (63% of 38) of respondents whose organizations have electric fleet vehicles indicated that the cost of EVs compared to gas or diesel models is a barrier preventing their organization from purchasing additional EVs for their fleet (Table 10). Other primary barriers reported by respondents included concerns about vehicle range and where to charge (45% each).

Table 10. Barriers Preventing Respondent Organizations from Purchasing Additional EVs For Their Fleet (n=38; Multiple Responses Allowed)

Barriers to Fleet Electrification	Count	Percent
Cost too high compared to gas or diesel model(s)	24	63%
Concerns about vehicle range	17	45%
Concerns about where to charge (chargers owned by others)	17	45%
Not aware of an electric version	10	26%
Concerns about longevity of battery	9	24%
Unable to install chargers on property	7	18%
Cost of charging infrastructure	1	3%
Something else	4	11%
Not sure	4	11%

3.3.3 Likelihood of Future Fleet Electrification

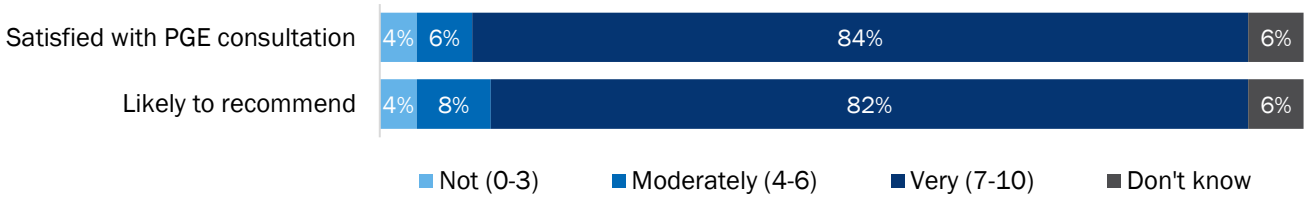
Nearly half (48%) of surveyed technical assistance recipients indicated that they are very likely to purchase or lease an EV in the next three years and an additional 16% indicated they are somewhat likely (Figure 6).

Figure 6. Likelihood of Purchasing or Leasing an EV within the Next Three Years (n=50)

3.4 Satisfaction with Technical Assistance

Recipient satisfaction with PGE's technical assistance is high and most recipients are likely to recommend PGE's consultation services to colleagues. About three-quarters (84%) of respondents indicated being very satisfied with the technical assistance they received from PGE (Figure 7). Similarly, about three-quarters (82%) of respondents indicated they would be very likely to recommend the technical assistance they received from PGE to a colleague or other industry professional.

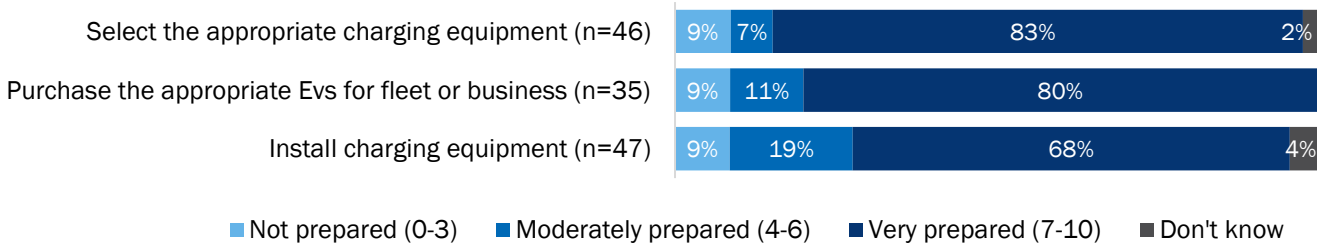
Figure 7. Respondents' Satisfaction with the Technical Assistance they Received from PGE and Likelihood to Recommend the Technical Assistance Received from PGE (n=50)



While respondents indicated high levels of satisfaction with the technical assistance they received, five indicated that they would have liked additional information. Respondents most often indicated they would have liked more information about financial assistance including incentives and grants (five mentions). Remaining respondents reported they would have liked more information on the availability of PGE's design services (one mention), opportunities for sharing charging data (one mention), and easier access to the information that was provided through the technical consultation (one mention).

The technical assistance provided by PGE staff is effective in preparing businesses and organizations to electrify their fleets and install workplace charging. Respondents mostly indicated that after receiving a consultation from PGE staff, they were very prepared to select the appropriate charging equipment, install charging equipment, and purchase the appropriate EVs for their fleet or business (Figure 8).

Figure 8. Respondents' Level of Preparedness After Receiving a Consultation from PGE*



*Note: Analysis excludes respondents who provided "not applicable" responses.

3.5 Source of Awareness and Topics Discussed

Most respondents learned about PGE's consultation services through PGE staff. About two-thirds (60% or 30 respondents) of surveyed technical assistance recipients said they learned about PGE's consultation services through a PGE Key Customer Manager or other PGE staff (Table 11).

Table 11. Ways Respondents Learned About PGE Consultation Opportunity (n=50; Multiple Responses Allowed)

Ways Learned About PGE Consultation	Count	Percent
PGE Key Customer Manager (KCM)	14	28%
Other PGE staff	16	32%
Colleague or someone in industry	18	36%
PGE's ride-and-drive implementer	11	22%
PGE website	8	16%
Emails from PGE	5	10%
Class, webinar, or conference where PGE speaker presented	5	10%
Letter or postcard from PGE	1	2%
PGE's dealer engagement implementer	1	2%
Something else	2	4%

During their consultations, respondents discussed a range of topics with PGE staff, most of which covered the costs associated with charging infrastructure and financial and technical resources available for charging infrastructure (Table 12).

Table 12. Topics Discussed During Consultations (n=50; Multiple Responses Allowed)

Topics Discussed	Count	Percent
Charging Infrastructure		
Associated costs	37	74%
Technical resources available	35	70%
Financial resources available	31	62%
PGE distribution systems upgrades required	23	46%
Benefits to your business or organization	16	32%
Fleet Electrification		
Associated costs	21	42%
Financial resources available	19	38%
Technical resources available	18	36%
Benefits to your business or organization	16	32%

Ten respondents indicated that they would have liked additional information during their consultation with PGE staff. One respondent wanted more information about opportunities to share information they were compiling, such as power metering of high-power chargers for trucks. Another reported wanting to see more active involvement from PGE in planning EV charging locations and help in developing long-term business models, including a financial plan to fund charging installations and maintain the chargers in the long term. Eight other respondents indicated wanting more information about design services PGE can provide (one

mention), assistance or more information to improve the interface between their city government and electricians (one mention), and information about financial assistance (including funding for installing employee charging stations), incentives, and timelines for when they may be available (six mentions).

3.6 Awareness of PGE's Transportation Electrification Resources

Nearly all (84%) respondents reported having seen or being aware of at least one of PGE's EV resources, campaigns, or discounts. PGE's Electric Avenues (60%) and website (54%) were the most frequently cited resources (Table 13).

Table 13. PGE EV Resources, Campaigns, or Discounts Respondents Have Seen or Heard Of (n=50; Multiple Responses Allowed)

PGE EV Resources, Campaigns, or Discounts	Count	Percent
PGE's Electric Avenues	30	60%
PGE's website	27	54%
PGE's Drive Change Fund	22	44%
PGE's Workplace Charging Program	18	36%
Emails on EV services or classes	15	30%
PGE's and Nissan's $3,500 Nissan Leaf discount	12	24%
National Drive Electric Week advertising	11	22%
Social media information on EVs	10	20%
EV educational kiosks at dealerships	8	16%
None or don't know	8	15%

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Memorandum

To: John Boroski, Portland General Electric

From: Zac Hathaway and Harry Gao, Opinion Dynamics

Date: 9/15/2022

Re: PGE Transportation Electrification Pilot Program – 2022 Electric Car Guest Drive and EV Charger Exhibit Intercept Survey Results

---

This memo summarizes the results of the third and final wave of Ride-and-Drive intercept surveys. The research team fielded the surveys at the 2022 Electric Car Guest Drive and Electric Vehicle (EV) Charger Exhibit at Portland Community College's Sylvania campus. Higher income residential homeowners who were enrolled in a Portland General Electric (PGE) Green Future renewable energy program were invited via email to attend the event. The event included 10 EVs attendees could register to test drive, in addition to charging information and demonstration chargers.

The key objectives of the Ride-and-Drive intercept surveys are to understand:

- How attendees heard of the Ride-and-Drive event and reasons for attending;
- Satisfaction with the event and the EV they test drove;
- Consideration and intention to purchase or lease an EV in the near future;
- Attendee exposure to other Portland General Electric (PGE) outreach and education campaigns or resources; and
- Characteristics of those attending (income, location, ridesharing/on-demand delivery vehicle use, and experience with an EV).

Analyses of the third Ride-and Drive intercept survey revealed the following key findings:

- Respondents attended the event primarily to test drive EVs. Many attendees reported being at least somewhat knowledgeable about EVs, with some having experience driving EVs or already owning an EV of their own.
- Attendees reported high satisfaction with all aspects of the Ride-and-Drive, although some would have liked to see more vehicles available to test drive. Most indicated that the event had increased their likelihood to buy or lease an EV.
- About half of the attendees confirmed receiving and engaging with some of PGE's EV marketing campaigns through email or social media, but generally were less aware of PGE's other EV resources or discounts.
- The primary concern of attendees for purchasing or leasing an EV is the vehicle cost.
- Large events with several vehicles available for test drives and many attendees present a challenge for participant surveys. For future events, PGE should consider additional interceptors or survey modes to increase coverage.

1. Methodology and Survey Disposition

On August 13, 2022, the research team conducted an intercept survey during an EV Ride-and-Drive event at the Electric Car Guest Drive and EV Charger Exhibit at Portland Community College's Sylvania campus. The event was the largest of the three events at which the research team fielded intercept surveys. When we last conducted intercepts at a Ride-and-Drive event in November 2019, four vehicles were available to drive, 47 people attended, and 30 test drove vehicles. At this event, 10 vehicles were available, 252 people attended, and 136 test drove vehicles (Table 1 and Table 2). The research team attempted to survey attendees who test drove an EV at the event. In total, the team completed 37 surveys at the event.[1]

Table 1. Summary of Ride-and-Drive Participants and Dispositions

Disposition	Count
Number of attendees	252
Number of individuals who test drove a vehicle	136
Refusals	2
Completed surveys with those who test drove a vehicle	37

Table 2 summarizes the vehicles that survey respondents test drove. The event included a variety of popular vehicle types, including a truck, sports utility vehicles (SUVs), and sedans. Most respondents drove the Rivian R1T truck, followed closely by the Ford Mustang Mach E SUV.

Table 2. EVs Driven by Survey Respondents (n=37; Multiple Responses Allowed)

Vehicle Driven	Count
Rivian R1T	17
Ford Mustang Mach E	15
KIA EV6	8
Polestar 2	6
Hyundai Ioniq 5	5
KIA Niro	5
Tesla Model S	5
Chevy Bolt	4
Tesla Model Y	4
Tesla Model 3	3
Nissan Leaf	1

[1] Not all individuals who test drove a vehicle were surveyed due to the event being spread across a large event space and attendees leaving the area prior to being surveyed.

2. Respondent Characteristics

Respondents generally represented households with high annual income. Over two-thirds (23 of 37) of those who provided their income reported household income of $125,000 or more, while only one respondent had a household income of less than $75,000 (Table 3).

Table 3. Respondents' 2021 Annual Household Income, before Taxes

Household Income	Count
Less than $15,000	1
$15,000 TO $19,999	0
$20,000 to $29,999	0
$30,000 to $39,999	0
$40,000 to $49,999	0
$50,000 to $74,999	0
$75,000 to $99,999	5
$100,000 to $124,999	3
$125,000 or more	23
Refusals	5
Total	**37**

Most respondents lived in homes with their own off-street parking making it easier to charge an EV at home. The vast majority (34 of 37) reported residing in a single-family detached house with a driveway, with the remaining respondents residing in a single-family attached home, a duplex with parking, or a mobile home (one mention each). Nearly all respondents (36 of 37) reported owning their homes. Based on the zip-codes provided by respondents, all but one (36 of 37) reported living in the Portland metropolitan area, with the remaining participant living in Woodburn, Oregon.

Given the parking situation of respondents, it is not surprising that all respondents reported that they would charge their new vehicle at home. About one-third (10 of 37) of respondents mentioned they would also charge at their workplace and two mentioned that they would charge at a PGE Electric Avenue.

Over two-thirds (28 of 37) of respondents reported leasing or owning two or more vehicles, typically driving their vehicles 100 miles or less per week (Table 4). No respondents reported using their current vehicle(s) for ridesharing or on-demand delivery.

Table 4. Respondents' Vehicle Use (n=37)

Respondent Vehicle Characteristics	Count
Number of vehicles leased or owned by household	
1	8
2	23
3 or more	5
None	1
Miles driven per week for personal reasons	
50 or less	8
51 to 100	15
101 to 200	5
201 to 400	1
Over 400	3
Don't know	5

3. Awareness of Event and PGE EV Information and Resources

Over two-thirds (26 of 37) of respondents reported being aware at least one PGE EV resource, campaign, or discount prior to attending the event (Table 5). Respondents most commonly reported being aware of EV-related emails from PGE (18 of 37), EV-related social media posts (15 of 37), PGE's $500 rebate for purchasing and installing a Level 2 home charger (13 of 37), and PGE's Electric Avenue charging stations (8 of 37). Three respondents were aware of and had used PGE's online EV Cost and Savings Calculator, all of whom found the calculator to be at least somewhat helpful in comparing EV costs and savings compared to gas vehicles.

Table 5. PGE EV Resources, Campaigns, or Discounts Seen Before Attending the Event (n=37; Multiple Responses Allowed)

PGE Information and Resources	Count
Email from PGE	18
Social media information from PGE on EVs	15
PGE's $500 rebate for purchasing and installing a PGE-approved level 2 home charger	13
PGE's Electric Avenue charging stations	8
PGE's online EV Costs and Savings Calculator	3
PGE's Smart Charging Program	3
Interactive displays at dealerships with vehicle charging information	1
PGE's Electric Avenue at Portland International Auto Show	1
PGE's evPulse Program for Tesla vehicle owners	1
PGE's Electric Vehicles and Charging webpage	0
None	6
Don't know	5

4. Reasons for Attending

All but one respondent reported attending the event to test drive an EV (Table 6). About one-third (14 of 37) also wanted to learn more about EVs. Respondents also attended the event to learn about public charging availability (9 of 37), learn about EV rebates or discounts (8 of 37), and to learn about charging costs (5 of 37).

Table 6. Reason for Attending Ride-and-Drive Event (n=37; Multiple Responses Allowed)

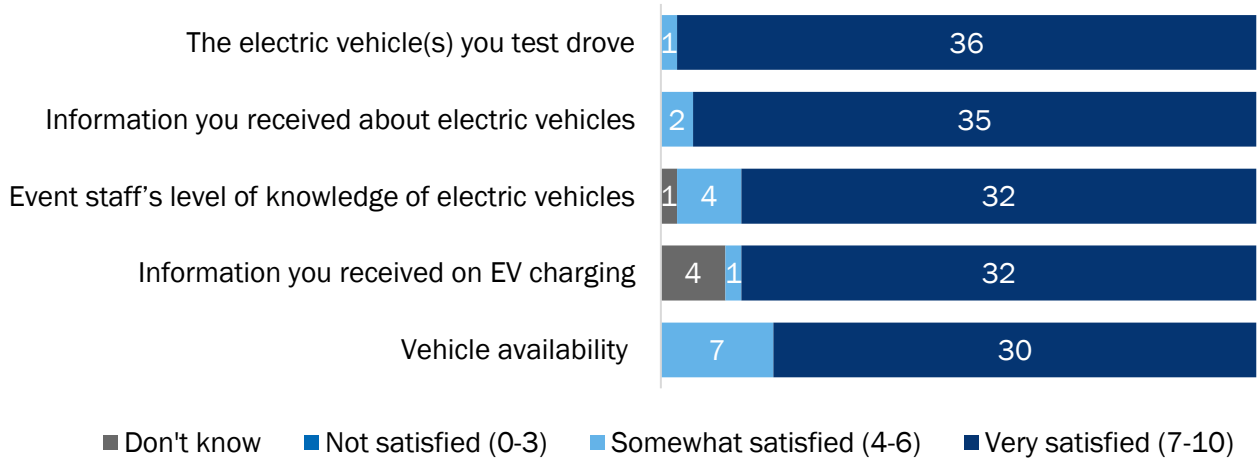
Reason for Attending	Count
To test drive EVs	36
To learn more about EVs	14
To learn about the types of charging available	9
To learn about EV rebates or discounts	8
To learn about charging costs	5

The Ride-and-Drive event attracted an audience that had some prior experience with EV and is likely to purchase one. About one-third of respondents (12 of 37) already owned an EV or plug-in hybrid vehicle of their own. Of respondents who do not already own an EV, about two-thirds (16 of 25) have driven one. Additionally, all respondents, including those that already own an EV themselves, confirmed that they were either very likely (35 of 37) or somewhat likely (2 of 37) to purchase or lease an EV within the next five years.

5. Event Feedback

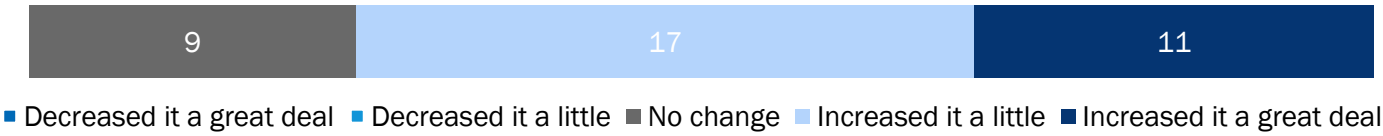
Survey respondents reported high levels of satisfaction with the event, especially in terms of the EVs they test drove and the information they received (Figure 1). A minority of respondents (7 of 37) reported being less satisfied with vehicle availability. These respondents mentioned that the wait time to test drive some of the more popular EVs at the event was longer than they anticipated.

Figure 1. Respondent Satisfaction with the Event (n=37)



Just under one-third (11 of 37) of respondents indicated that the Ride-and-Drive event increased their likelihood of purchasing or leasing a plug-in vehicle "a great deal." About half (17 of 37) noted the event had increased their likelihood by "a little." The remaining nine respondents did not feel that the event had changed their likelihood of purchasing a plug-in vehicle. None of the respondents said that their experience at the Ride-and-Drive reduced their likelihood to purchase a plug-in vehicle.

Figure 2. Effect of Ride and Drive Event on Likelihood of Purchasing or Leasing an EV (n=37)



While about two-thirds (24 of 37) of respondents were aware of PGE's Electric Avenues, only a few (5 of 37) reported that the availability of the Electric Avenues influenced their consideration of EVs.

Even after the test drive, respondents mentioned some concerns they had about purchasing or leasing an EV (Table 7). Respondents were primarily concerned about purchase price of the vehicle (26 of 37) and the current lack of available EVs for purchase (13 of 37), while other more technical issues like safety and reliability, were less concerning.

Table 7. Potential Barriers Preventing Respondents from Purchasing or Leasing a Plug-in Vehicle
(n=37; Multiple Responses Allowed)

Purchasing or Leasing Barrier	Count
Purchase price of vehicle	26
Lack of available EVs for purchase or lease	13
Driving range (number of miles on a single charge)	7
Availability of public charging stations	4
Vehicle safety	4
Inability to charge at home	2
Inability to charge at work	2
Reliability	2
Time required to charge battery	2
Cost of charging the vehicle/Vehicle maintenance costs	2
Manufacturer/company reputation	1
Not applicable – already own or lease an EV	4
Don't know	2

Over two-thirds (27 of 37) of respondents reported not needing additional information about EVs. Among the seven respondents who wanted additional information, five had questions about federal and state rebates for EVs, while the other two wanted information on charging options, particularly at home.

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PGE Electric Avenues TNC and On-Demand Delivery Driver Focus Group Memo

Round 2

To: John Boroski, Portland General Electric
From: Zac Hathaway, Lenore Zeuthen, and Sam Lamos, Opinion Dynamics
Date: October 26, 2022
Re: Round 2 TNC Focus Group Findings

Introduction and Key Findings

This memo summarizes the results of an online focus group discussion Opinion Dynamics hosted with eight Portland General Electric (PGE) customers who either recently drove or currently drive for a Transportation Network Company (TNC) or an on-demand delivery company and currently own or lease an electric vehicle (EV) or plug-in hybrid electric vehicle (PHEV). All participants were PGE Electric Avenue (EA) subscribers. The focus group was held on August 24, 2022, and the discussion explored participants' experiences as a TNC driver or on-demand delivery driver, and their experiences using EVs and PGE's Electric Avenue charging sites for ridesharing and on-demand deliveries. Opinion Dynamics also hosted a focus group in 2020 with TNC drivers who were considering purchasing an EV.

This research revealed the following key findings:

- Drivers are satisfied with EA chargers and have noticed that uptime has generally improved over the past year;[1] however, they would like to see greater consistency across charging sites. Drivers also noted that chargers listed as online on EV charging apps are not online upon arrival. They mentioned that real-time user input on apps such as PlugShare and Shell Recharge would be helpful so that PGE can quickly identify issues and fix chargers.
  - **Recommendation:** Consider providing outreach to EA users informing them that they can use apps such as PlugShare and Shell Recharge to report issues at EA sites. Outreach could include emails to EA users and additional signage at EA sites. Continue to have staff monitor and address customer-reported issues as they occur.
- Drivers would like to see more chargers at the current EA locations, especially the Downtown Portland and Beaverton EA sites. Drivers most commonly charge at these locations and would like to see more fast charging equipment to allow for increased driver turnover. Drivers mentioned that additional charging ports are needed due to increased EV adoption in the area.

[1] "Uptime" is the amount of time that a charger is online and available for use.

- **Recommendation:** Increase the number of charging ports to accommodate the increasing number of EV drivers.

- Drivers reported that additional EA charging locations are needed in the Tigard and Lake Oswego areas. Drivers would like to increase their driving range and therefore need additional charging stations across Portland and adjacent areas.
- Participants reported issues at the Downtown EA location including: EV drivers parking vehicles in charging stations without charging, vehicles left overnight, and non-electric delivery vehicles blocking the station. This station was also reported as being one of the most heavily used by drivers. Drivers felt additional accountability for illegal parking and charger idling is needed to make it easier to charge at this location.
  - **Recommendation:** Increase enforcement for illegal parking in EV spaces and EVs parking in charging spaces without charging, especially at the Downtown EA.
  - **Recommendation:** Consider charger idling fees to mitigate the number of drivers leaving their vehicles connected to chargers for extended periods of time.
- Drivers who live in multifamily buildings without access to charging are less likely to purchase another EV due to lack of charging infrastructure. Drivers had concerns about charger availability and range and therefore said they were less likely to purchase another EV in the future.
  - **Recommendation:** Increase support to multifamily customers though multifamily on-site charging programs and additional on-street pole charging and EA sites located near multifamily properties.
- Drivers noted that amenities similar to those provided at gas stations would be helpful at EA locations. Divers indicated that amenities such as trash cans, bathrooms, and vending machines would improve their charging experience. Additionally, drivers reported that shaded charging stations would prevent their cars from overheating while charging on hot days.
  - **Recommendation:** Offer amenities at charging stations similar to those offered at gas stations where possible or co-locate new chargers near shopping centers, restaurants, and bathrooms.
- Drivers mentioned that PGE's EA charging sites should be more widely marketed to drivers. A majority (5 of 8) of drivers learned about EA by driving past an EA site or using one. Only one driver recalled receiving an email about PGE's EA sites. One driver reported that their local car dealerships were unaware of PGE's EA sites when they purchased their EV.
  - **Recommendation:** Expand direct marketing to PGE customers to increase awareness of EA sites. Consider partnering with the following entities to help market PGE's EAs:
    - TNC companies and on-demand delivery companies
    - Car dealerships that sell EVs
    - Multifamily properties near EA sites

Methods

Recruitment

Opinion Dynamics recruited from a list of 153 EA subscribers provided by PGE. We sent an email to all 153 EA subscribers and asked them to fill out a short screening survey. The survey confirmed PGE was their electric service provider, they owned an EV, and they could participate in a focus group at the specified time and date. After EA subscribers responded to the screening survey, the research team called interested respondents and confirmed that they were either current or recently retired TNC or on-demand delivery drivers.[2] The team recruited 12 participants, eight of whom attended the online focus group.

At the outset of the focus group, the moderator explained to the participants that they were free to agree and disagree with one another and encouraged them to share their true thoughts and opinions. The focus group was recorded with participants' permission. After completing the focus group, participants were provided a $100 virtual gift card. Drivers who also completed a mapping assignment prior to the focus group were given an additional $25 incentive. Additional details regarding the mapping assignment are provided below.

Mapping

We asked participants to complete a brief mapping assignment prior to the focus group to show where additional public charging is needed around the city. We provided two maps: one of the wider Portland metropolitan area and one map of areas close to downtown Portland. We asked participants to mark the places and routes they frequent while working including:

- Commonly used charging locations
- Routes they frequently drive
- Neighborhoods or specific locations where they pick up or drop off frequently
- Places they frequently stop for errands, food, or breaks

Six of the eight drivers completed the mapping assignment[3]. A combined map is provided in the Charging Habits and Experience section. The drivers' original maps are provided in Appendix A.

Focus Group Participants

Drivers in the focus group represented a range of TNC drivers. Half of the drivers (4 of 8) drove for on-demand delivery, two drove for on-demand delivery and TNCs, and one drove for TNCs only. One participant had recently stopped TNC driving in the last six months.

Drivers all possessed relatively new EVs with the median vehicle age being three years. The oldest vehicle was 10 years old. Some of these vehicles were PHEVs (3 of 8) while the majority were EVs (5 of 8). Three participants owned a secondary internal combustion engine (ICE) vehicle, and one owned a secondary hybrid.

[2] "Retired drivers" reported working for a TNC company in the last year, but are not currently driving for a TNC company.
[3] Two of the six drivers who completed the mapping assignment did not attend the focus group; however, we included their maps in the combined map below.

Two of the participants who owned secondary ICE vehicles reported that they only use those cars for longer trips. The remaining participant rarely used their secondary ICE vehicle.

Drivers drove for TNC companies frequently. Half of the drivers (4 of 8) drove every day while the other half drove a few times a week. Half of the drivers (4 of 8) noted that TNC driving was their primary source of income while the other half reported it was not. Drivers were evenly split regarding how far they drive every week. Drivers responded evenly across the four milage categories ranging from less than 100 miles a week to over 1,000 miles each week.

Table 1 provides a summary of participant characteristics.

Table 1. Participant Characteristics

Participant	EV Make and Model	Vehicle Type	Driver Type	Miles Driven per Week for TNC or On-Demand Delivery	Home Type	Home Charger
Participant 1	2019 Nissan Leaf	EV	On-demand delivery	Over 1,000 miles	Single Family	Level 2
Participant 2	2019 Nissan Leaf	EV	Previously drove for TNC	101 to 400 miles	Multifamily	None
Participant 3	2022 Polestar 2	EV	TNC and on-demand delivery	701 to 1,000 miles	Single Family	Level 2
Participant 4	2017 Chevy Volt; 2017 Ford Focus	PHEV; EV	TNC & on-demand delivery	Over 1,000 miles	Multifamily	None
Participant 5	2017 Chevy Volt	PHEV	On-demand delivery	100 miles or less	Single Family	Level 1
Participant 6	2021 Hyundai IONIQ	EV	On-demand delivery	101 to 400 miles	Multifamily	None
Participant 7	2012 Nissan Leaf	EV	On-demand delivery	100 miles or less	Single Family	Level 1
Participant 8	2022 Kia Nero	EV	TNC	701 to 1,000 miles	Single Family	Level 1

Awareness of EV Resources

Most drivers (5 of 8) conducted their own independent research to find information about EVs. A few drivers mentioned using YouTube (three mentions) or websites such as Reddit (two mentions), both of which allow for individuals to post about their experiences. Two drivers reported visiting the PGE website to find information. After using an EA site to charge, one driver visited the PGE website where they learned about the EA subscription. Another driver stated that it was easy to navigate the PGE website and apply for a home charging incentive.

Drivers typically learned about PGE's EA chargers and subsequently the available subscription after using an EA charging station (four mentions). Drivers typically did not know about the EA subscription until they used an EA charger. One participant received an email from PGE after using an EA charger, notifying them about the subscription. Two drivers reported finding the EA subscription through independent research. One driver mentioned learning about it through information provided by Forth. Only one driver reported that they knew about EA chargers prior to using a charger since it was near their workplace.

Charging Habits and Experience

All drivers primarily use apps such as PlugShare and Shell Recharge to locate charging stations. Other apps mentioned included the Nissan Leaf app and the Volta app (one mention each). A couple of drivers reported using Google to find charging stations (two mentions) and others reported being aware of EV-related resources available through Uber (three mentions).

Most drivers primarily rely on EA sites for their charging needs, regardless of owning a home charger. The median proportion of charging at EA sites was 70% (Table 2). Three of the five drivers with home charging predominantly use EA sites for their charging needs. The other two drivers with home chargers split their charging between home charging and EA and non-EA public charging. Drivers without home chargers (3 of 8) relied almost entirely on public charging stations. Two of these drivers used EA chargers over 90% of the time compared to non-EA chargers. The other driver split their charging evenly between EA and non-EA charging sites.

When using public charging, drivers predominantly use EA sites to charge their vehicles compared to non-EA sites. Most drivers (5 of 8) mentioned they charge their vehicle at EA sites more than or equal to 50% of the time. Comparatively, most drivers (6 of 8) reported using non-EA sites less than or equal to 10% of the time to charge their vehicle.

Table 2. Percent of Driver Charging at PGE's EA Sites, Non-EA Public Sites, and At Home

Participant	EA Sites	Non-EA Public Sites	Home
Participant 2	95%	5%	N/A
Participant 1	90%	0%	10%
Participant 6	90%	10%	N/A
Participant 8	90%	0%	10%
Participant 3	50%	25%	25%
Participant 7	50%	0%	50%
Participant 4	45%	45%	10%[4]
Participant 5	20%	10%	70%
Median	**70%**	**8%**	**10%**

Drivers generally agreed that there were not enough charging stations around the Portland metropolitan area to meet demand. One driver noted the following about their charging experience:

"I was just saying the biggest surprise for me is that there isn't adequate charging. It's not widespread still. And it seems like in 2022 that there would be a lot more charging, and it seems everywhere you go, there's maybe one or two Level 2 chargers, and then nothing else. Or it's all for a different car. So, my experience has been frustrating from that perspective of finding adequate Level 2 charging for the need."

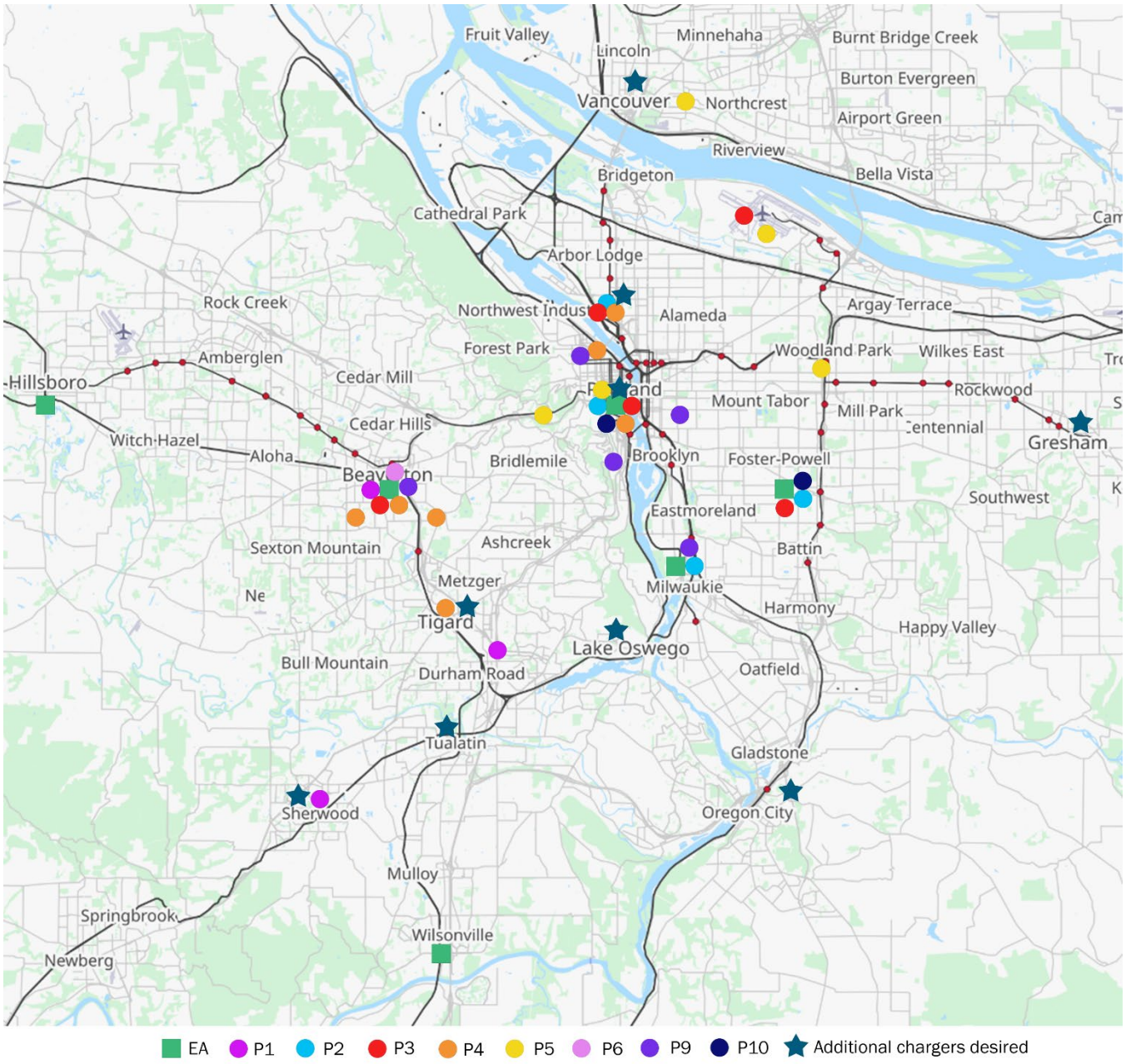
– Participant 5

[4] This driver does not have a dedicated home charger but reported using an extension cord from their apartment to the street to charge their vehicle. For this reason, the number of home chargers reported in Table 1 does not align with Table 2.

Charging Locations

The research team combined the maps from the drivers who completed the mapping assignment to identify commonly used charging locations, routes they frequently drive, frequent pick up or drop-off neighborhoods or locations, and places they frequently stop for errands, food, or breaks prior to the focus group. Figure 1 shows commonly used EA and non-EA charging sites used across the Portland metropolitan area and suggested locations for new EA sites.

Figure 1. Combined Driver Maps



Drivers would like to see more charging ports at the most commonly used EA sites, including the Downtown Portland (3 of 8) and Beaverton (3 of 8) EA sites. Drivers also mentioned they would prefer higher-powered (150kW) fast chargers at the Downtown Portland EA charging site.

One driver provided insight into why they would like to see more public charging stations:

"The more, the better. The farther we can go in Oregon, then the better. Right now, we're just kind of stuck to this little area on the 5 [Freeway]. Can't go into [Interstate 84] too far. Can't go really down south past Salem. So, you are kind of just stuck up here in the northwest part of Oregon." – Participant 2

Figure 1 shows the areas where drivers indicated that additional public charging should be installed with a blue star. The most requested areas for additional public charging sites included:

- Tigard (4 mentions)
- Lake Oswego (4 mentions)
- Sherwood (2 mentions)
- North Portland / St. Johns Area (2 mentions)
- Troutdale / Gresham Area (2 mentions)
- Southeast Portland (1 mention)
- Tualatin (1 mention)

Drivers chose chargers based on charger type or proximity to specific locations. Drivers reported choosing chargers based on the speed of charging (five mentions), the proximity to their location or destination (three mentions), or proximity to amenities such as stores, restrooms, or other conveniences (three mentions). The remaining drivers noted their vehicles are not equipped for fast charging (two mentions), or that they utilize both fast chargers and Level 2 chargers (one mention). Most drivers (6 of 8) mentioned their EVs can utilize fast chargers. Given the time that it takes them to charge their vehicle, drivers will typically look for charging stations with amenities such as restaurants, grocery stores, and shopping malls. One driver mentioned charging has altered where and when they shop based on charger availability:

"When it comes to my plan of charging it's - the EV has changed how I group my trips. I go specifically to stores now that have charging, those are my first priority. So, it's changed my habit in terms of where I shop and how I, when I go." – Participant 5

Drivers are aware of EA peak pricing periods but are more concerned with finding available chargers than with the increased charging rate.[5] Three drivers agreed that the EA peak pricing periods are less of an issue than finding a charging station available. While they noted that charging outside of the peak pricing period would be ideal, they felt that finding an open stall was a significant enough obstacle that they would willingly charge during the peak pricing period. All three drivers reported it was most difficult to find open chargers at the Downtown Portland site.

[5] Peak pricing periods occur from 3:00 p.m.– 8:00 p.m. every weekday, during which time charging costs an additional $0.19/kWh.

Charging Issues

Drivers reported difficulties with charging stations, including vehicles illegally parking in or blocking charging spaces, and electric vehicles parking in charging spots without charging or leaving their vehicle there overnight. One-third of drivers (3 of 8) also noted that large trucks commonly block the designated charging spaces. Drivers most commonly reported these issues occurring at the Downtown Portland EA site. Additionally, three drivers mentioned issues with other EV drivers forcefully unplugging the charger from their vehicle and or hitting the emergency stop button to stop their vehicle from charging in order to charge their vehicles.

Although some drivers still report issues with EA chargers, participants feel that charging reliability and uptime has improved over the last year. One driver reported that lack of reliability among EA charging stations prompted them to purchase memberships for different charging platforms. Other drivers reported there has been a noticeable difference in uptime across chargers, with one driver stating:

> *"It seemed like about a year ago, the PGE stations for me are pretty unreliable, especially Downtown [Portland], it seemed like they were always broken. And they started replacing, I think, some of the stations with the newer models of chargers at some of the other locations, which seem to work really, really great. But the ones downtown, for - at least from my experience, still don't work that well. They've gotten better, it feels like in the last year-ish. But, like I mentioned before, they're slower, they're the 50 kilowatt chargers."*
>
> – Participant 3

In keeping with one driver's experience above, a couple of drivers also mentioned that they would like to see the Downtown Portland EA chargers replaced with newer fast-charging equipment.[6] Due to the popularity of the Downtown Portland site, participants reported that upgrading the chargers would allow more drivers to charge (three mentions).

[6] Note that PGE upgraded chargers at the Downtown Portland EA site in 2022 and plans further upgrades in 2023.

Charging Sites

Drivers suggested that charging sites with amenities similar to those at gas stations would improve the charging experience, as would deploying charging sites close to stores, restaurants, and bathrooms. Drivers agreed that shade would be a particularly helpful amenity, especially on hot days to keep their car from overheating. Table 3 provides a list of charging location amenities suggested by participants:

Table 3. Amenities Mentioned by Participants

Amenity	Number of Mentions
Shade	3
Lighting at site	2
Security presence (e.g., security guard, cameras)	1
Trash cans	1
Bathrooms	1
Vending machine	1
Air for tires	1
Carwash	1
Vacuums	1
Squeegees	1

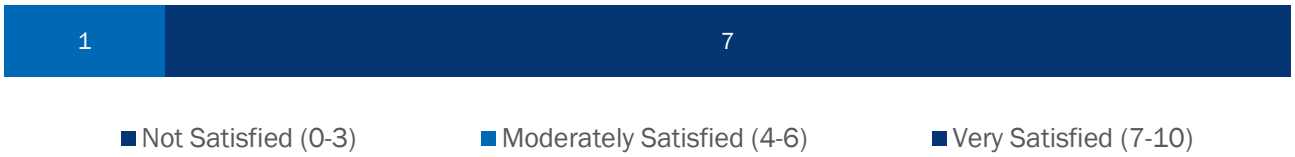
Drivers also reported that they would like to see more accuracy on the Shell Recharge app regarding known issues and garner real time feedback from users. One driver mentioned that it would be useful if the app could provide more accurate monitoring of chargers, including when chargers are online or offline. Additionally, one driver would like to see the app utilize more driver feedback to report real-time issues.

Three drivers reported that security is a concern while charging at specific locations. Drivers agreed that the Downtown Portland and Eastport Plaza sites felt the most unsafe. One driver noted they are on constant guard while charging because they are concerned about being robbed. Drivers also noted they will only charge at night at locations with lighting (two mentions) or a security guard (one mention).

Sentiments Towards Electric Vehicles

Overall, drivers expressed high levels of satisfaction with their EVs. Nearly all participants (7 of 8) rated their satisfaction with their EV as a seven or higher on an 11-point scale (Figure 3). One participant who reported moderate satisfaction with their EV noted they have to stop to charge at least once a day for an hour. A couple of drivers also raised concerns about limited vehicle range (two mentions) and the future cost of the battery replacement (one mention).

Figure 2. Driver Satisfaction with EV (n=8)



Drivers who live in multifamily properties are less likely to purchase another EV due to lack of charging infrastructure. Two drivers who live in apartments mentioned their next vehicle purchase would be a traditional or hybrid vehicle due to range (one mention) and charging concerns (two mentions); neither have access to a home charger. As a result, both reported being entirely dependent on public charging stations. They stated that as more people switch to EVs they are noticing that there are fewer chargers available at the charging sites they frequent, making them want to switch back to a traditional ICE vehicle. According to one driver:

"I'm starting to notice that the chargers, the fast chargers, because I don't - I live in an apartment, so I have to use charging stations. And they're starting to become busy, to the point where you pull up, and there's nowhere to charge. And I'm very dependent on fast charging, so if I pull up, it's usually planned accordingly. I don't have really enough range to go to another one. A really old truck sounds more appealing to me now than an EV." – Participant 2

EV Benefits

Some drivers (3 of 8) reported they prefer the EV driving experience to that of an ICE vehicle (Table 4). One driver also reported the ability to charge their EV overnight was a great perk. Another driver mentioned the ability to capture energy while driving downhill saved them from having to charge as often as well. Drivers also reported that driving an EV was fun:

"I just love the way it drives. The driving experience for me is just far superior to any other car. Combustion engine just not the same. Not the same league. They're really fun to drive." – Participant 3

Table 4 provides a listing of the benefits associated with EVs mentioned by drivers.

Table 4. Benefits of Driving an EV

Benefit	Number of Mentions
EVs cost less to own than ICE vehicles	7
EVs make driving for TNC companies more profitable	7
Driving experience superior to ICE vehicle	3
Less maintenance required	2
Being able to charge overnight	2
Performance	1
Fast charging available	1
Regenerative braking	1
One pedal driving	1

EV Challenges

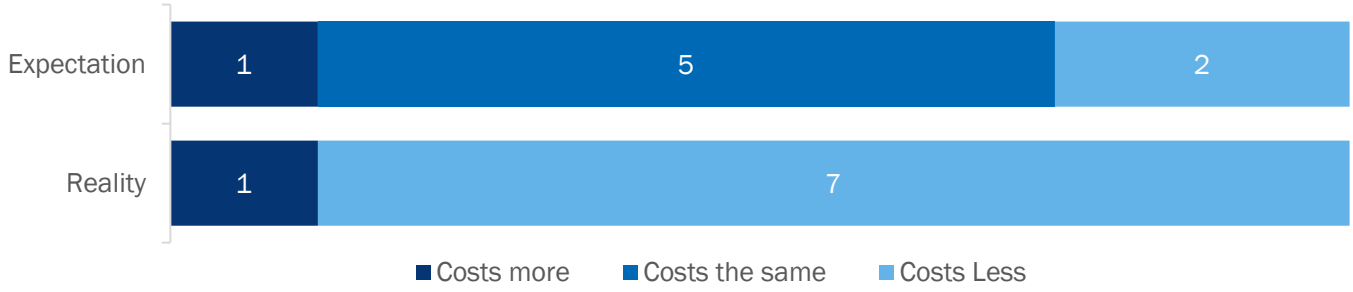
Half of drivers (4 of 8) reported that battery longevity was a concern as they are unsure of typical EV battery lifespans. One driver mentioned that battery longevity is always a concern. The turnaround time for battery replacement meant another driver was unable to drive his EV for a few months. Another driver was concerned about the cost associated with replacing their battery, which they estimated would be between $5,000 and $6,000. One driver mentioned:

"My biggest concern with EVs is you never know when your battery is going to go. I think that's the worst part of owning an EV." – Participant 4

Costs

Nearly all drivers (7 of 8) mentioned owning an EV was less expensive than owning an ICE vehicle.[7] Additionally, most drivers felt that their actual cost to drive an EV cost less than they expected, as shown in Figure 3. Only one driver mentioned they felt driving an EV cost more than what they had expected, but they were unable to provide an explanation.

Figure 3. Driver Expectations of EV Costs Versus Reality of EV Costs



A majority of drivers (7 of 8) feel that driving an EV for TNC companies was more profitable than driving an ICE vehicle. Only one driver felt that driving an EV led to minimal savings, if any.

Most drivers (5 of 8) mentioned they purchased an EV due to gas prices. Other drivers referenced environmental reasons and the maintenance or repair costs of ICE vehicles (two mentions each) influenced their decision to purchase.

All drivers were current EA subscribers, with some subscribed to other charging companies such as Electrify America and/or ChargePoint. One driver mentioned they had multiple subscriptions to maximize their chances of finding an available charger. Most drivers (7 of 8) agreed they have saved money using the EA subscription and/or home charging compared to purchasing gas.

Home charging costs vary depending on charger level. Two drivers used Level 1 charging and two owned a Level 2 charger. One driver who used Level 1 charging estimated their electric bill increased around $10–$15 per month due to charging their EV at home. One driver felt charging at home was very affordable: approximately $0.04/mile. Another felt the addition of their Level 1 charging was negligible to their electricity bill. A third estimated spending $30/month using their Level 2 charger. Only one driver reported being enrolled in PGE's Time of Day pricing and being very conscientious of peak times when charging at home.

[7] One driver mentioned that since their previous vehicle was already paid off, they had decided to purchase a higher-end EV. Resultingly, their overall costs were higher; however, they acknowledged that this was a difficult comparison to make.

Appendix A. Individual Participant Maps

Figure 4. Participant 1 Broad Map

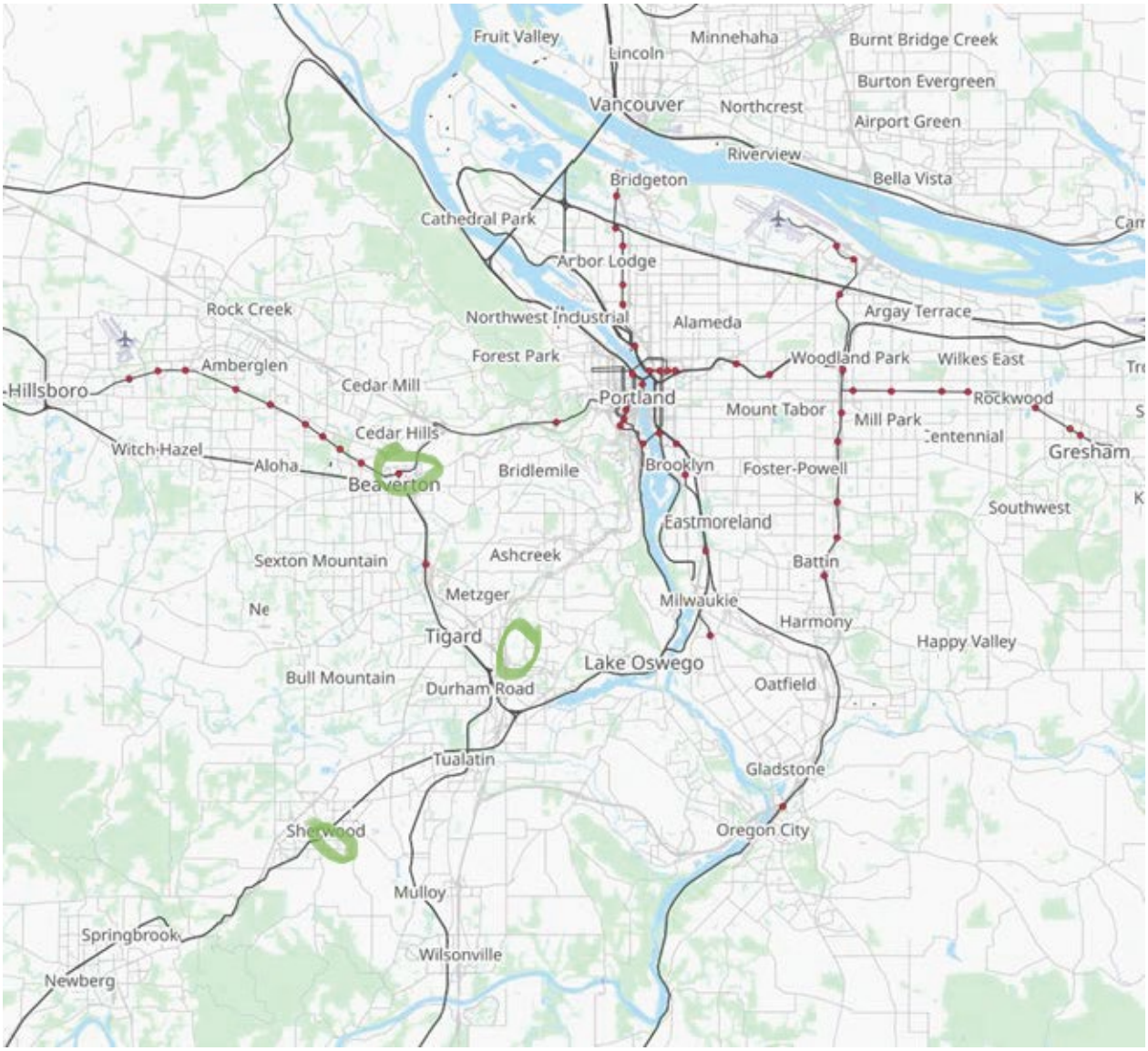


Figure 5. Participant 2 Broad Map

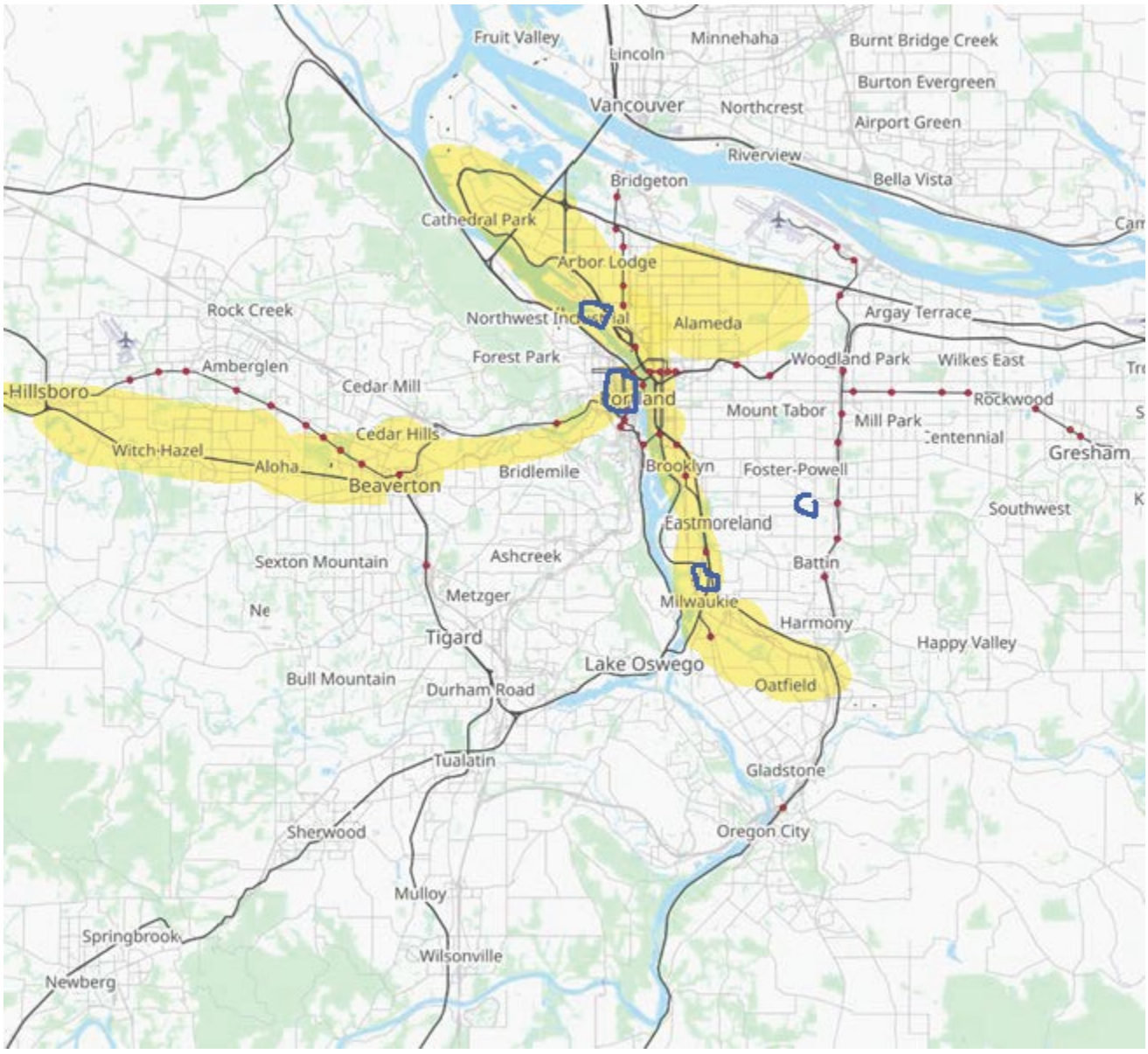


Figure 6. Participant 2 Focused Map

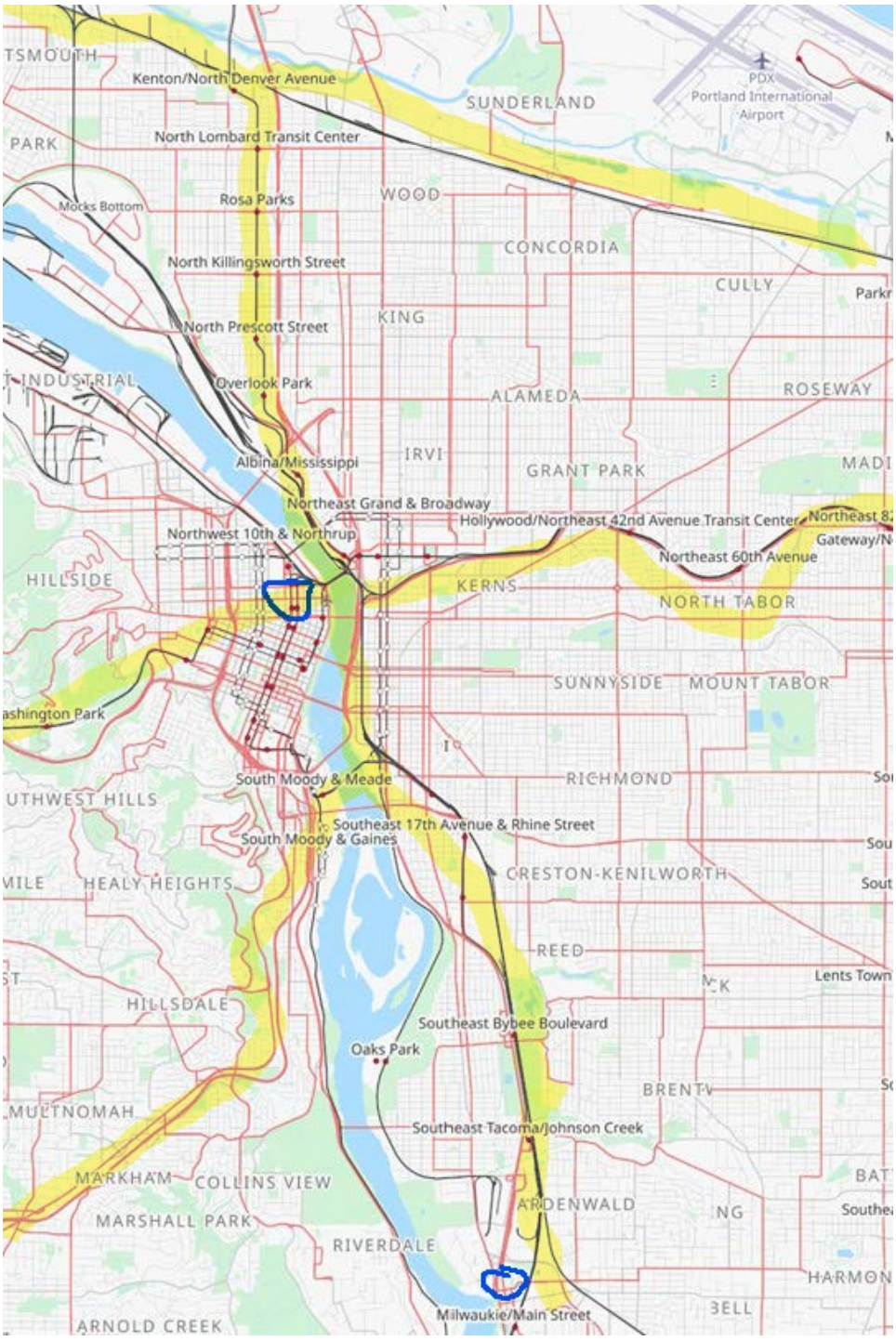


Figure 7. Participant 3 Broad Map

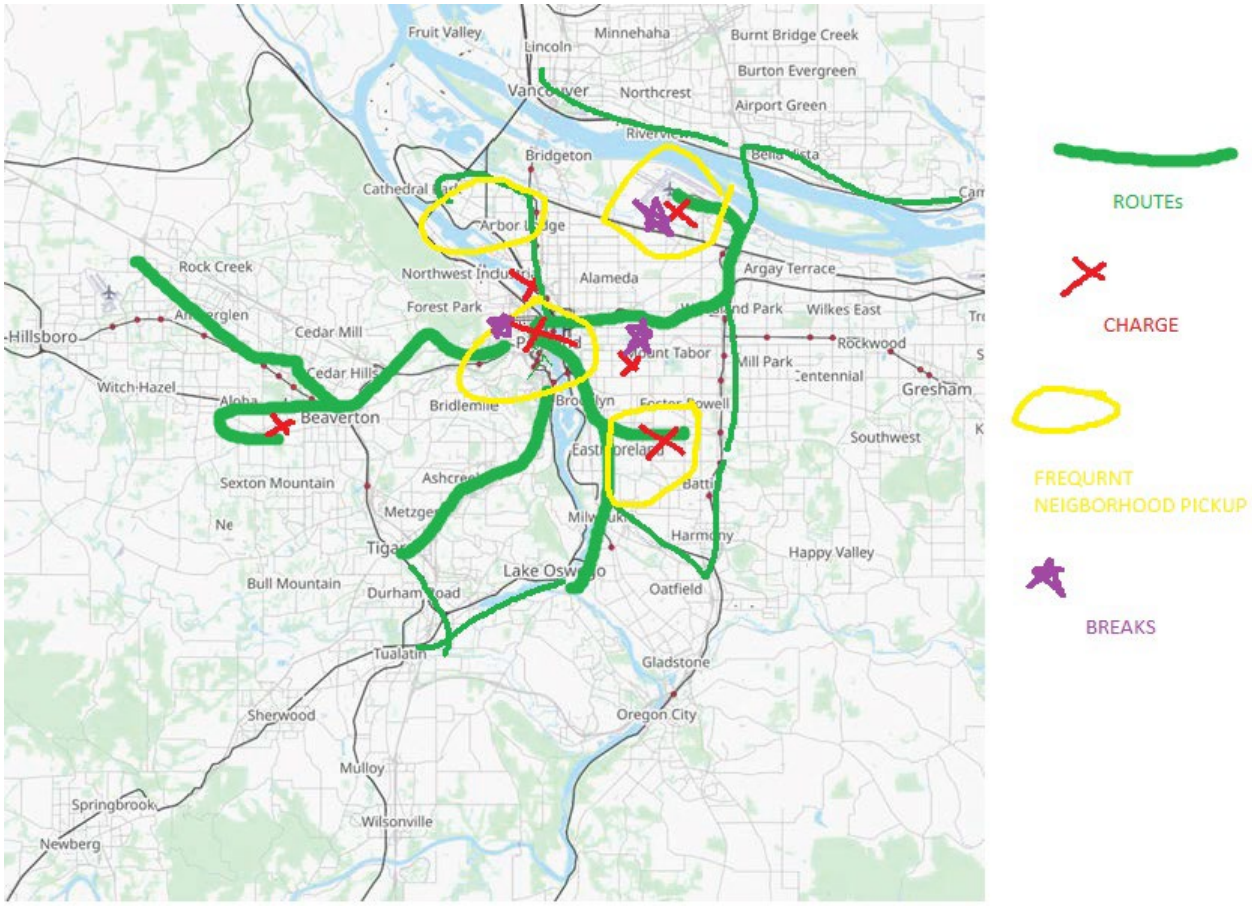


Figure 8. Participant 3 Focused Map

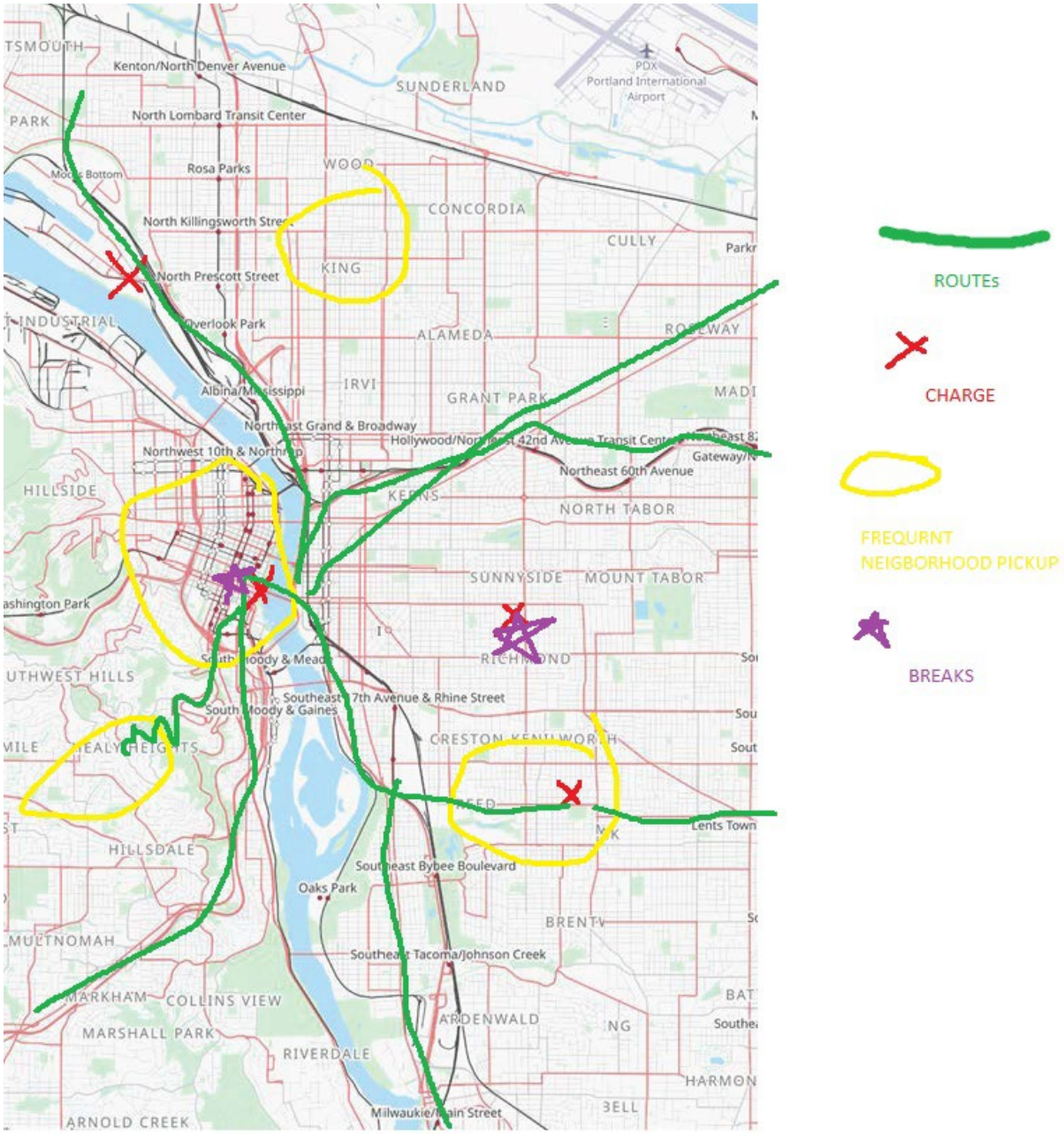


Figure 9. Participant 4 Broad Map

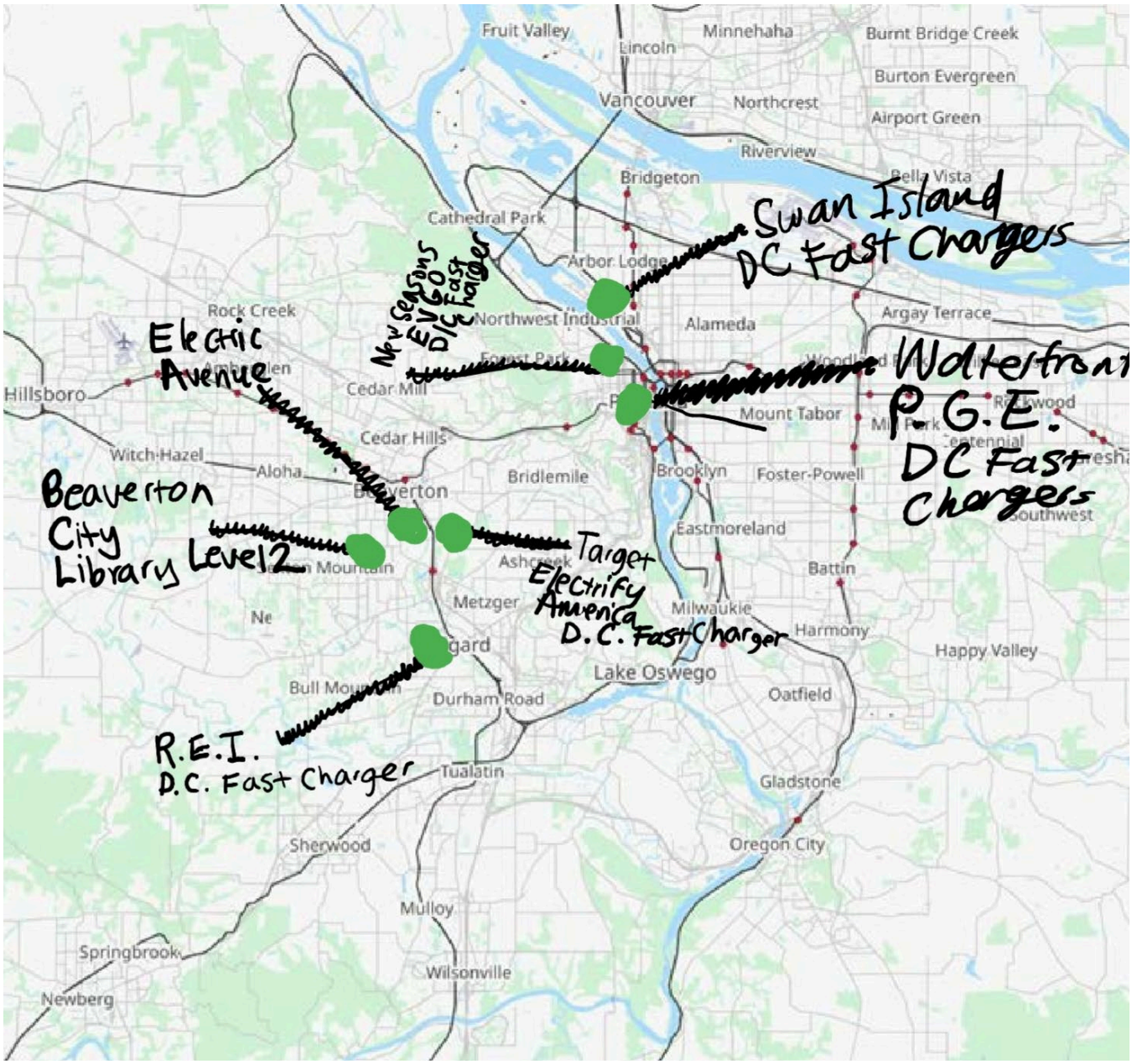


Figure 10. Participant 6 Broad Map

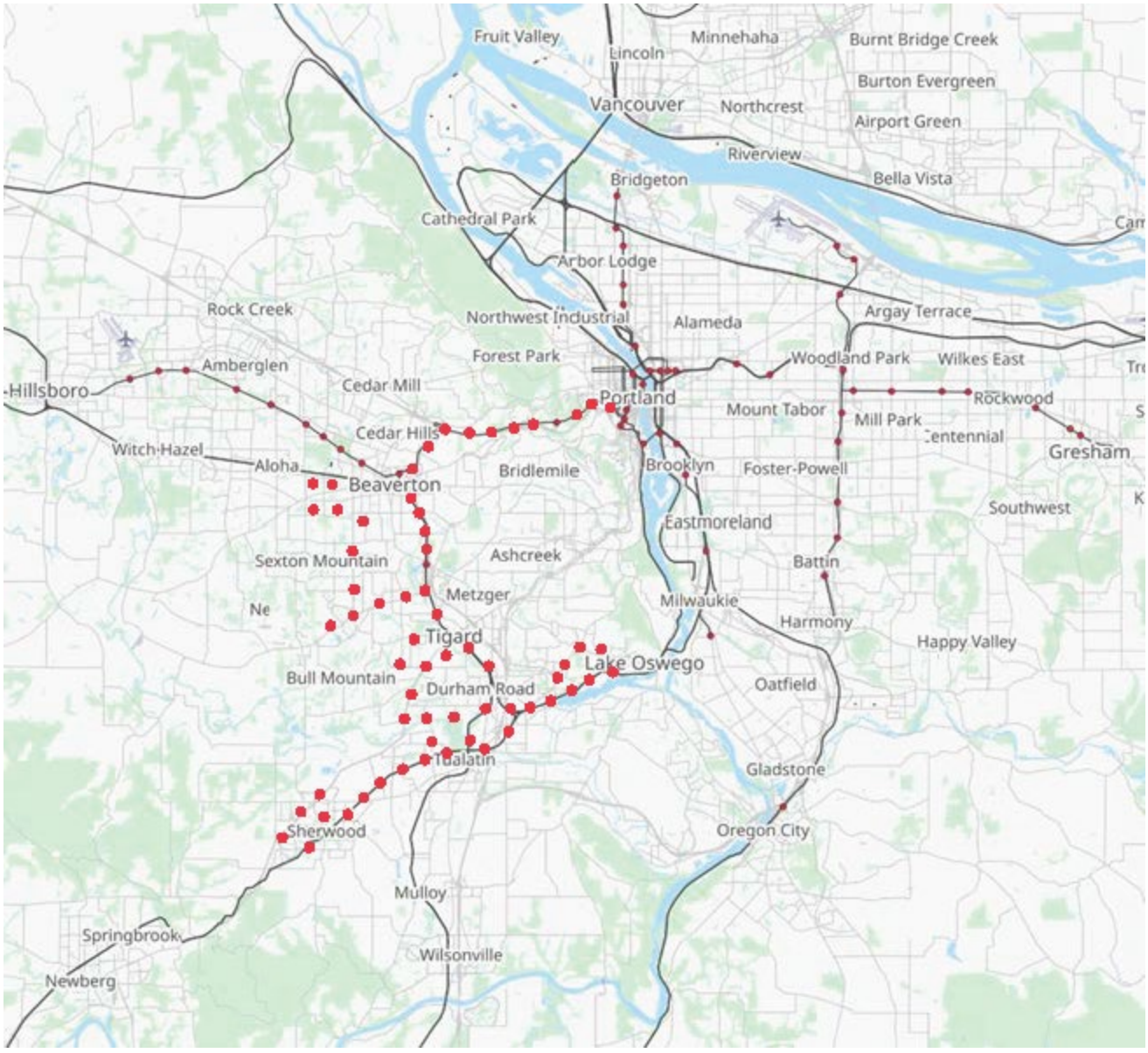


Figure 11. Participant 6 Focused Map

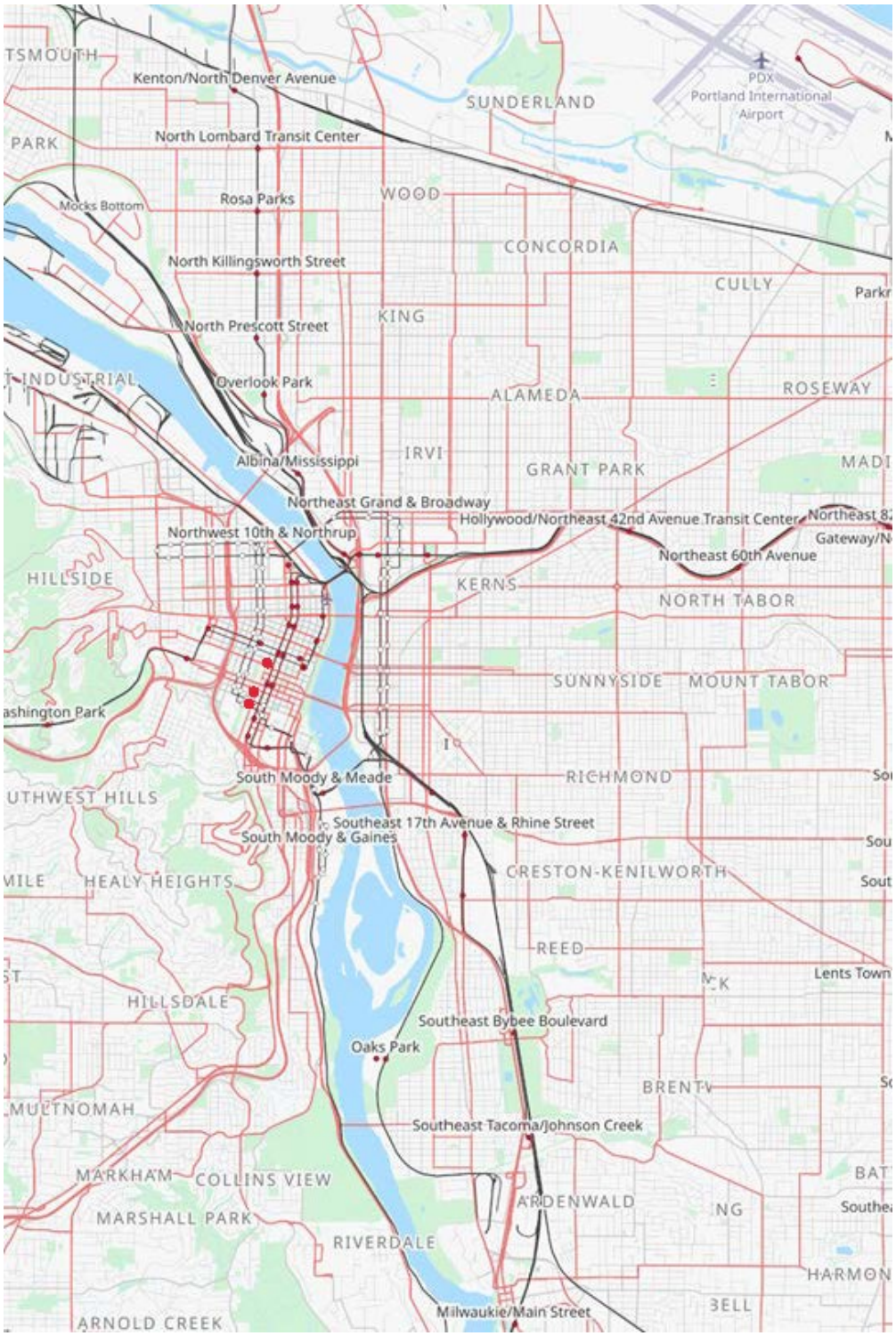


Figure 12. Participant 9 Broad Map

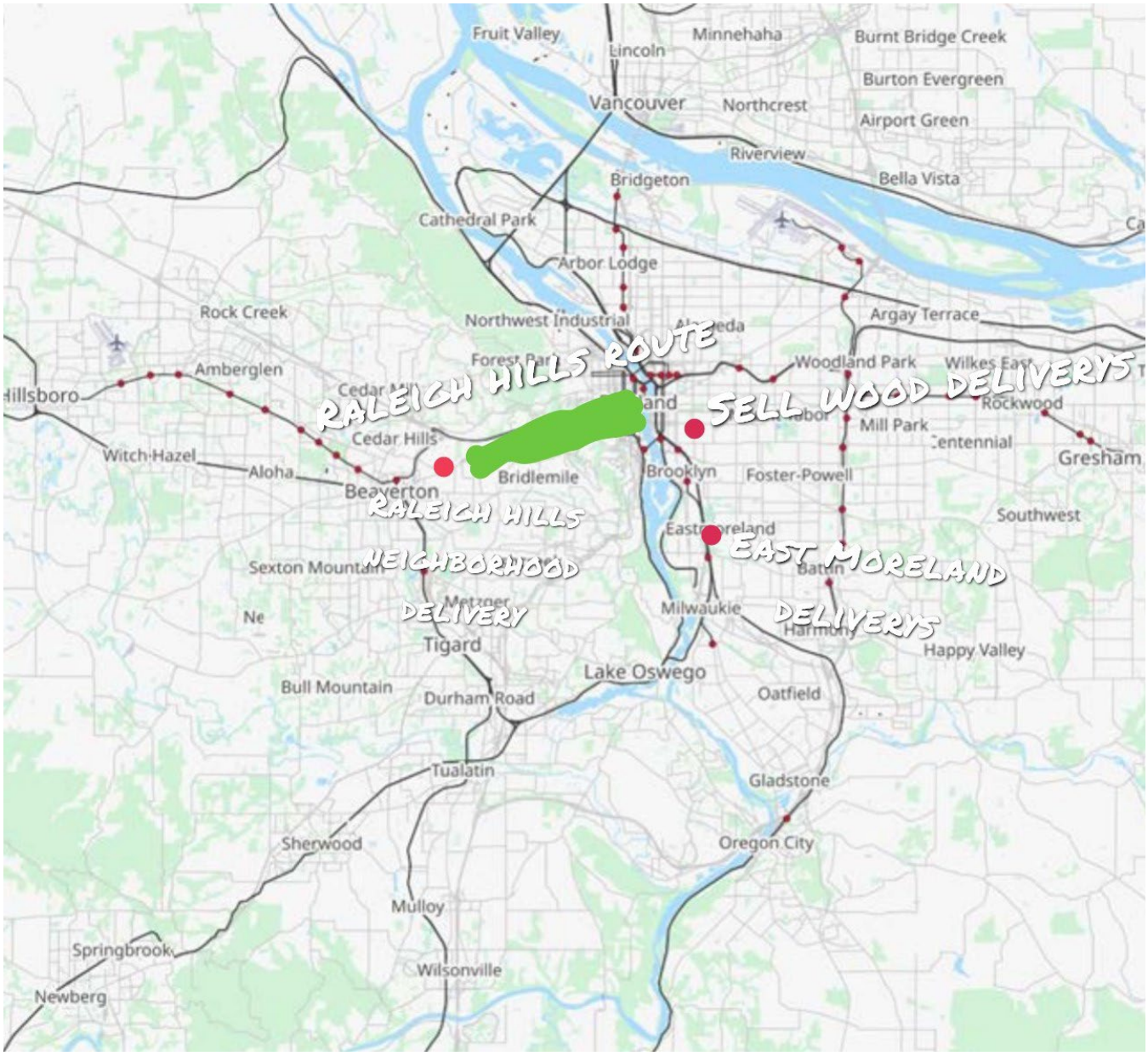


Figure 13. Participant 9 Focused Map

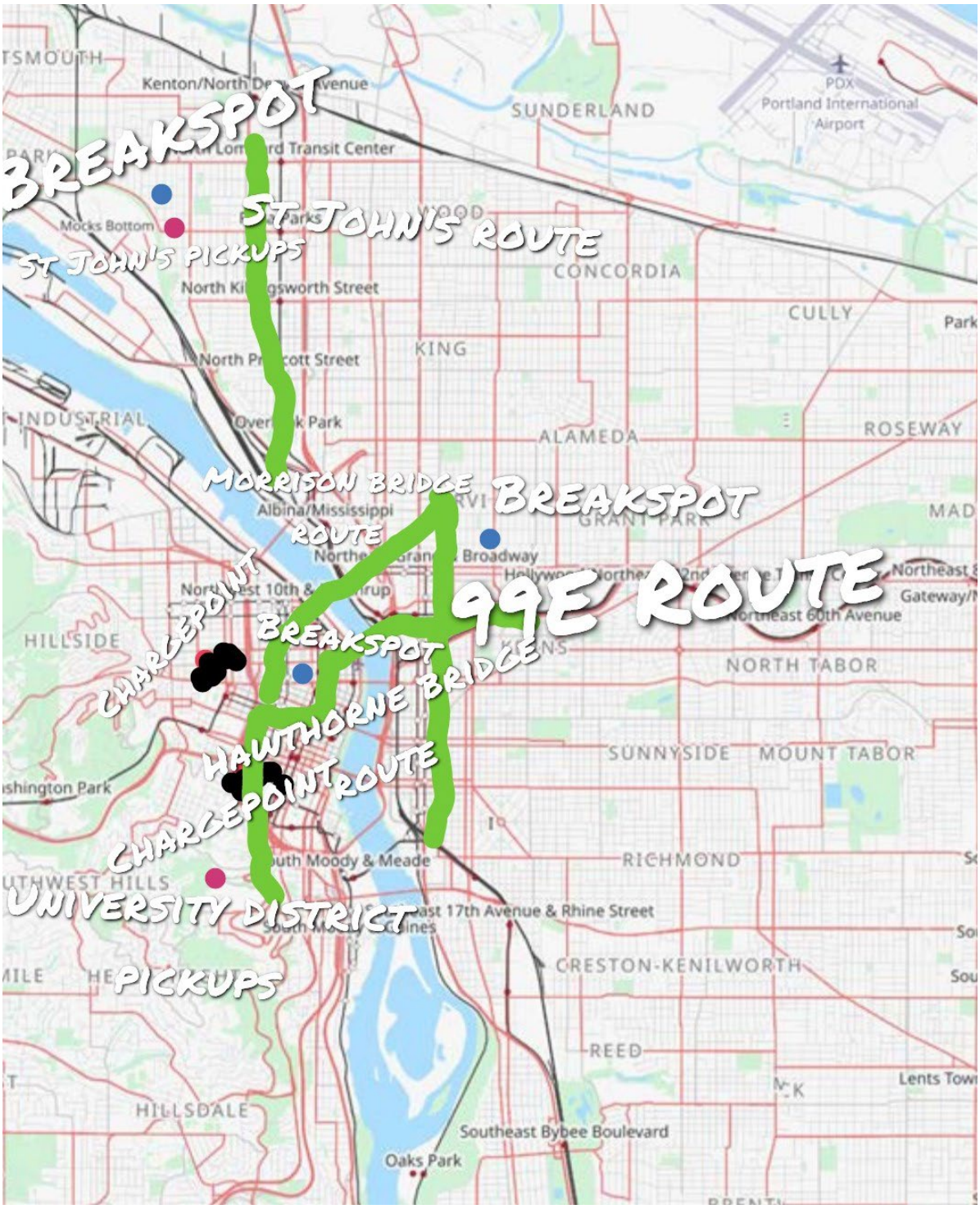
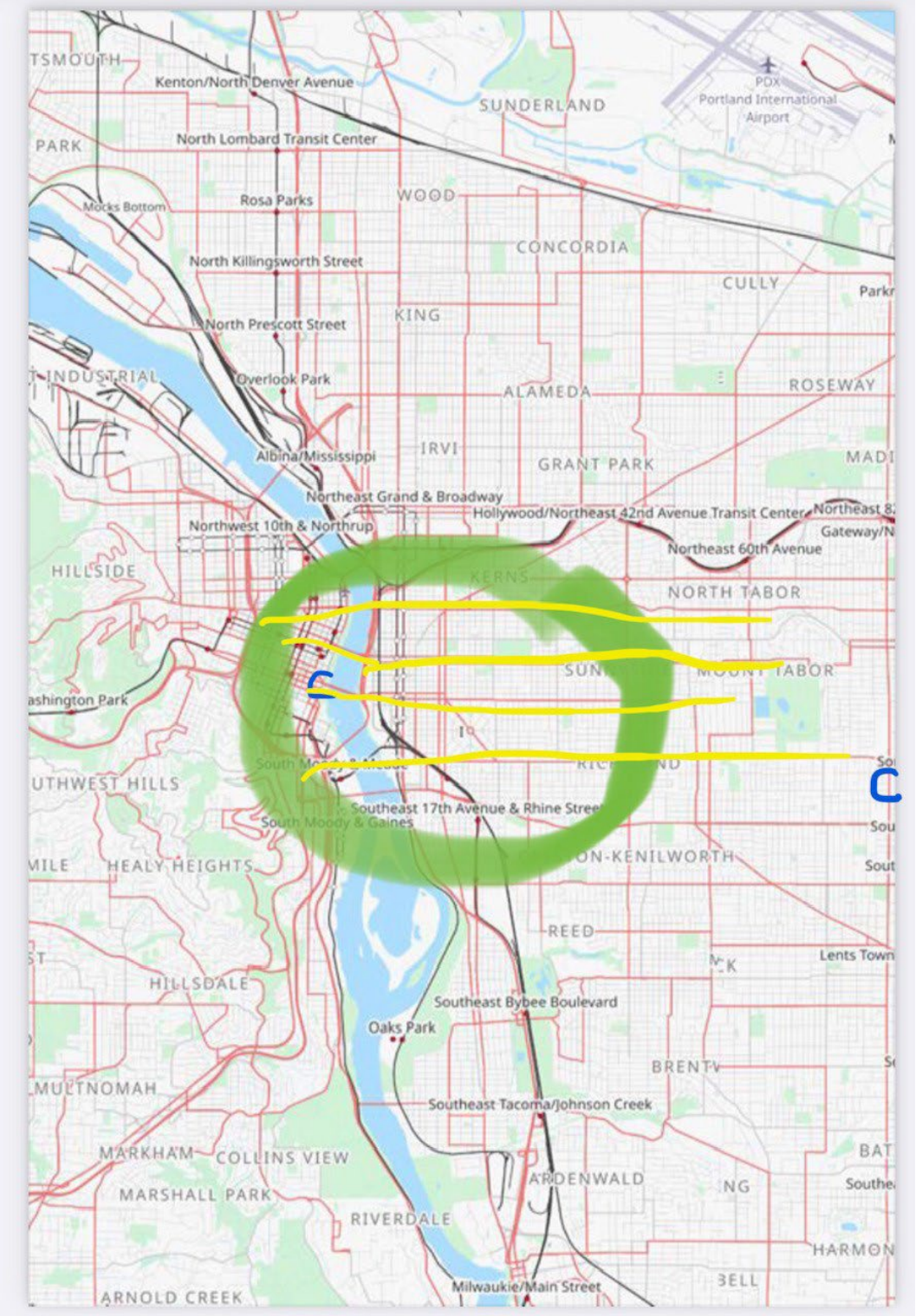


Figure 14. Participant 10



Opinion Dynamics

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Memorandum

To: John Boroski, Portland General Electric

From: Zac Hathaway and Harry Gao, Opinion Dynamics

Date: 11/17/2022

Re: PGE Transportation Electrification Pilot Program – 2022 Electric Avenue Intercept and Online Survey Results

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This memo summarizes the results of the Electric Avenue (EA) intercept and online web surveys. The research team fielded in-person intercept surveys at six of PGE's seven EA sites in May 2022.[1] To supplement data collected at EA sites, the research team also conducted a web survey in September 2022 with EA users.

The key objectives of the EA surveys are to understand:

- The demographic and household characteristics of EA users
- Charging practices of EA users
- User satisfaction with PGE's EAs and desired changes

Analyses of the EA surveys revealed the following key findings:

- EA users primarily learn about PGE's EAs through wayfinding apps or word of mouth. Other sources like the PGE website, emails from PGE, and other marketing efforts are less successful in building awareness.
- EA users are generally satisfied with their experience charging at an EA, although improved charger reliability, ability to reserve a charger, additional amenities (e.g., shelter from the elements, lighting, restrooms nearby), and additional chargers could encourage higher utilization of EA sites.
- EA users tended to have lower levels of satisfaction with high traffic EA locations, including the Downtown Portland and East Portland EAs. Reasons for dissatisfaction with the Downtown Portland EA included availability of open chargers and charger reliability. Reasons for dissatisfaction with the East Portland EA included charger reliability, convenience of the EA location, and site experience.
- EA users prefer a mix of payment options with PGE's EAs, including options for paying an hourly flat rate, a monthly subscription, and paying per kWh. Additionally, about two-thirds of EA users who are PGE customers would like to have the option to pay for EA charging on their home electric bill.
- EA monthly subscribers are more likely to use PGE's EAs because they live or work nearby and use EAs more frequently compared to non-subscribers. Subscribers are also somewhat more likely to live in multifamily homes compared to non-subscribers.

[1] The research team did not field intercept surveys at PGE's Salem EA site because the site was offline due to construction at the Oregon State Capital building where the EA is located.

Methodology and Survey Disposition

In May of 2022, the research team conducted intercept surveys at six PGE EA sites. Due to a lower than anticipated survey response, we conducted web surveys in September 2022 with additional EA users. For the web survey sample, PGE provided a list of monthly EA subscribers and those who pay per hour for EA use ("non-subscribers"). The research team removed any potential PGE staff and those who had participated in a transportation network company (TNC) driver focus group conducted by the research team in August 2022. The web survey included two screening questions that confirmed respondents were not PGE employees and had charged at an EA site. Respondents to both surveys were offered a $5 gift card as an incentive to complete the survey. A total of 159 surveys were completed, 124 via web and 35 via intercept (Table 1).

Table 1. Summary of EA Respondents and Disposition by Survey Type

Disposition	Intercept Survey	Web Survey	Total
Completes	35	124	159
Screen-outs	0	12	12
Refusals	4	0	4

Table 2 summarizes the responses received from each EA location and survey type. Intercept survey respondents were asked to focus on the EA where they had been charging at the time of the survey while web survey respondents were asked to think of the EA that they most often use. The Downtown Portland location near the World Trade Center was the EA with the most responses, followed by the East Portland and Beaverton locations.

Table 2. EA Completes by Location and Survey Type

Location	Intercept Survey	Web Survey	Total
Downtown Portland	9	63	72
East Portland	9	19	28
Beaverton	7	17	24
Milwaukie	6	12	18
Wilsonville	2	8	10
Hillsboro	2	6	8
Total	**35**	**124**	**159**

EA User Characteristics

Most (95%) respondents reported owning battery electric EVs (BEVs), with few (5%) reporting owing plug-in hybrid EVs (PHEVs). Table 3 and Table 4 provides a summary of the make and models of BEVs and PHEVs driven by respondents.

Table 3. Respondent BEV Vehicle Make and Models (n=150)

BEV Make and Models	Percent
Nissan Leaf	34%
Chevrolet Bolt	28%
KIA Niro	8%
Ford Mach-E	6%
Hyundai Kona	6%
KIA Soul EV	6%
Audi e-tron	3%
Other BEVs*	9%

*All other vehicles each made up less than 2% of total EVs

Table 4. Respondent PHEV Vehicle Make and Models (n=9)

PHEV Make and Models	Percent
Volkswagen e-Golf	44%
Toyota RAV4 Prime	22%
Honda Clarity	11%
Chrysler Pacifica EV Hybrid	11%
BMW i3	11%

A majority (76%) of respondents reported PGE provides service at their homes. About two-thirds (64%) of respondents reported residing in single-family homes, with the remaining living in multifamily homes (34%) or manufactured homes (2%). Surveyed EA users were considerably less likely to report living in single-family homes compared to EV owners in PGE's service territory (64% compared to 92%).[2] Further, EA monthly subscribers were somewhat more likely to report living in multifamily homes compared to non-subscribers (41% compared to 32%). About two-thirds (61%) of respondents reported owning their homes.

Nearly all (92%) respondents used their EVs for personal use, with some using their EVs for rideshare driving (10%), on-demand delivery driving (5%), or for other commercial purposes (6%). Slightly over one in ten (13%) respondents reported using their vehicles for both personal and commercial purposes.

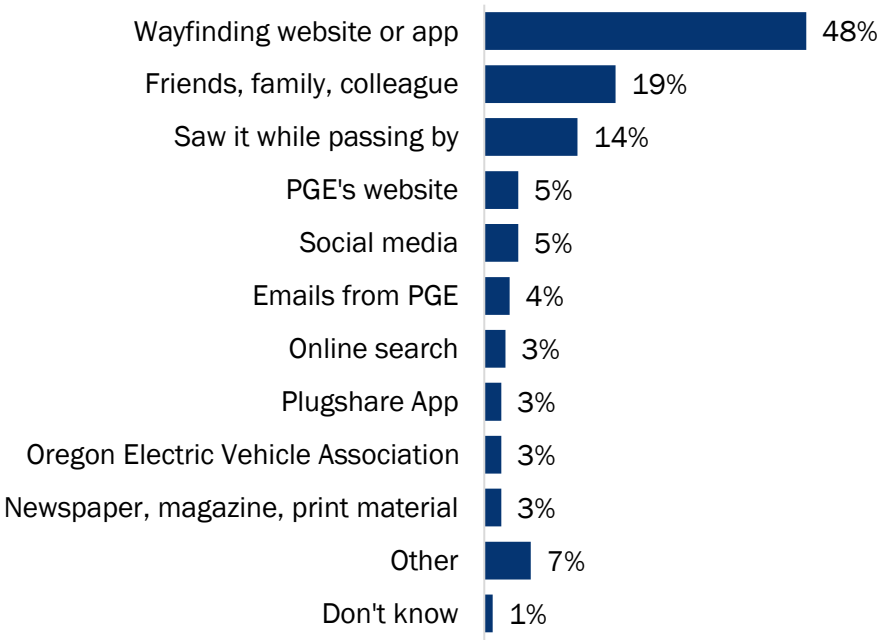
Awareness of EAs and Payment Methods

Respondents generally learned about PGE's EAs through non-PGE sources. Nearly half (48%) of respondents reported learning about PGE's EAs through a wayfinding website or app, with about one-fifth (19%) learning

[2] Based on 2021 survey of EV owners in PGE's service territory conducted by Opinion Dynamics. Survey results can be found in the 2021 Annual Report.

about them from friends, family, or colleagues (Figure 1). Few respondents reported learning about PGE's EAs from the PGE website (5%), social media (5%), or emails from PGE (4%).

Figure 1. Source of Awareness of PGE's EAs (n=159; Multiple Responses Allowed)



Infrequent use and lack of awareness prevent customers from subscribing to PGEs EAs. About one-third (33%) of respondents reported using the monthly EA subscription plan, while the rest reported using flat rate charging either by pre-paying through the Shell Recharge app (40%) or paying at the time of charging using a credit card (28%). When non-subscribers were asked why they did not have a monthly subscription, not using EAs frequently enough was by far the most cited reason (73%), followed by not knowing about the subscription (26%; Table 5).

Table 5. Reasons for Not Subscribing to PGE EAs (n=159; Multiple Responses Allowed)

Reason	Percent
Use EAs infrequently	73%
Did not know about the subscription	26%
Cost is too high for subscription	20%
Location of EAs is not convenient	10%
Unable to use DC fast charging	5%

Respondents are generally satisfied with EA pricing and the payment process. Three-quarters of respondents were very satisfied with both the price of EA charging and the payment process (Figure 2). When asked for suggestions for payment process improvements, comments were mainly focused on replacing flat-rate pricing with per-kWh pricing or issues with the Shell Recharge app.

Figure 2. Satisfaction with EA Pricing and Payment Process (n=159)

When asked about their preferred payment method, opinions were mixed. Nearly equal numbers of respondents reported they would prefer to pay for just the amount of energy they used (37%) as prefer a monthly subscription (35%). The remaining respondents prefer flat rate charging (28%). Nearly all (85%) respondents who reported preferring to pay for the amount of energy they used, indicated they typically pay a flat rate when charging at PGE's EAs. Additionally, about two-thirds (61%) of PGE customers reported they would like to have the option to pay for EA charging on their home electric bill.

Reasons for using EAs and User Experiences

Reasons for using PGE's EAs differed between monthly subscribers and non-subscribers. When asked the main reason for charging at PGE's EAs, monthly subscribers were more likely to indicate that they live or work nearby, whereas non-subscribers were more likely to report passing through the area for errands when charging (Table 6).

Table 6. Main Reason for Charging at Surveyed EA

Reason	Subscribers (n=50)	Non-Subscribers (n=109)
Live nearby	38%	21%
Work nearby	26%	15%
Plan my trips so I can charge at this EA regularly	18%	14%
Have other errands to do in the area	8%	26%
Travelling through the area but do not regularly use this EA*	6%	13%
Needed fast charging	0%	3%
Another reason	4%	9%
Total	**100%**	**100%**

*Item only displayed to intercept survey respondents. Some web respondents mentioned in open-ended comments that they were traveling through the area and do not regularly use PGE's EAs and were coded into this response option.

Monthly subscribers are more likely to be frequent users of PGE's EAs. Four-fifths (80%) of subscribers reported charging at an EA at least once a week, compared to just over one-quarter (28%) of non-subscribers (Table 7).

Table 7. Frequency of Charging at an EA

Frequency	Subscribers (n=50)	Non-Subscribers (n=109)
Several times per week	58%	8%
About once per week	22%	20%
2-3 times a month	6%	14%
About once per month	6%	20%
Rarely	6%	31%
Once	2%	6%
Total	**100%**	**100%**

Length of EA charging sessions varied by charger type. Nearly all (98%) respondents who reported using direct current fast charging (DCFC) at PGE's EAs indicated typically charging for less than two hours, while nearly half (43%) of respondents who use Level 2 charging typically charge for two or more hours (Table 8).

Table 8. Typical Charging Duration, by Type of Charger Used

Charging Time	DCFC (n=122)	Level 2 (n=37)
Less than 30 minutes	9%	8%
30 minutes to 1 hour	55%	16%
1 to 2 hours	34%	32%
2 to 3 hours	2%	24%
More than 3 hours	0%	19%
Total	**100%**	**100%**

Most respondents report charging their EVs at PGE's EAs outside of EA peak hours (3pm – 8pm) and a majority are aware of the peak surcharge. Nearly three-quarters (71%) of respondents reported that they typically charged outside of the hours between 3pm and 8pm, when a surcharge of $0.19/kWh is assessed. About two-thirds (60%) of respondents reported they aware of the peak surcharge. Among those who were aware of the surcharge, about one-quarter (24%) reported charging during peak hours compared to one-third (33%) of those who were not aware of the surcharge.

Table 9. Typical Charging Times (n=159)

Charging Hours	Percent
Before 9am	6%
Between 9am and 3pm	52%
Between 3pm and 8pm	30%
After 8pm	13%
Total	**100%**

Other than their most frequently used EA site, the most common location for respondents to charge their electric vehicles was at home. About two-thirds (64%) of respondents reported charging at their homes in addition to using their most frequently used EA site, or the EA site that they were surveyed at (Table 10). At home charging was more common among respondents who reported living in single family homes compared to those living in multifamily homes (81%, compared to 26%).

Table 10. Other Charging Locations Used (n=157; Multiple Responses Allowed)

Location	Percent
At home	64%
Other EA sites	20%
At work/office	11%
Electrify America charging network	8%
ChargePoint charging network	4%
Other public charging locations*	25%

*Other charging locations include EVgo, Volta, Tesla Superchargers, municipal charging stations, and the Portland International Airport.

Influence of EAs on EV Purchase

The availability of PGE's EAs is moderately influential in respondents' decision to purchase or lease EVs. Over half (57%) of respondents were aware of PGE's EAs prior purchasing their EV. Among those who were aware of EAs prior to purchasing their EV, about half (52%) indicated PGE's EAs were either "somewhat" or "very" influential in their decision to purchase or lease their vehicles (Figure 3).

Figure 3. Influence of Availability of EAs on Purchase Decisions Among Those Aware of EAs Prior to Purchase (n=90)

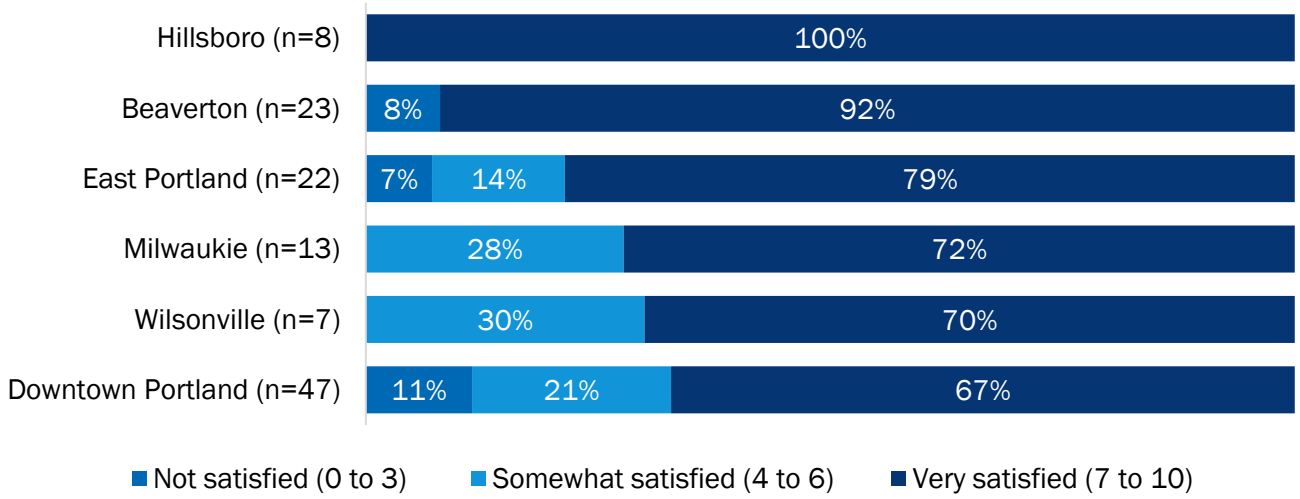
Respondent Satisfaction and Feedback

We asked respondents to rate their satisfaction of specific aspects of the EA they typically charged at or, for intercept survey respondents, the site where the survey was conducted. We broke results down by EA site to gauge the differences in user experience- by site.

While respondents are generally satisfied with charger availability, those who typically use the Downtown Portland site are least satisfied. About one-third (32%) of respondents indicated some dissatisfaction with charger availability at the Downtown Portland EA (Figure 4). The site usage analysis that we conducted as part of the 2020 Annual Report found that the Downtown Portland EA site was the highest utilized EA, which is likely leading to limited charger availability. Further, during a 2022 focus group with TNC and on-demand delivery drivers, participants mentioned issues at the Downtown Portland EA including: EV drivers parking vehicles in charging stations without charging, vehicles left overnight, and non-electric delivery vehicles blocking the station. This station was also reported as being one of the most heavily used by TNC and on-

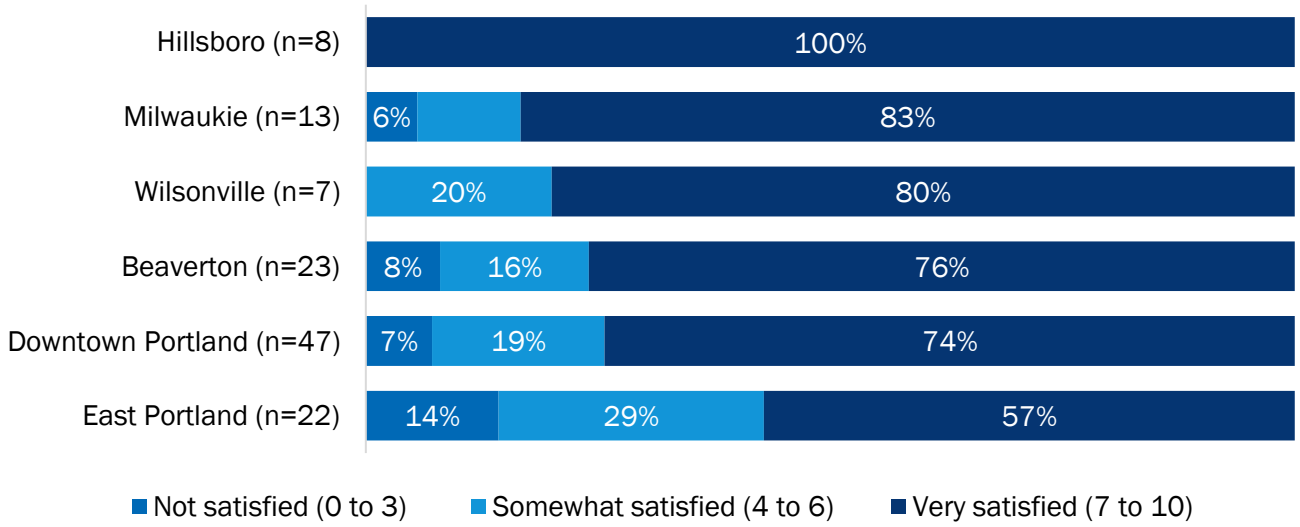
demand delivery drivers. In open ended comments, 13 respondents who typically use the Downtown Portland location mentioned that they would like to see additional chargers at this location.

Figure 4. Satisfaction with Availability of Open Charging Stations



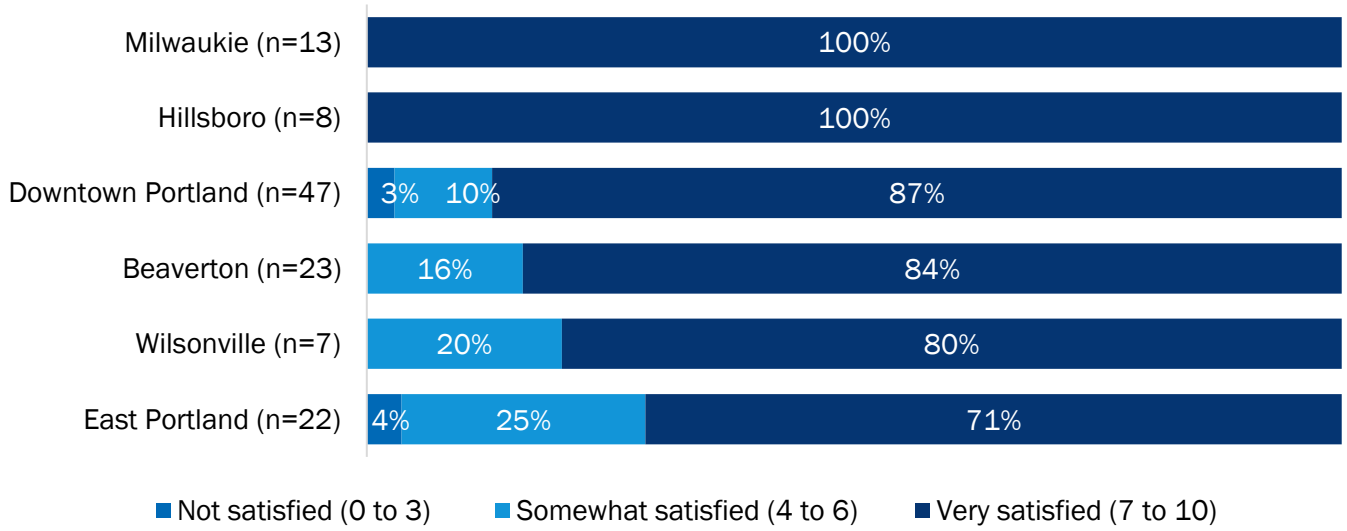
Respondents have concerns about charger reliability at some EA sites. While satisfaction with charger reliability was moderate to high for most sites, a few who typically use the East Portland, Downtown Portland, and Beaverton EA sites expressed dissatisfaction (Figure 5).

Figure 5. Satisfaction with Charger Reliability



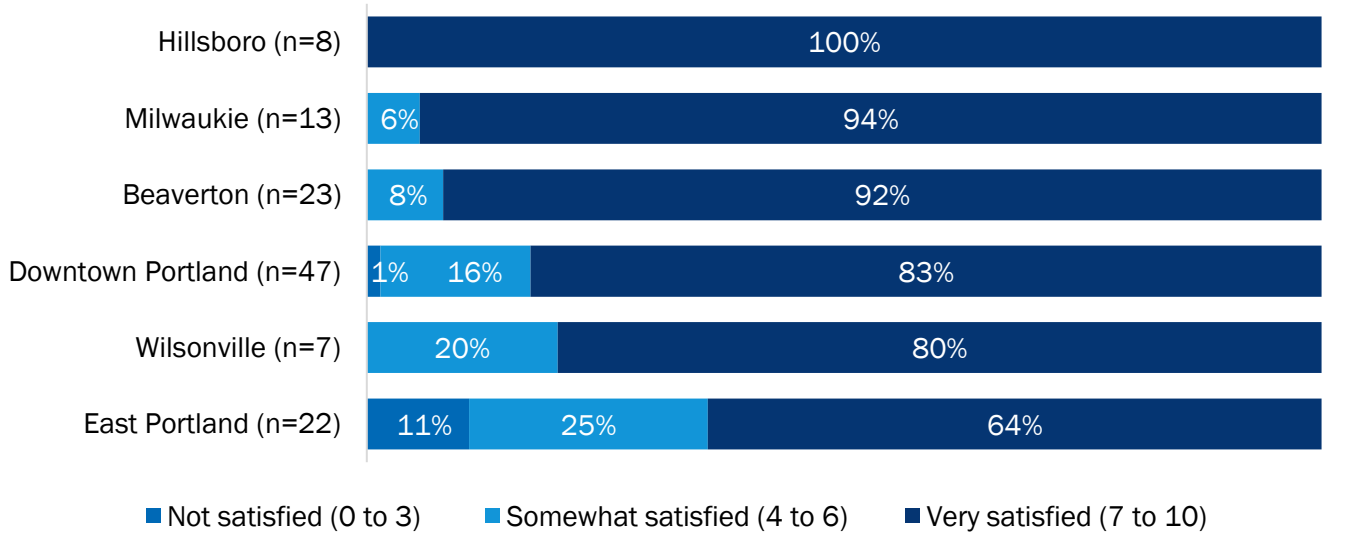
Nearly all respondents were at least somewhat satisfied with the location of each EA. Respondents who were very satisfied ranged from 71% for East Portland to 100% for the Hillsboro and Milwaukie EAs (Figure 6).

Figure 6. Satisfaction with Convenience of Location



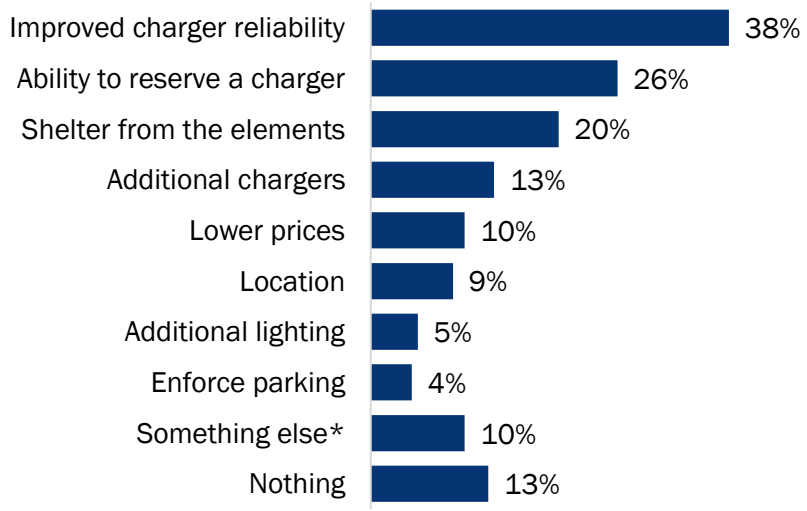
Respondents were generally satisfied with their on-site experience at PGE's EAs, with somewhat lower satisfaction with the East Portland EA site. Those that were "very satisfied" ranged from 64% for East Portland EA users to 100% for those who used the Hillsboro EA (Figure 7). When asked to suggest improvements, one respondent who charged at the East Portland EA felt that the chargers should be, "[placed] closer to a business I want to frequent while I wait. [Being in] the middle of a huge parking lot means a long unsheltered walk anywhere." Other suggestions for improvements to PGE's EA sites mentioned by more than one respondent included having restrooms nearby (n=4), adding trash cans to EA locations (n=3), and better lighting at night (n=3).

Figure 7. Satisfaction with Site Experience



After using EAs, respondents were generally satisfied with various aspects of the charging experience. However, when asked what would encourage them to use EAs more, nearly 90% suggested at least one area for improvement (Figure 8). The most mentioned area of improvement was to improve charger reliability (38%). Respondents who charged at the Downtown Portland EA were particularly likely to mention a need to improve charger reliability, with nearly half (49%) of these users reporting a need for improved charger reliability.

Figure 8. Suggestions to Encourage more Frequent Usage of EA (n=159; Multiple Responses Allowed)



*Includes response suggestions such as safety concerns, public restrooms nearby, and longer charger cords.

Throughout the survey, respondents indicated that they would like to see additional chargers to meet the rising demand. When asked which location would be most important for them to have additional charging available, a majority wanted to see them along major roads or highways (62%), with shopping centers (44%), and recreational areas (40%) also being popular locations (Table 11).

Table 11. Suggestions for Additional EA Charger Locations (n=159; Multiple Responses Allowed)*

Location	Count
Along major roads or highways	62%
Shopping centers or malls	44%
Parks or recreational areas	40%
Central business districts (e.g., Downtown Portland)	31%
Public buildings (e.g., city halls or libraries)	25%
Parking lots or garages	24%
Neighborhood streets in parking strips or on utility poles	20%
Apartment/condominium buildings	16%
Educational facilities	8%

*Respondents were allowed to select up to three locations

At the end of the survey, respondents were given the option to provide additional suggestions to improve their EA charging experience. Of the 87 respondents who provided comments, the two most common suggestions were to increase the number of chargers at EA sites and to improve charger reliability (Table 12).

Table 12. Open-Ended Suggestions for Improvement (n=87; Multiple Mentions Allowed)

Suggestion	Count
Increase number of chargers	30%
Improve charger reliability	20%
Pricing changes	9%
Enforce Parking	7%
Improve app reliability	7%
Shelter from elements	7%
Install nearby bathroom/trash cans	6%
Other suggestions*	15%

*Other suggestions include faster charging speed, better lighting at night, extended parking time (more than 2 hours), having lockable touch screens, and a longer extension cord