

Transportation Electrification Infrastructure Needs Analysis (TEINA)



**Oregon
Department
of Transportation**

Final Report

Oregon's Transportation Electrification Infrastructure Needs Analysis (TEINA)

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Foreword

This report was produced by the Oregon Department of Transportation's Climate Office under the guidance and direction of Mary Brazell (Agency Project Manager), Amanda Pietz (Climate Office Director), and Zechariah Heck. Collaborative support and guidance were also provided by the Oregon Department of Energy through Jessica Reichers and Rebecca Smith.

The consultant project team that assisted the Climate Office in the production of this report included Wayne Kittelson (project manager), Susan Mah, and Christopher Bame, Kittelson & Associates (prime contractor); Chris Nelder, Shenshen Li, Britta Gross and Lynn Daniels, RMI; Stacy Thomas and Alexander Nelson, HDR, Inc.; and Rhett Lawrence, Jeanette Shaw, Jeff Allen, Eric Huang, Whit Jamieson, and Kelly Yearick, Forth.

The project received additional feedback and suggestions from an Advisory Group consisting of Greg Alderson, Portland General Electric; Tom Ashley, Greenlots; Phil Barnhart, Emerald Valley Electric Vehicle Association; Chris Chandler, Central Lincoln Public Utility District; Marie Dodds, AAA Oregon; Judge Liz Farrar, Gilliam County; Ingrid Fish, City of Portland; Stu Green, City of Ashland; Jamie Hall, General Motors; Zach Henkin, Cadeo Group; Joe Hull, Midstate Electric Cooperative; Juan J Serpa Muñoz, Eugene Water and Electric Board; Vee Paykar, Climate Solutions; Cory Scott, Pacific Power; Jairaj Singh, Unite Oregon; Charlie Tracy, Oregon Trail Electric Cooperative; and Dexter Turner, OpConnect. The Oregon Department of Transportation and the consultant project team acknowledge with sincere appreciation the feedback and suggestions provided by the Advisory Group members while also noting that the members were not asked and have not formally endorsed the content of this report either individually or collectively.

August 2022 Updates

The TEINA report was updated in August 2022 and replaces the original version released in June 2021.

This updated report incorporates the results of a refined methodology used to calculate charging port requirements for light-duty vehicles in 2025, 2030, and 2035 under all analysis scenarios. The major findings of the study are unchanged, illustrating the exponential growth needed for EV charging infrastructure in Oregon. Graphics in the report have been updated where necessary.

The refined methodology used to calculate charging port requirements provides a more accurate distinction between urban and rural areas, and their associated charging port requirements. The methodology also:

- Distributes public Level 2 and DC Fast Charging ports based on the number of currently owned passenger vehicles.
- Distributes workplace Level 2 ports based on the number of jobs.
- Corrects the Corridor Light-Duty Vehicle use case by removing duplicative counting of charging ports needed in each of the milestone years.

Charts, figures, tables, and text have been revised throughout the report and the appendices to reflect the refined methodology, and to present the revised analysis results for these light-duty vehicle use cases: Urban, Rural, Corridor, Disadvantaged Communities, and Transportation Network Companies.

The use cases for Local Commercial and Industrial Vehicles, Transit and School Buses, and Long-Haul Trucking did not require updates and remain consistent with the original report.

Intended Use of Report

Governor Kate Brown called for a needs analysis on transportation electrification infrastructure in Executive Order 20-04. Transportation electrification goals set forth in Senate Bill 1044 (2019) are specifically referenced as a guide for the analysis. Thus, the modeling assumptions and, subsequently, the results, are based on targets provided in Senate Bill 1044 - not actual real-world data (e.g., electric vehicle registrations or electric vehicle chargers installed today). This report is intended to give policymakers an idea of the needs and potential policies required to achieve Oregon's electrification goals as called for in Senate Bill 1044. While the modeling used to inform the report findings is granular to the census tract or county level (as appropriate for the various use cases modeled), the report is not intended to be used as the implementation plan for the deployment of transportation electrification infrastructure.

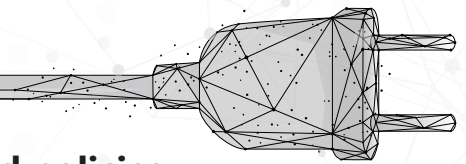
1. Executive Summary

The move toward electrically powered vehicles is well underway, and the speed of their adoption is accelerating at a dramatic pace. Oregon is fast approaching an inflection point of zero emission vehicle (ZEV) adoption, driven by market forces, manufacturer commitments, technology improvements, and federal and state climate policies. Public, private, and utility investments in transportation electrification infrastructure are therefore needed to serve Oregonians and businesses using electric vehicles today and in the future.

The goal of Oregon's Transportation Electrification Infrastructure Needs Analysis (TEINA) study is to evaluate the likely future charging infrastructure needs of all modes of electric transportation. As such, it is a needs analysis intended to set the stage for development of a follow-up deployment strategy. TEINA focuses on light-duty vehicle (LDV) charging needs while also including transit, delivery, freight,

and micromobility vehicles during the modeling period of 2020–2035. Directed by Oregon Governor Kate Brown's Executive Order 20-04 on climate action, the TEINA study is designed to evaluate charging infrastructure needs to meet the light-duty zero emission vehicle adoption goals articulated under 2019 Oregon Senate Bill 1044 (Senate Bill 1044) while also examining charging needs for other vehicle types and use cases. Charging needs of rural drivers, and those residing in historically marginalized communities, are of particular note. Additionally, the study recommends policies and implementation priorities required to accelerate infrastructure deployment, with special emphasis on the near-term to ensure Oregon sets an appropriate pace to achieve all of its midterm and longer-term milestones. Both the TEINA goals and Oregon's Senate Bill 1044 light-duty zero emission vehicle (ZEV) goals are reflected in the following graphic.

Oregon's Transportation Electrification Infrastructure Needs Analysis

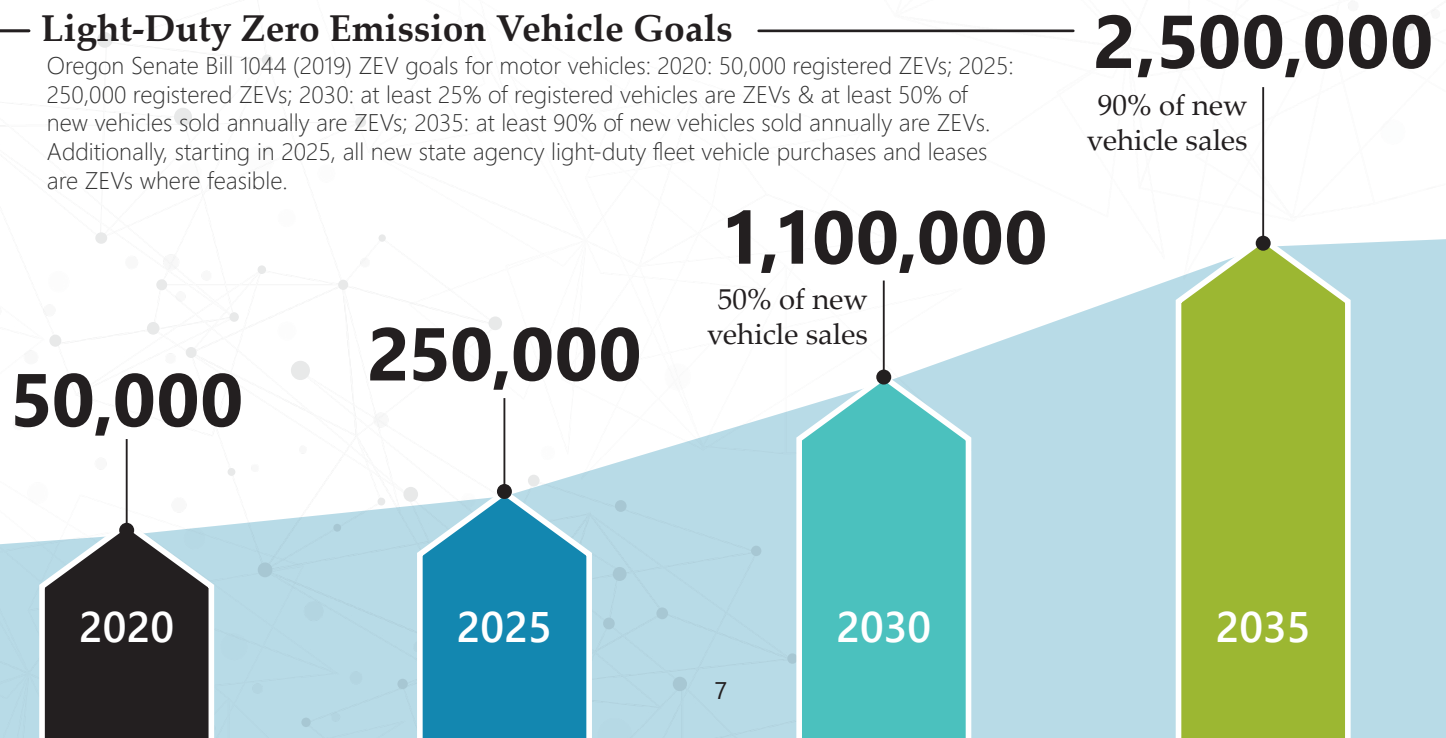


Evaluate future charging infrastructure needs of light-duty vehicles and other modes of electric transportation.

Recommend policies and implementation priorities to accelerate charging infrastructure.

Light-Duty Zero Emission Vehicle Goals

Oregon Senate Bill 1044 (2019) ZEV goals for motor vehicles: 2020: 50,000 registered ZEVs; 2025: 250,000 registered ZEVs; 2030: at least 25% of registered vehicles are ZEVs & at least 50% of new vehicles sold annually are ZEVs; 2035: at least 90% of new vehicles sold annually are ZEVs. Additionally, starting in 2025, all new state agency light-duty fleet vehicle purchases and leases are ZEVs where feasible.



To achieve the vision of ubiquitous zero emission vehicle (ZEV) charging access, six overarching electric vehicle (EV) infrastructure goals emerged from the Transportation Electrification Infrastructure Needs Analysis (TEINA) study.

Electric Vehicle Infrastructure Goals



Support rapid deployment of EV charging infrastructure in homes, along travel corridors, at work and fleet depots, at travel destinations, and in multi-unit dwellings.



Ensure EV charging infrastructure is equitable and accessible to all Oregonians (including all communities, income levels, and geographic locations).



Ensure the public charging experience is user-friendly, convenient, safe, and consistent.



Ensure that EV charging offers all consumers and fleets the benefit of lower electric fueling costs.



Ensure utilities are positioned for rapid expansion of EV charging statewide. Utilities must plan for and supply increasing demands for electricity while exploring resiliency in the event of power outages.



Develop foundational policies and provide resources to support community members, businesses, local governments, and tribes to build and benefit from a ZEV future, including educational and technical resources, EV-ready residential and commercial buildings, a skilled workforce, and increased support for micromobility solutions.

The study was primarily focused on the sizeable and thus critically important light-duty vehicle (LDV) sector; however, a total of nine different use cases were modeled: Urban LDVs, Rural LDVs, Corridor LDVs, Local Commercial and Industrial Vehicles (also referred to as medium-duty vehicles), Transit and School Buses, Transportation Network Companies (such as Uber and Lyft), Long-Haul Trucking, Micromobility, and the specific infrastructure needs

of Disadvantaged Communities. Broadly speaking, and as expected, the public charging needs of the Urban and Rural LDV sectors are an order of magnitude greater than for the other transportation sectors (use cases). Across all sectors, there is an extraordinary need for charging infrastructure growth, not only by 2035 and well in advance of the large volume of EVs anticipated, but also a significant near-term need for growth over the next four years.

Modeling Results

Number of Charging Ports Needed by Use Case (Business as Usual Scenario)

	2020	2025	2030	2035
Urban Light-Duty Vehicles (LDVs)	1,489	7,254	33,062	71,676
Rural LDVs	1,176	6,037	27,988	60,892
Corridor LDVs	406	1,614	2,104	2,713
Local Commercial and Industrial Vehicles	10	371	949	1,836
Transit and School Buses	15	893	3,318	7,407
Transportation Network Companies (TNC)	0	23	183	207
Long-Haul Trucking	0	39	219	690
Disadvantaged Communities	171	852	3,917	8,506
Total Number of Charging Ports	3,267	17,083	71,740	153,927
Increase Over 2020 Level		523%	2,196%	4,712%

Note: Modeling assumes 50,000 electric vehicles in 2020. Projections reflect optimized Business as Usual results.

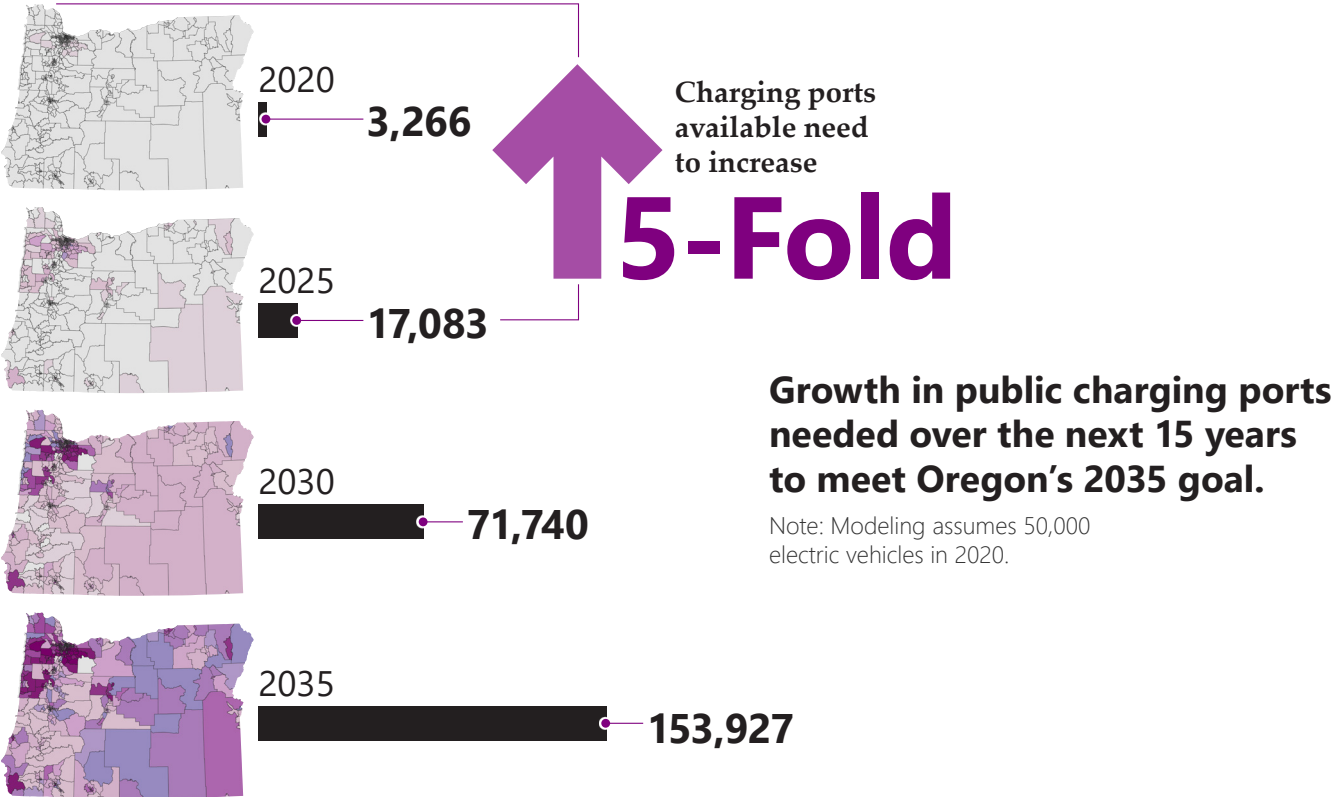
Light-Duty Vehicle Charging Ports Needed by Type of Charging Port (Business as Usual Scenario)

	2025	2030	2035
Workplace Level 2	7,220	33,304	72,379
Public Level 2	4,512	20,784	45,162
Public Direct Current Fast Charge (DCFC)	4,048	13,166	26,453

Note: LDV includes the Urban, Rural, Corridor, TNC, and Disadvantaged Communities Use Cases

As shown in the first graphic above, in the optimized Business as Usual scenario, 153,297 charging ports will be required by 2035—a 47-fold increase from required 2020 levels. In order to meet just the light-duty vehicle charging needs across all use cases, the second table summarizes the need for Level 2 workplace charging, public Level 2, and public DCFC. These figures highlight the rapid growth in EV charging infrastructure required over the next 5, 10, and 15 years.

The analysis assumes that in 2020, 90% of light-duty urban and rural electric vehicle (EV) charging takes place at home, but by 2035, this shifts to 60% of Urban and Rural light-duty vehicle (LDV) charging at home and takes into account that a significant portion of Oregonians live in multi-unit dwellings (MUDs) (e.g., apartments, duplexes, townhomes) where access to convenient overnight on-site charging can be a challenge.* The need for public charging grows exponentially from 2020 to 2035 and can be seen in the following heatmaps that show available charging ports across all use cases need to increase five-fold just from 2020 to 2025.



Though this study is largely focused on an assessment of the future public charging needs for light-duty EVs, it is worth noting the vast majority of light-duty EV charging today is accomplished by home charging and will remain the case for the foreseeable future. Today, a majority of early EV owners live in single-family homes with easy access to a Level 1 outlet or a Level 2 charging port. However, MUD residents often do not have access to a dedicated parking space, let alone an electrical outlet where they can reliably charge an EV. This study points to several policies to address MUDs charging needs, including public Direct Current Fast Charge (DCFC) community hubs as well as on-site Level 2 and off-site Level 2 public charging.

Home Charging Ports Needed (Business as Usual Scenario)	2020	2025	2030	2035
Note: Each cell identifies the number of home charging ports needed by year and, in parentheses, the percentage of homes assumed to have access to a home charging port.	45,000 (90%)	200,000 (80%)	770,000 (70%)	1,500,000 (60%)

Policy initiatives recommended in the Transportation Electrification Infrastructure Needs Analysis (TEINA) study address the critical need for significant public charging investments to meet demand and develop confidence among the driving public that EV charging will be as easy as refueling a gasoline vehicle. Rapid growth in public charging is essential to achieve mainstream adoption of EVs. However, the TEINA study also describes the need for broadly adopted building codes that will ensure all homes and MUD in the future are built with an EV-ready charging capability, so that owners and renters alike have more equitable access to home charging—and aren’t solely reliant on potentially more costly public charging solutions.

* According to the U.S. Census Bureau's 2014-2018 American Community Survey, about one-quarter of Oregonians live in multi-unit dwellings.

Policy Recommendations

The near-term policy priorities are described below.

Zero emission vehicle (ZEV) infrastructure deployment strategy—
2 to 5 year focus, including opportunities for targeted state investment



Target equity in charging

- Ensure charging access for those eligible for Charge Ahead rebate.
- Incentivize workplace charging at employers, emphasizing women and minority-owned businesses and similar groups.
- Incentivize investment in charging deserts in rural areas.



Update Oregon's building codes and parking ordinances to make them electric vehicle (EV) ready



Develop and fund a statewide educational and technical assistance program for charging

- Develop fact sheets, technical resource documents, and website content.
- Create proactive outreach program that is comprehensive, is hands-on, and targets high priority markets.
- Serve as an initial point of contact, referring individuals to utilities and other resources.
- Provide guidelines and model processes for streamlining permitting.



Lead by example: install charging at state buildings and offices for employees and visitors



The Transportation Electrification Infrastructure Needs Analysis (TEINA) identifies Oregon's urgent need to increase EV charging infrastructure to meet the state's goals for growth in EVs, which will create an unprecedented shift in the way Oregonians fuel their vehicles. TEINA sets out EV infrastructure goals to provide Oregonians with confidence that EV charging will be as ubiquitous and convenient as fueling with gasoline, and recommends policies to achieve these goals.

Looking forward, TEINA points to priorities for both policies and implementation actions to achieve these goals. Priority EV infrastructure deployment actions in the near term fall into three focus areas: (1) **targeting light-duty EV charging needs**, while (2) **supporting depot charging** for fleets of all types, and (3) **planning for charging needs** of local commercial and industrial vehicles and long-haul trucking. A series of next steps is needed, to turn the recommendations identified by TEINA into realizable results. To implement TEINA's findings, a statewide ZEV charging infrastructure deployment strategy is being developed, with a 2–5 year focus, to fine tune and prioritize specific infrastructure actions needed to accelerate ZEV adoption—incorporating concerns for equity and geographic balance. In addition, three areas of study will be pursued: (1) A supplemental inquiry into the refueling needs of hydrogen fuel cell ZEVs; (2) An assessment of the barriers impeding accelerated adoption of electric micromobility (e.g., eBikes, eScooters, eTrikes), including concerns beyond charging infrastructure; and (3) Addendums to TEINA to facilitate stakeholder planning. These next steps will keep Oregon charging ahead, preparing for an electric future.

2. Introduction

Oregon is fast approaching an inflection point of zero emission vehicles (ZEV) adoption, driven by market forces, manufacturer commitments, technology improvements, and federal and state climate and EV policies. Recognizing the significant greenhouse gas benefits of EV adoption, the Oregon legislature passed Senate Bill 1044, which established ZEV adoption goals that would require 90% of new car sales be ZEVs by 2035. This extraordinary growth in electric vehicle adoption will create a fundamental, unprecedented shift in the way Oregonians fuel their vehicles. The current infrastructure for fueling vehicles is not adequate to support ZEVs, and a different type of infrastructure is required to meet this demand.

To guide this transition, Oregon Governor Kate Brown directed the Oregon Department of Transportation (ODOT) to conduct a Transportation Electrification Infrastructure Needs Analysis (TEINA) in Executive Order 20-04. Accordingly, ODOT hired a consultant team and formed advisory and focus groups to evaluate and highlight needs. Based on the TEINA research, stakeholder listening sessions, scenario development, and modeling of future electric fueling needs, it is clear that Oregon's existing foundation of EV charging infrastructure needs to grow exponentially over the next 15 years to drive—and supply—transportation electrification throughout Oregon.

Access to EV charging infrastructure is uniformly cited as one of the key barriers to EV adoption. Unlike current fueling infrastructure, electric charging infrastructure can, and should, be installed where people live, work, travel, and play. Critically important to instilling confidence among Oregon's EV drivers is a public network of EV charging along highway corridors and at travel destinations, workplaces, fleet depots, and for Oregonians living in multi-unit dwellings (apartments, duplexes, townhomes). Charging infrastructure is needed to support all Oregonians and the full spectrum of electric transportation, including light-duty vehicles, electric transit and school buses, commercial and local delivery EVs, electric long-haul freight trucks, and electric bikes and scooters. Heightened private sector, public sector, and utility engagement will be critical to achieve the needed future ZEV charging infrastructure.

This report summarizes the results of the TEINA project, including the findings of the infrastructure needs assessment, policy recommendations and implementation priorities. **The TEINA project was organized along five major task areas.**

1 Existing Conditions

Review, inventory, and understand existing geographic and ZEV charging port distribution characteristics in Oregon.

2 Literature Review

Conduct a literature review to provide insights into how Oregon's situation compares with other efforts being undertaken across the country. In addition, an in-depth review of activities within three states (Colorado, New York, and California) that are providing national leadership in ZEV adoption was performed to explore models for Oregon to emulate.

3 Stakeholder Engagement

This project included an extensive stakeholder engagement process to solicit important project input regarding insights and activities being undertaken by the many different entities that are actively engaged in promoting the planning, design, and implementation of transportation electrification infrastructure in Oregon. Input was received from several sources, including:

- A 17-member Advisory Group that reviewed, contributed to and critiqued activities and findings;

- 12 separate listening sessions, each of which focused on the concerns of representatives regarding ZEV adoption and charging for a particular use case; and
- Public comments received throughout the life of the project via a website and as part of four public meetings.

4 Infrastructure Needs Assessment

This effort represented the heart of the project and consists of the modeling analysis and findings regarding infrastructure needs in Oregon. Three bookend scenarios were used to establish a range of expected infrastructure needs across three target dates (2025, 2030, and 2035) for each of nine use cases (e.g., Rural Light-Duty Vehicles, Transit and School Buses, etc.) as well as an optimized condition that considered all use cases in combination.

5 Policy Recommendations

Policy recommendations and infrastructure deployment priorities were developed based on the information obtained during the study. The recommendations and infrastructure deployment priorities are presented in several different ways to enhance their usability, including:

- In the context of overall infrastructure goals;
- In accordance with infrastructure priorities and approach by major use case; and
- As a list of top five recommended policy priorities to support Oregon's future plan for a ZEV charging infrastructure deployment.

The main body of this report focuses on the results of the infrastructure needs assessment, the policy recommendations, and the implementation priorities. Detailed findings relative to the existing conditions, literature review, stakeholder engagement, and the assumptions and methodology used in the infrastructure needs assessment can be found in the appendices.

The goal of Oregon's TEINA study was to evaluate the likely future charging infrastructure needs in order to ultimately achieve the state's ZEV adoption goals articulated under Oregon Senate Bill 1044 for the milestone years 2025, 2030, and 2035. Though the study focused largely on the sizeable and thus critically important light-duty vehicle (LDV) sector, a total of nine different use cases were modeled: Urban LDVs, Rural LDVs, Corridor LDVs, Local Commercial and Industrial Vehicles, Transit and School Buses, Transportation Network Companies (TNCs) providing ridehailing services (e.g. Uber, Lyft), Long-Haul Trucking, Micromobility, and the specific infrastructure needs of Disadvantaged Communities.

Broadly speaking, and as expected, the public charging needs of the urban and rural LDV sector are an order of magnitude greater than for the other transportation sectors (use cases*). Across all sectors, there is an extraordinary need for charging infrastructure growth, not only by 2035 and well in advance of the large volume of EVs anticipated, but also a significant near-term need for growth over the next four years ahead of vehicle acquisition decisions.

** For light-duty vehicle use cases, the TEINA assessment focuses on future public charging needs, while incorporating assumptions about the significant proportion of charging that will occur at home locations. In 2020, 90% of charging is assumed to take place at home locations, but by 2035 this proportion decreases to 60%, reflecting more access to public and workplace charging and greater ZEV adoption by residents of multi-unit dwellings who often face challenges securing charging at home locations.*

Scenario Overview

Three scenarios were used in this study to bracket the possible trajectories for the Oregon economy between 2020 and 2035 in light of the COVID-19 pandemic. As specified in Executive Order 20-04 directing this transportation electrification infrastructure needs analysis, all three scenarios were created to ultimately meet the zero emission vehicle (ZEV) objectives set out in Senate Bill 1044 by 2035. The scenarios contemplate a number of factors, such as overall economic vigor and activity, evolving technologies, consumer preferences, future policies, the changing cost of charging, potentially changing demographics, and the character of the economic recovery from the pandemic.

Three TEINA infrastructure scenarios were modeled for Oregon.

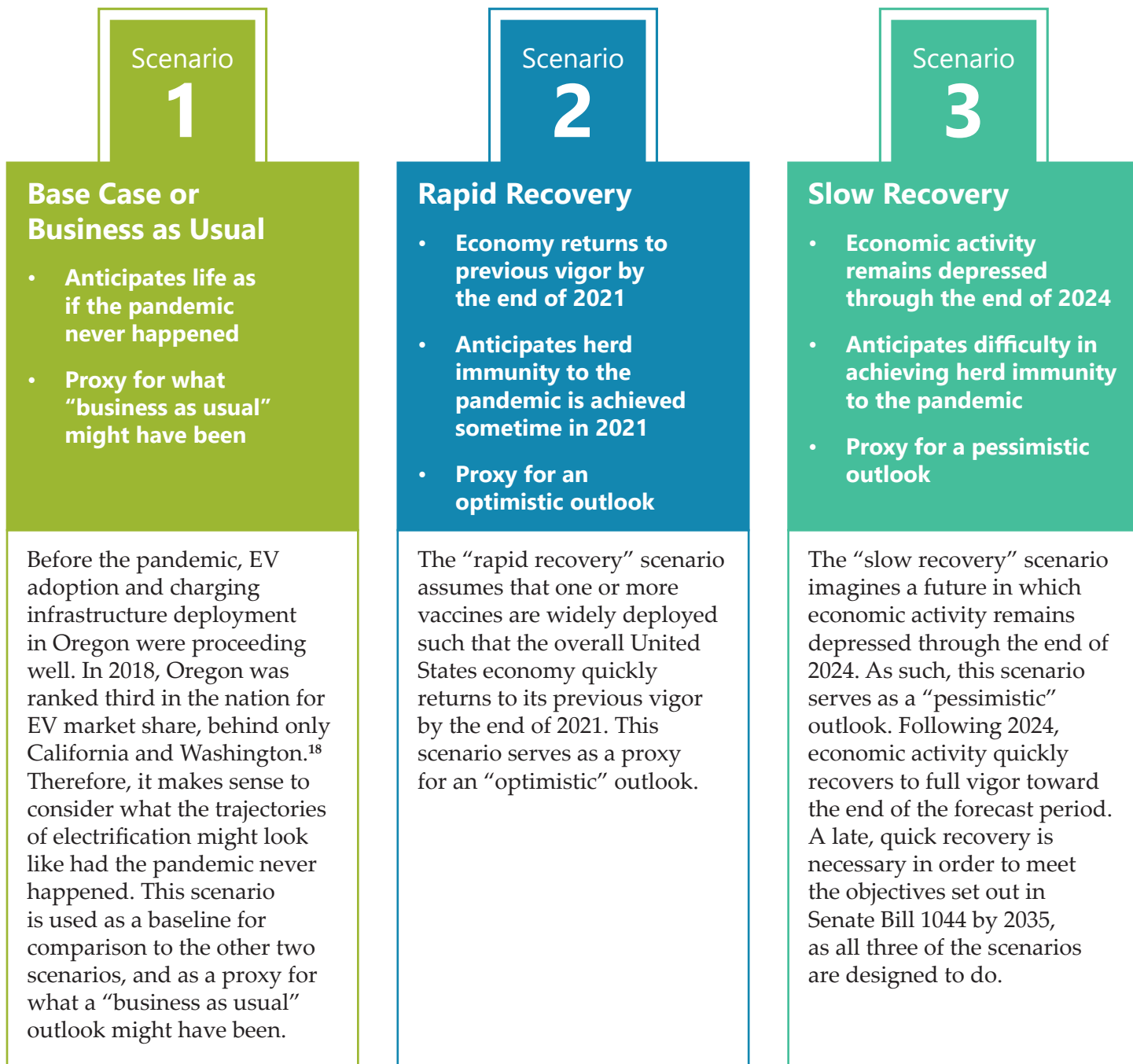


Figure 1. Three Scenarios Modeled for Oregon

Note: For report brevity, only the Business as Usual scenario results are shown. All results are available in the Appendix.

3. Modeling Analysis and Results

Approach and Assumptions

A comprehensive analysis methodology was employed to estimate electric vehicle (EV) charging port needs for each use case across three scenarios and for each of three target years (2025, 2030, and 2035). **Table 1** provides an overview summary of the stepwise methodology followed to model each use case. It also summarizes key assumptions that underlie the analysis for each use case.

Model Optimization

The modeling treated each use case individually, as if a dedicated set of charging ports existed for each one. In reality, some charging ports will be used by multiple use cases, so an optimization pass on the model results was performed to estimate how such sharing might reduce the total number of charging ports needed in Oregon.

The optimization modeling is visualized graphically in Figure 2 and described in greater detail subsequently. As Figure 2 illustrates, some chargers needed for the Urban LDV and Rural LDV use cases will also serve Local Commercial and Industrial Vehicles. Therefore, the total number of chargers needed for Local Commercial and Industrial Vehicle use cases is reduced. Overlaps between other use cases are also seen in the graphic and described subsequently.

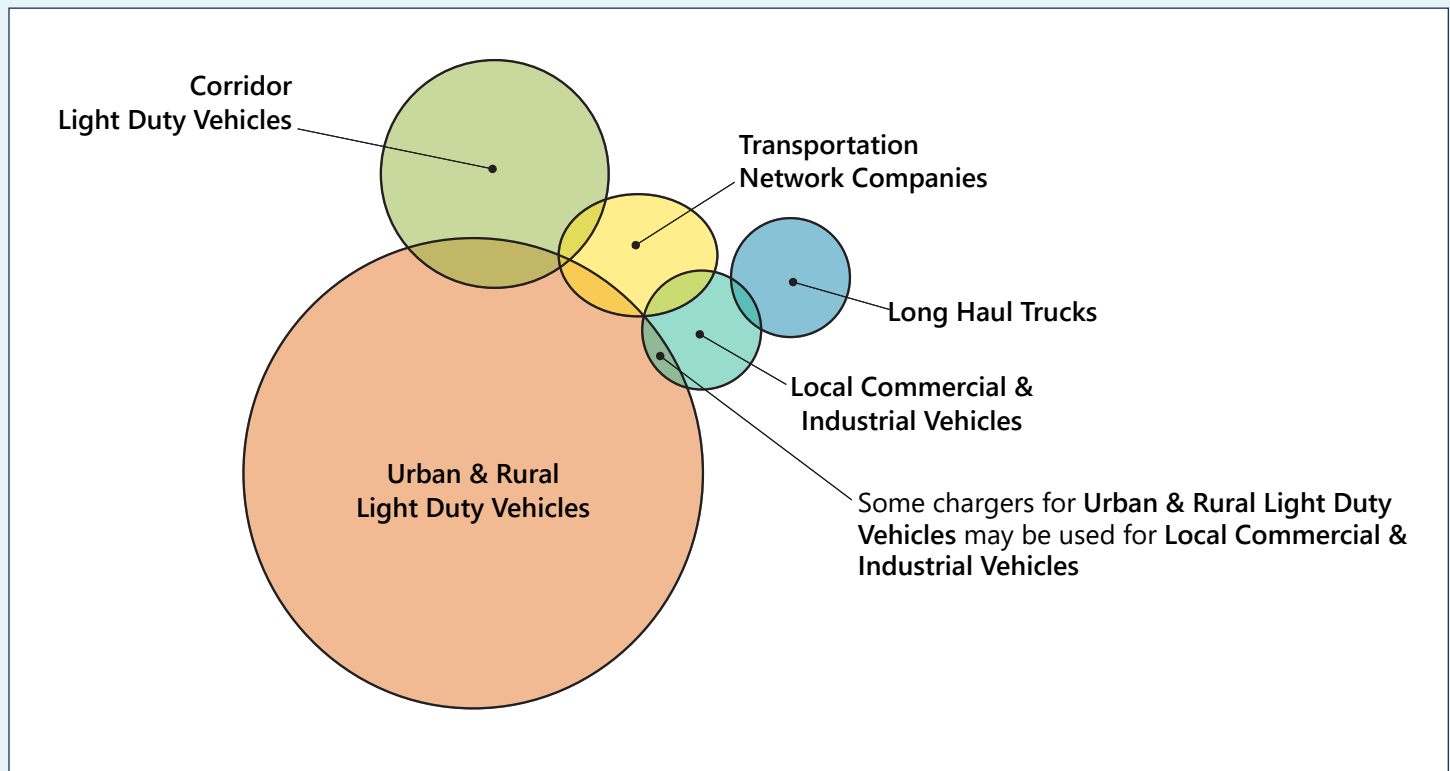


Figure 2. TEINA Model Optimization

Table 1. Modeling Methodology and Assumptions by Use Case

Modeling Methodology by Use Case	Assumptions
<p>Urban Light-Duty Vehicles</p> <p>Step 1: Forecast the total number of light-duty vehicle (LDV)— both electric vehicles (EVs) and internal combustion engine (ICE) vehicles—throughout the modeling period in Oregon.</p> <p>Step 2: Define census tracts as urban if they have a population density of at least 500 people per square mile or an employment density of at least 750 jobs per square mile.</p> <p>Step 3: Use the ratio of existing passenger vehicles in urban and rural census tracts, to forecast the number of EVs in urban areas of Oregon.</p> <p>Step 4: Use models derived from National Renewable Energy Laboratory’s (NREL’s) Electric Vehicle Infrastructure Projection (EVI-Pro) Lite modeling tool to forecast the number of public Level 2, public Direct Current Fast Charge (DCFC) charging ports, and workplace Level 2 ports in urban areas throughout Oregon.</p> <p>Step 5: Allocate public Level 2 and public Direct Current Fast Charge (DCFC) charging ports proportionally to the number of existing passenger vehicles in the census tract compared to all urban census tracts in Oregon. Allocate workplace Level 2 chargers to census tracts proportionally to the number of jobs in the census tract compared to all urban census tracts in Oregon.</p>	<p>Number of Urban eLDV is 159,000 (2025), 735,000 (2030), 1,599,000 (2035); 90% of all LDV charging is at home in 2020, decreasing to 60% in 2035 as more workplace and public charging ports are installed; DCFC power = 150kW</p>
<p>Rural Light-Duty Vehicles</p> <p>Step 1: Same as the Urban use case.</p> <p>Step 2: Define census tracts as rural if they have a population density less than 500 people per square mile and an employment density less than 750 jobs per square mile.</p> <p>Step 3: Use the ratio of existing passenger vehicles in urban and rural census tracts, to forecast the number of EVs in rural areas of Oregon.</p> <p>Step 4: Use models derived from National Renewable Energy Laboratory’s (NREL’s) Electric Vehicle Infrastructure Projection (EVI-Pro) Lite modeling tool to forecast the number of public Level 2, public Direct Current Fast Charge (DCFC) charging ports, and workplace Level 2 ports in rural areas throughout Oregon.</p> <p>Step 5: Allocate public Level 2 and public Direct Current Fast Charge (DCFC) charging ports proportionally to the number of existing passenger vehicles in the census tract compared to all rural census tracts in Oregon. Allocate workplace Level 2 chargers to census tracts proportionally to the number of jobs in the census tract compared to all rural census tracts in Oregon.</p>	<p>Number of Rural eLDV is 91,000 (2025), 421,000 (2030), 915,000 (2035); Home charging assumptions same as for Urban LDV; DCFC power = 150kW</p>
<p>Corridor Light-Duty Vehicles</p> <p>Step 1: Forecast the total number of LDV traveling along corridors by interpolating between ODOT annual average daily traffic (AADT) historic data for 2018 and forecasted data for 2038. Assume 68% of the AADT is LDV.</p> <p>Step 2: Estimate the total electrical capacity required by eLDV on corridors.</p> <ul style="list-style-type: none"> a. Estimate the total number of eLDV considering Oregon’s EV adoption goals (from 2% in 2020 to 55% in 2035). b. Assume vehicle efficiency increases overtime (from 3.3 miles per kW in 2020 to 5 miles per kW in 2035). c. Assume increasing utilization of chargers (from 20% in 2020 to 35% in 2035) <p>Step 3: Estimate the number of 150 kW chargers needed to meet the previously estimated electrical capacity on 30-mile segments of each corridor.</p>	<p>LDV average 68% share of traffic on all major corridors in the state; 150kW charging on all corridors over the period; 20% charging port utilization rate in 2020 (35% in 2035)—i.e. the share of hours in a day the charging port is in use</p>

Modeling Methodology by Use Case

Assumptions

Local Commercial and Industrial Vehicles

Step 1: Forecast the electric vehicle miles traveled (VMT) for medium-duty vehicle (MDV) in each of the milestone years based on the projections used in the West Coast Clean Transit Corridor Initiative (WCCTCI) study.

Step 2: Calculate the energy required for the MDV VMT. To begin this calculation, we multiplied the vehicle's energy efficiency by the VMT.

Step 3: Forecast the charging ports needed (assumed 350kW) in each census tract to provide the energy calculated in Step 2.

eMDV daily VMT is 567,000 (2025), 1,345,000 (2030), 2,351,000 (2035); 10% en route charging + 90% depot in 2020 (50% en route in 2035); 15% charging port utilization rate in 2020 (30% in 2035); 21% of MDV are electric by 2035; DCFC power = 350kW

Transit and School Buses

Step 1: Starting with the number of transit and school buses in the state, develop a forecast for the number of school buses (both EV and ICE) in each county, based on its share of the population and the transit agencies service areas.

Step 2: Forecast the number of eBuses needed through 2035 statewide based on growth rate factors.

Step 3: Apply charging port to transit bus ratios to determine the number of 60kW DCFCs for transit buses, and charging port to school bus ratios to determine the number of Level 2 charging ports for school buses.

Number of eTransit buses is 234 (2025), 874 (2030), 1,992 (2035); 75% of market by 2035 and 90% of new sales; 60kW depot charging; 1:1 charging port per Bus (growing to 2:1 after 2030); Number eSchool buses is 720 (2025), 2,832 (2030), 6,411 (2035); 75% of market by 2035 and 90% of new sales; Level 2 school bus charging; 1:1 charging port per bus

Transportation Network Companies

Step 1: Forecast the transportation network company (TNC) vehicle miles traveled (VMT) in each county through 2035. Distribute the total statewide VMT per year across the counties, based on each county's share of the state population. To establish a 2019 baseline for the TNC VMT, perform a regression of TNC shares of VMT based on population density.

Step 2: Convert the TNC VMT into number of TNC vehicles based on the weighted average TNC VMT in California.

Step 3: Apply vehicle-to-charging port ratios to the number of EV from Step 2, to determine the number of charging ports by county that will be needed for TNC EVs.

eTNC daily VMT is 93,000 (2025), 888,000 (2030), 1,258,000 (2035); For TNC drivers with no access to home charging, use vehicle-to-plug ratio of 33 EV/plug; 22% of TNC drivers have access to home charging in 2025, 33% in 2030 and 44% in 2035; Public DCFC = 150kW

Long-Haul Trucking

Step 1: Forecast the electric VMT for heavy-duty vehicle (HDV) (statewide, not just highways) in each of the milestone years based on the electric HDV sales projections used in the West Coast Clean Transit Corridor Initiative (WCCTCI) study.

Step 2: Calculate the energy required for the HDV VMT.

Step 3: Determine the energy needed to be provided en route by census tract as well as the number of 500kW charging ports to support the trucks (500kW is maximum charging rate for HDVs entering the market today).

Long-haul freight daily VMT is 68,000 (2025), 289,000 (2030), 802,000 (2035); 0% eTruck sales in 2020 increase to 15% sales in 2035; 10% en route charging + 90% depot in 2020 (50% en route in 2035); 1/3 of VMT comes from out-of-state trucks

Micromobility

Step 1: Estimate the portion of trips made using micromobility in counties defined as rural or urban.

Step 2: Estimate the reduction in needed Urban/Rural LDV charging ports, proportionally to the portion of trips made using micromobility.

Micromobility; Assumes 110V outlets at home, work, public destinations; Urban: 3% of trips in 2020 up to 25% in 2035, Rural: 0% of trips in 2020 up to 5% in 2035

Disadvantaged Communities

Step 1: Census tracts are defined as disadvantaged if the median household income is less than \$48,800.

Step 2: The number of public Level 2, public Direct Current Fast Charge (DCFC) charging ports, and workplace Level 2 charging ports is increased by 25% in census tracts defined as disadvantaged.

The optimization modeling makes two assumptions:

1

The overall impact of sharing in each use case will be quite modest, because the modeling assumes that at some point, as the electric vehicle (EV) fleet grows, the utilization of charging ports will be maximized (typically assumed at 30% utilization, or roughly 8 hours/day). Therefore, the hours of the day that charging ports will not be in use will be fairly minimal and are generally assumed to be the late night and very early morning hours.

2

As the EV fleet grows, the use of charging ports by EVs in multiple use cases will increase.

Not all use cases will have potential overlap with other use cases, as shown in **Figure 2**. No overlap is expected in the following cases:

- Transit buses and school buses are expected to use dedicated charging ports.
- Ultra-high speed Direct Current Fast Charge (DCFC) charging ports for long-haul trucks won't likely be usable by any other vehicle use cases.
- Workplace Level 2 will likely be restricted to employee use.

After optimization, it is estimated in 2035:

- 18% of estimated charging ports for transportation network company (TNC) drivers could be eliminated without affecting the level of service provided.
- 25% of corridor charging can be met by urban and rural light-duty vehicle (LDV) charging ports.
- 10% of local commercial and industrial vehicle charging can be met by urban and rural LDV charging ports.
- 5% of long-haul trucking charging can be met by leveraging local commercial and industrial charging ports.

The full analysis and results of the optimizations are provided in the appendix.

Results

The modeling results for the base scenario, or Business as Usual scenario, are below. The results for all scenarios can be found in can be found in Appendix D.

This Business as Usual scenario is the baseline for comparison to the other two scenarios, and a proxy for what a business as usual outlook might have been. This scenario uses the zero emission vehicle (ZEV) adoption and charging infrastructure trends that existed before 2020 as a basis, and then applies a classic technology adoption S-curve to depict how those trends might have continued through 2035 had the pandemic never happened.

For example, if the economy reverts to the historical mean within two or three years, then the “rapid recovery” scenario would depict an unrealistically rapid economic recovery while the “slow recovery” scenario would depict an unrealistically slow economic recovery, and this scenario would offer a more accurate view of the future.

The Business as Usual scenario is characterized in Table 2.

Table 2. Business as Usual Scenario Characteristics by Target Year

Business as Usual Scenario Characteristics by Target Year	
2025	<ul style="list-style-type: none">• Electric vehicles (EVs) across some key segments have reached sticker-price parity with internal combustion engine (ICE) vehicles, driving a spike in consumer interest.• The market share for EVs is 8%, commensurate with the 2025 goal of Senate Bill 1044.• Public Direct Current Fast Charge (DCFC) are now available within a 50-mile radius of anywhere in the state.• Charging networks have expanded significantly and Level 2 charging ports are increasingly installed in public, workplace, and multi-unit dwelling (MUD) parking lots.• “Range anxiety” about the availability of charging stations is no longer prevalent.• In keeping with the Senate Bill 1044 targets, 250,000 zero emission vehicles (ZEVs) are registered in the state, and 25% of new light-duty vehicles purchased or leased by state agencies are ZEVs. 95% of these vehicles are EVs with the remainder being hydrogen fuel cell vehicles.
2030	<ul style="list-style-type: none">• Driven by the electrification trends in the urban areas and the significant price advantage that EVs now have over ICE vehicles, EV adoption spreads out from the urban cores to the rural areas of the state, led by electrified pickups and electrified farm equipment.• In keeping with the Senate Bill 1044 targets, 25% of registered vehicles and at least 50% of new vehicle sales are ZEVs.• All new light-duty vehicle (LDV) purchases or leases by state agencies are ZEVs. EVs make up 95% of these vehicles.
2035	<ul style="list-style-type: none">• Gasoline stations that do not offer EV charging ports have started disappearing from the state, making it less convenient and more expensive to own a personal ICE vehicle. Gasoline station coverage has largely shrunk toward the major highway corridors.• Rising state taxes on carbon-emitting fuels as part of the state’s overall climate policies as well as shrinking global oil industry put upward pressure on gasoline and diesel prices. EVs have become dominant in all vehicle classes.• EVs account for 90% of new vehicle sales.

Urban Light-Duty Vehicles (LDVs)

Urban charging ports serve a variety of drivers and use cases, making it feasible to provide charging services at a variety of power levels and charging session durations. This is important because providing power supply to urban charging sites can be costly, and electric vehicle (EV) charging loads at these sites should be managed as much as possible. Cost optimization also means using slower charging ports whenever practical. Additionally, demographic analysis can provide insights into the local density of multi-unit dwellings (MUDs) vs

single-family homes or the density of workplaces—both leading to an improved ability to more accurately size public charging stations. Urban stations are more likely to deliver less than a full charge in each charging session, as drivers plug in opportunistically to top up their vehicles while shopping or doing other tasks. A five-fold increase in urban public charging is required by 2025, including 4,000 workplace charging ports, 2,300 public Level 2, and 970 Direct Current Fast Charge (DCFC).

Key Takeaways

- Home charging will represent 90% of all light-duty vehicle (LDV) charging in the near term, while decreasing over time to 60% in 2035 as more workplace and public charging becomes available and as MUD residents represent a larger segment of the zero emission vehicle (ZEV) driver population. Encouraging and enabling home charging (especially with demand side management capability) for all urban dwellers will continue to be important throughout.
- A near term priority focus and support for workplace and urban DCFC charging hubs (addressing both Transportation Network Companies (TNCs) and MUDs), as well as depot charging for public and private fleets, will be needed.

Though MUDs were not modeled as a separate use case, it is worth noting the special needs of these residents. The vast majority of EV charging today is accomplished with convenient, overnight charging at home. A majority of early EV owners live in single-family homes where there is easy access to a Level 1 outlet or a Level 2 charging port. However, residents of MUDs often do not have access to a dedicated parking space, let alone an electrical outlet where they can reliably charge an EV. And retrofitting MUDs with EV charging ports has proven to be both challenging and costly. Until building codes are enacted that require EV-ready parking spaces in all new MUDs, and until the majority of MUDs have introduced EV charging ports (Level 1, Level 2 or DCFC), MUD residents will need to rely on other public charging solutions including workplace charging, curbside charging in the vicinity of the MUD, or neighborhood DCFC charging hubs located near areas with dense concentrations of MUDs. Ultimately, convenient, overnight home charging is of the highest importance for the widespread and equitable adoption of EVs.

As shown in **Figure 3**, a five-fold increase in the total number of charging ports over 2020 levels is needed in the Business as Usual scenario to meet the urban LDV requirements by 2025, and a 22-fold increase is needed by 2030. Heat maps showing the spatial distribution of these charging port needs for the combined Urban LDV and Rural LDV use cases are presented at the end of the next section (that is, at the end of the section discussing the Rural LDV use case).

Most of the charging ports needed by 2030 are workplace Level 2 and public Level 2 charging ports. However, DCFC charging ports play a very critical role in bringing about the widespread adoption of EVs as these stations can be more visible to consumers and address lingering concerns over range-anxiety and the availability of public charging. Two somewhat countervailing trends will also drive the need for DCFC: a) increased consumer adoption of EVs, and b) more people choosing not to own vehicles and to use ridehailing services (TNCs) instead, because those services will rely on public DCFC.

Because public Direct Current Fast Charge (DCFC) and public Level 2 charging ports tend to be operated by private sector charging network operators or “site hosts” like big-box retailers, the deployment of these charging ports will largely depend on the economics and requirements of operating those networks. This speaks to the importance of policy supports, like requiring buildings and lots to pre-wire for Level 2 charging ports, or demand charge relief and advanced tariff designs that improve the economics of operating public DCFC networks. However, to achieve the required deployment of workplace Level 2 charging ports, public policy will likely need to take the form of incentives to encourage

employers to install Level 2 charging ports in their parking lots, and to encourage their employees to adopt electric vehicles (EVs) that use them.

Note also that Oregon Senate Bill 1044 aimed to reach 50,000 registered zero emission vehicles (ZEVs) in Oregon by the end of 2020; actual adoption was short of that goal by a third, at 33,547. This illustrates the enormous challenges of mobilizing all critical actors at the same time to ensure the successful achievement of targets, including utilities, regulators, state agencies, infrastructure providers, the operators of fleets, and consumers themselves.

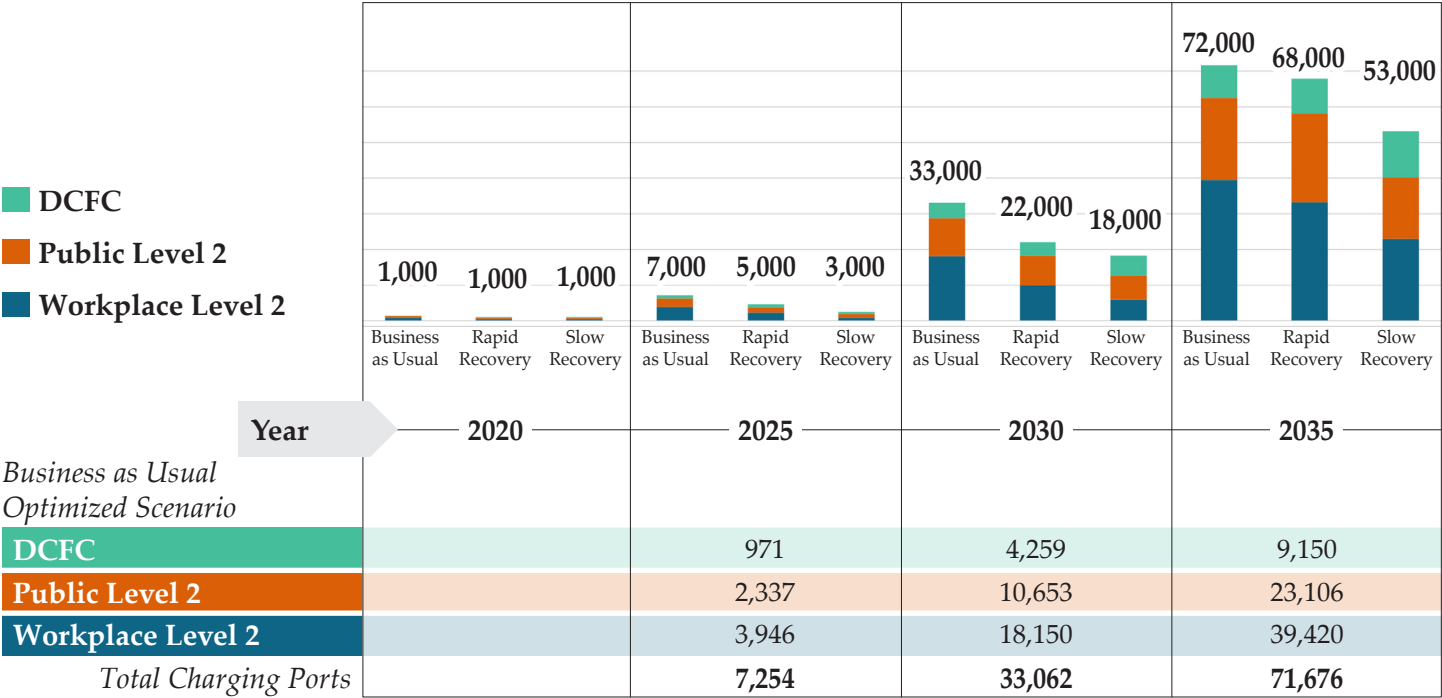


Figure 3. Total Number of Charging Ports for Urban eLDVs

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Urban Light-Duty Vehicle (LDV) Charging

The following list identifies some of the key barriers posing challenges to Urban LDV charging. These barriers, along with the associated policy recommendations presented under “Policy Recommendations,” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Cost of electric power upgrades and charging port installation (conduit, trenching)
- Inconsistent fees and/or rates for public charging
- Limited multi-unit dwelling and workplace charging
- Limited EV focused government planning, programs, policies and resources
- Limited government planning or guidance for EV infrastructure needs

Rural Light-Duty Vehicles (LDVs)

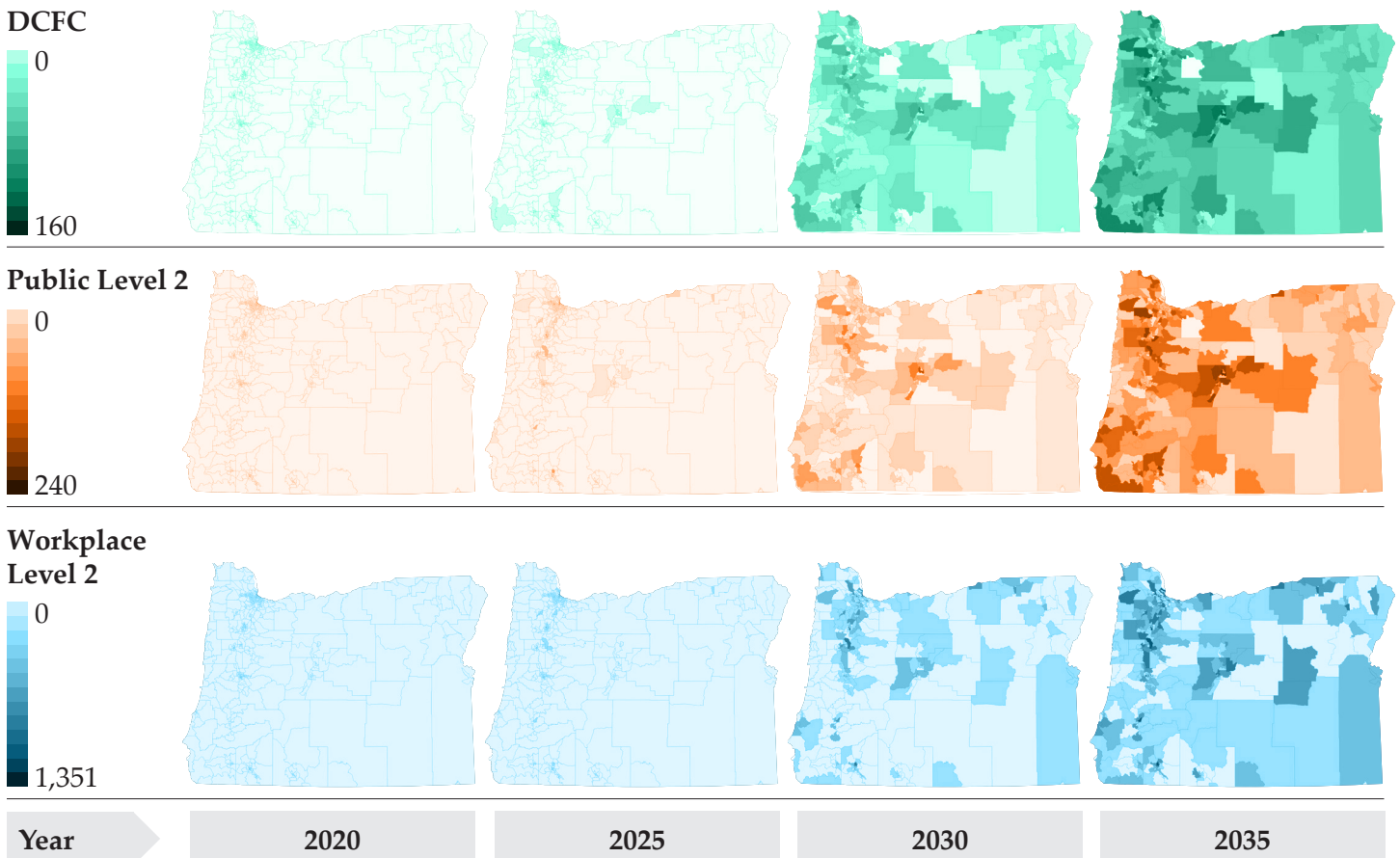
The needs of rural drivers often result in longer travel distances than urban drivers, with charging stations that are likewise more widely spaced. As a result, these charging stations generally require larger power capacity to deliver a faster charge. Rural charging stations are often challenged to meet a wide variety of use cases, from long-distance travelers

passing through, to farmers needing to charge up specialized farming equipment. Rural towns may have charging needs (and opportunities) that differ from rural corridors. For example, public Level 2 charging ports can be located in rural communities near restaurants, shopping, tourist destinations, etc., to encourage the support of local businesses.

Key Takeaways

- A five-fold increase in rural public charging is required by 2025, including 2,800 workplace charging ports, 1,900 public Level 2, and 1,300 Direct Current Fast Charge (DCFC). Encouraging and enabling home charging, with demand side management capability, will continue to be important throughout.
- In the 2025 Business as Usual scenario, roughly one third of all LDV electric vehicles (EVs) will be located in rural areas (91,000 of 250,000). Given longer distance travel in these areas (and recognizing the larger geographical area) and even with additional workplace charging ports, the need for rural DCFC charging ports in the next five years (1,300 by 2025) exceeds the need for DCFC in urban areas (970).

Charging Ports Needed in Urban & Rural LDV Use Cases



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

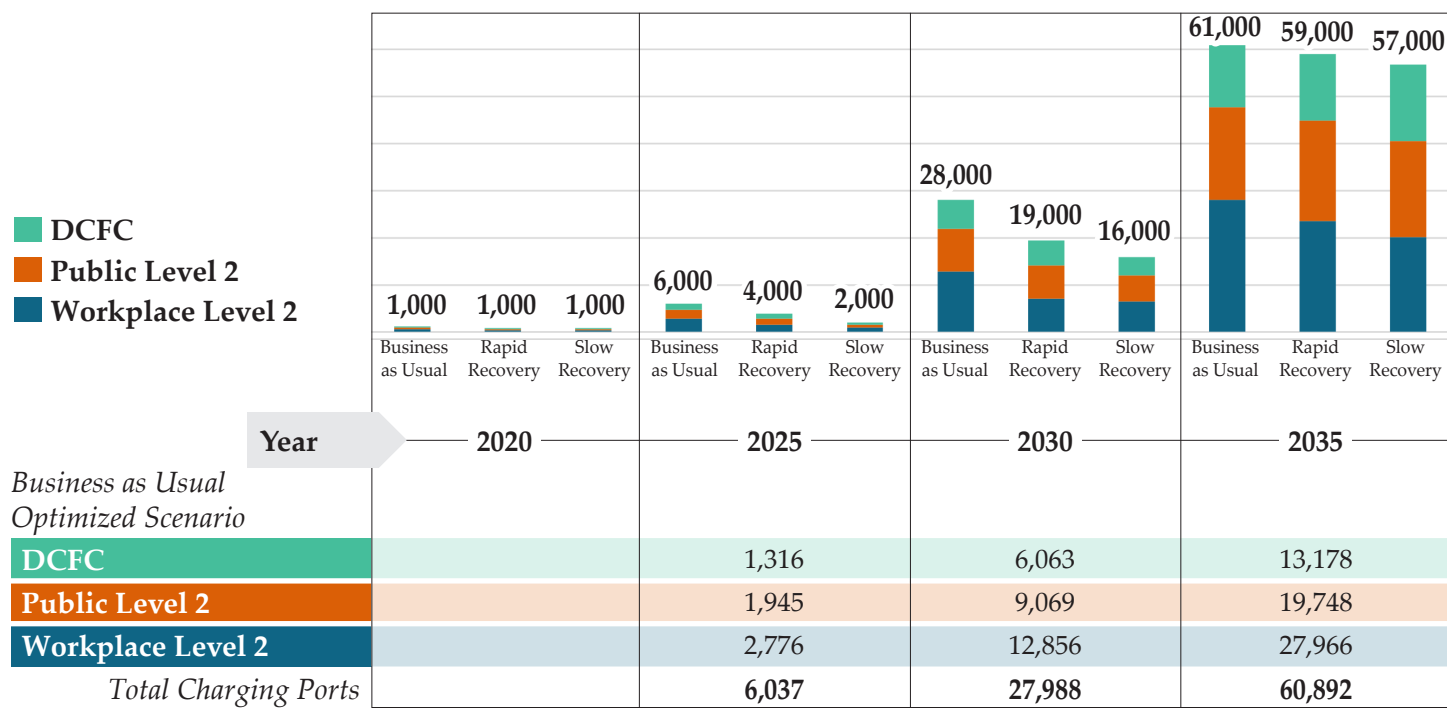


Figure 4. Total Number of Charging Ports for Rural eLDVs

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Rural Light-Duty Vehicle (LDV) Charging

The following list identifies some of the key barriers posing challenges to rural light-duty vehicle (LDV) charging. These barriers, along with the associated policy recommendations presented under "Policy Recommendations," will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Inconsistent fees and/or rates for public charging
- Limited electric vehicle focused government planning, programs, policies and resources
- Limited venues that can support power, safety and amenities
- Increased need for Direct Current Fast Charge (DCFC), multi-use medium-duty vehicles and heavy-duty vehicles, and travel destination charging
- Demand charges and low utilization that reduce cost effectiveness

Corridor Light-Duty Vehicles (LDVs)

Today, charging stations along major corridors throughout the state mostly serve long-distance travelers with light-duty vehicles who need a fast charge, so these charging stations are typically high-speed Direct Current Fast Charge (DCFC) with large power requirements. LDV travelers also typically need access to amenities when they are stopped to recharge, so the availability of restaurants, convenience stores, and restrooms is important.

The heat maps below show the growth in electric LDV traffic along seven key highway corridors in Oregon over the period from 2020 to 2035. The corresponding bar graph shows that a four-fold increase in publicly available DCFC charging is required along Oregon’s major highway corridors by 2025 (growing from 400 DCFC plugs required in 2020 to 1,600 in 2025); a five-fold increase by 2030; and a seven-fold increase in DCFC infrastructure to reach 2,700 DCFC by 2035.

Key Takeaways

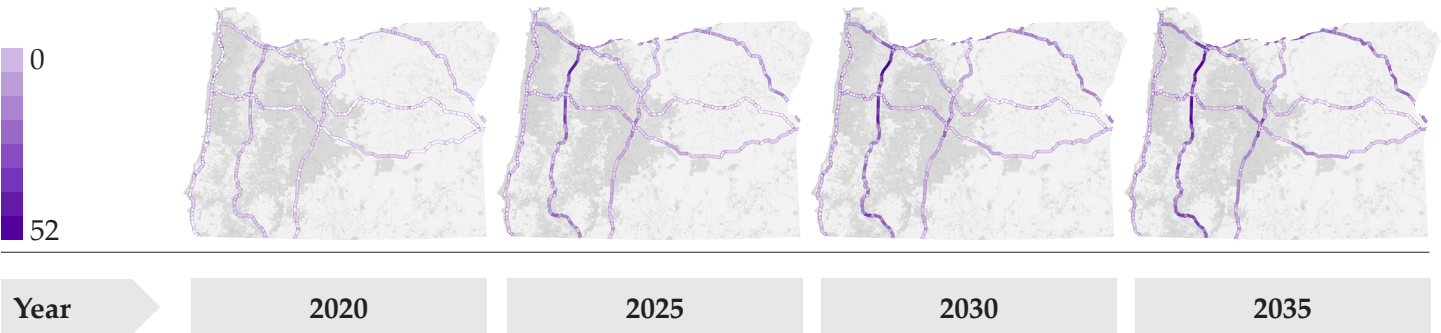
- A four-fold increase in publicly available DCFC charging is required by 2025.
- An overall near-term priority focus on Corridor LDV (including rural corridors and considering key destinations) is needed. Begin by prioritizing the near-term buildout of highly redundant Society of Automotive Engineers (SAE) Combined Charging System (CCS) DCFC on the West Coast Electric Highway (I-5, US 101, and other major roadways in Oregon).

To the extent practicable, consider a near-term goal of 25–50-mile maximum distance between charging stations on Oregon’s major highways (I-5, I-84, I-82, US 20, US 26, US 97, US 101) and 75–100-mile maximum distance between charging stations along remaining rural highways—eventually achieving a maximum of 25-mile station separation on all thoroughfares and extending the corridors so that all parts of the state are covered. To understand these proposed maximum station separation distances, consider that a vehicle traveling 50mph

will drive an hour before reaching the next electric vehicles (EV) charging station if the stations are placed 50 miles apart. Widespread EV adoption will require that consumers and commercial drivers are comfortable traveling long distances in an EV. But long distances without a charging station will continue the range-anxiety stigma that exists with EVs. Ubiquitous DCFC charging stations along highway corridors will instill the confidence consumers and other EV drivers need.

DCFC Charging Ports Needed in Highway LDV Corridor Use Case

Business as Usual Optimized Scenario



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

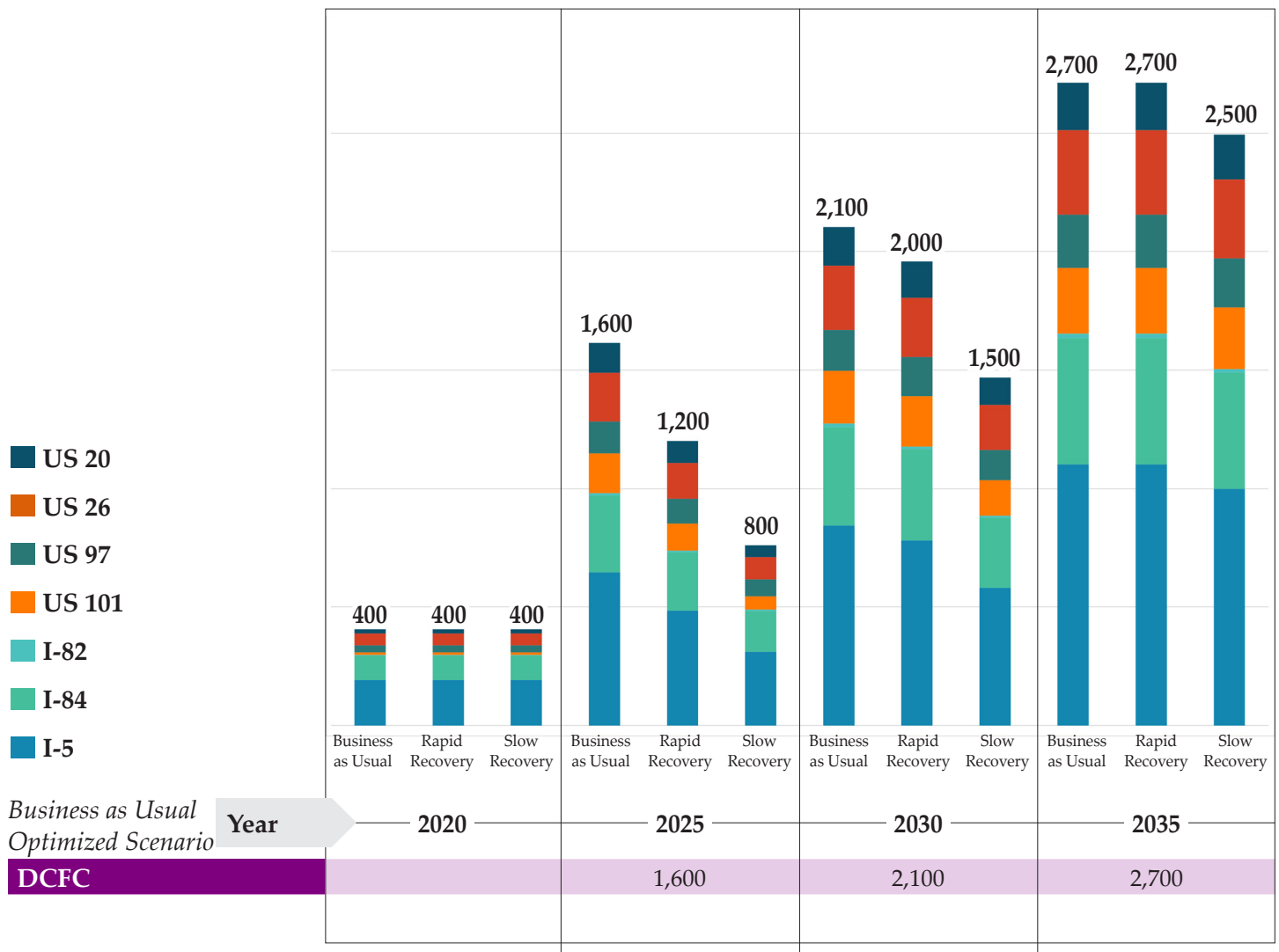


Figure 5. Total Number of Charging Ports for Corridor eLDVs

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Corridor Light-Duty Vehicle (LDV) Charging

The following list identifies some of the key barriers posing challenges to Corridor LDV charging. These barriers, along with the associated policy recommendations presented under “Policy Recommendations,” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Inconsistent fees and/or rates for public charging
- Limited venues that can support power, safety and amenities
- Increased need for Direct Current Fast Charge (DCFC), multi-use medium-duty vehicles (MDVs)/ heavy-duty vehicles (HDVs) and travel destination charging
- Demand charges and low utilization that reduce cost effectiveness
- Confusing and inconsistent user charging experience (payment systems, connectors)
- Uncertainty about charging standards, platforms for MDVs/HDVs

Local Commercial and Industrial Vehicles

Medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs) using internal combustion engines (ICEs) cause significantly more greenhouse gas (GHG) emissions than light-duty vehicles (LDVs), which is another important reason for considering them in the this study. Assuming Senate Bill 1044 LDV goals are met and vehicle manufacturers deliver not only a full range of suitable electric

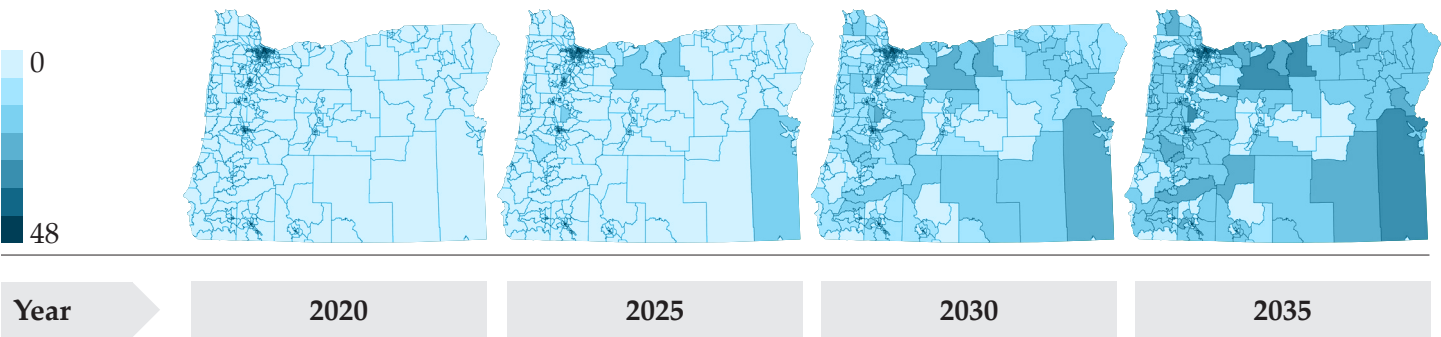
LDVs for all use cases, but also MDVs, there will be a variety of electric vehicles (EVs) with commercial and industrial uses that require charging infrastructure. Charging needs for this use case will depend on the range of EV models that manufacturers bring to market as well as the characteristics of improved battery capabilities and the charging requirements for these vehicles.

Key Takeaways

- Local medium-duty commercial fleet electrification, particularly in urban delivery, is likely to significantly precede the electrification of longer-distance trucking fleets.
- It's expected that only 10% of commercial medium-duty fleet charging in the early years (2020–2025) will be served by public “en route” charging, which leaves a substantial need for 90% of charging to be served at private depots. This will grow to 50% depot and 50% public en route by 2035.
- Prioritize support for the early electrification of commercial fleets, including support for pilots and private depot charging infrastructure on private property. In 2025, commercial fleets will require an estimated 371 public charging ports (350kW) or the equivalent (e.g., 2,597 at 50kW public charging ports) to serve the en route Direct Current Fast Charge (DCFC) charging needs of local commercial medium-duty vehicles (MDVs).

DCFC Charging Ports Needed in Local Commercial and Industrial MDV Use Case

Business as Usual Optimized Scenario



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

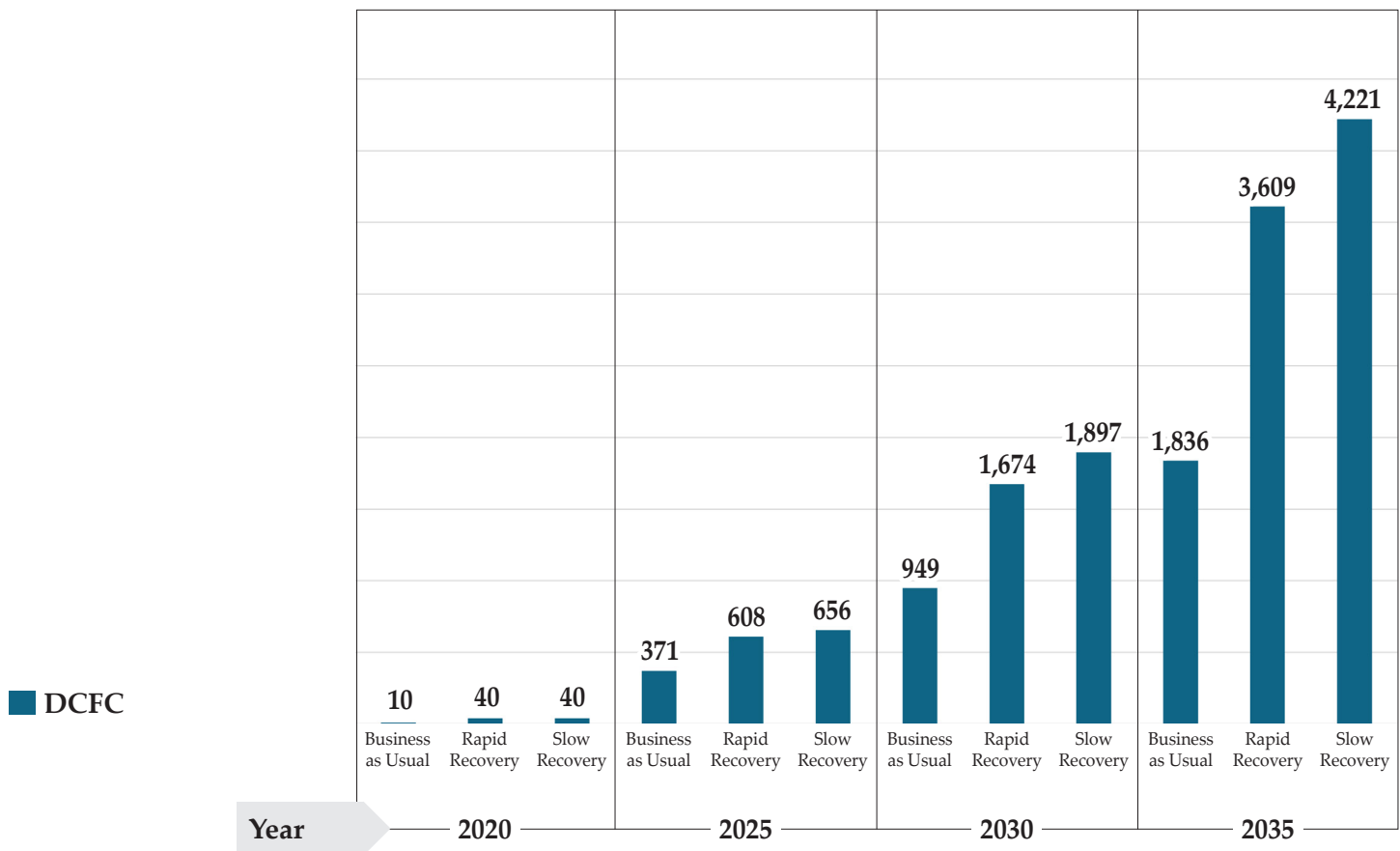


Figure 6. Total Number of Charging Ports for Local Commercial and Industrial eMDVs

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Local Commercial and Industrial Vehicle Charging

The following list identifies some of the key barriers posing challenges to Local Commercial and Industrial Vehicles charging. These barriers, along with the associated policy recommendations presented under “Policy Recommendations,” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Limited EV-focused government planning, programs, policies, and resources
- Economics of installing and operating charging ports (upfront, demand charge costs)
- Need for fleet training on how best to operate and manage electric vehicles charging
- Need for publicly available charging for medium-duty commercial vehicles (MDVs)/ heavy-duty vehicles (HDVs)
- Uncertainty about plug types, compatibility for MDV/HDV public charging

Transit and School Buses

Transit buses are a vehicle type most likely to rapidly electrify, and school buses are likely to begin electrifying quickly as well. Both types of buses are projected to be largely electrified fleetwide by 2035, which could add significant power demands

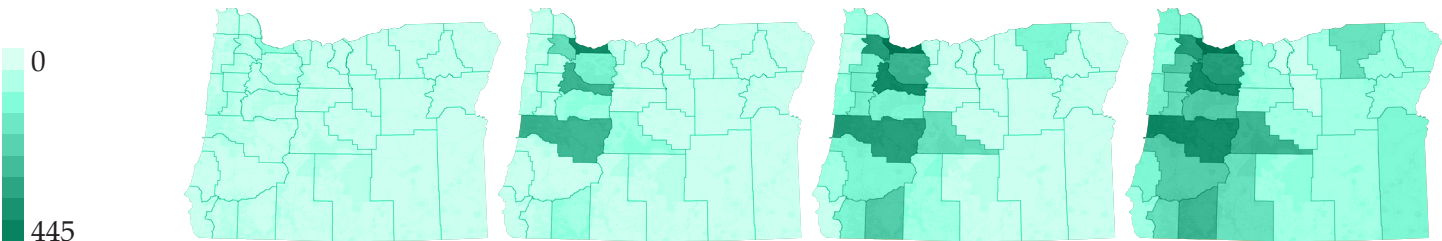
to utility distribution systems, and warrant demand management strategies. Both transit buses and school buses have unique duty cycles, passenger needs, and capabilities that require their charging infrastructure needs to be separately modeled.

Key Takeaways

- By 2035, 75% of the bus market will be electrified and 90% of new sales will be eBuses.
- Three quarters of all transit buses in the state and a vast majority of transit rides are provided by three transit agencies (Tri-County Metropolitan Transportation District of Oregon, serving Portland; Salem Area Mass Transit District, serving Salem; and Lane Transit District, serving Eugene).
- In the short term, expect virtually all charging to be at bus depots: Level 2 charging ports for overnight school bus charging and faster 60kW Direct Current Fast Charge (DCFC) charging ports for transit buses. See the Appendix D for more discussion of the assumptions.
- Partnerships between public transportation agencies, the state, utilities, and others are needed to address total cost of operation and available funds.
- Educational and technical support to bus fleet operators is needed to accelerate the transition.

DCFC Charging Ports Needed in Transit Bus Use Case

Business as Usual Optimized Scenario

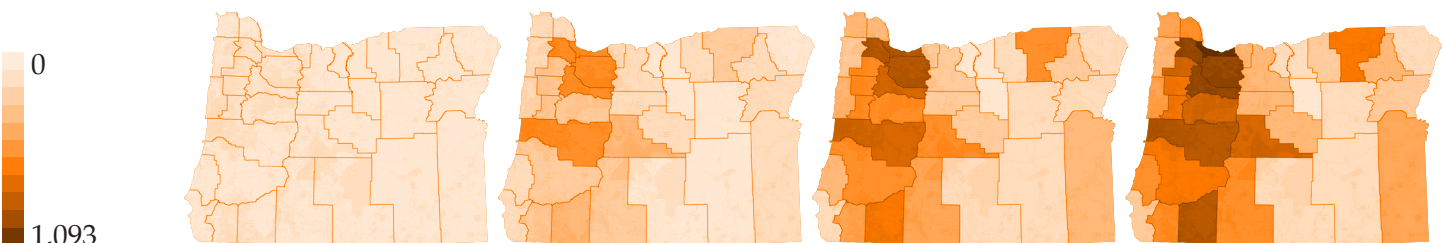


Year	2020	2025	2030	2035
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Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Level 2 Charging Ports Needed in School Bus Use Case

Business as Usual Optimized Scenario



Year	2020	2025	2030	2035
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Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

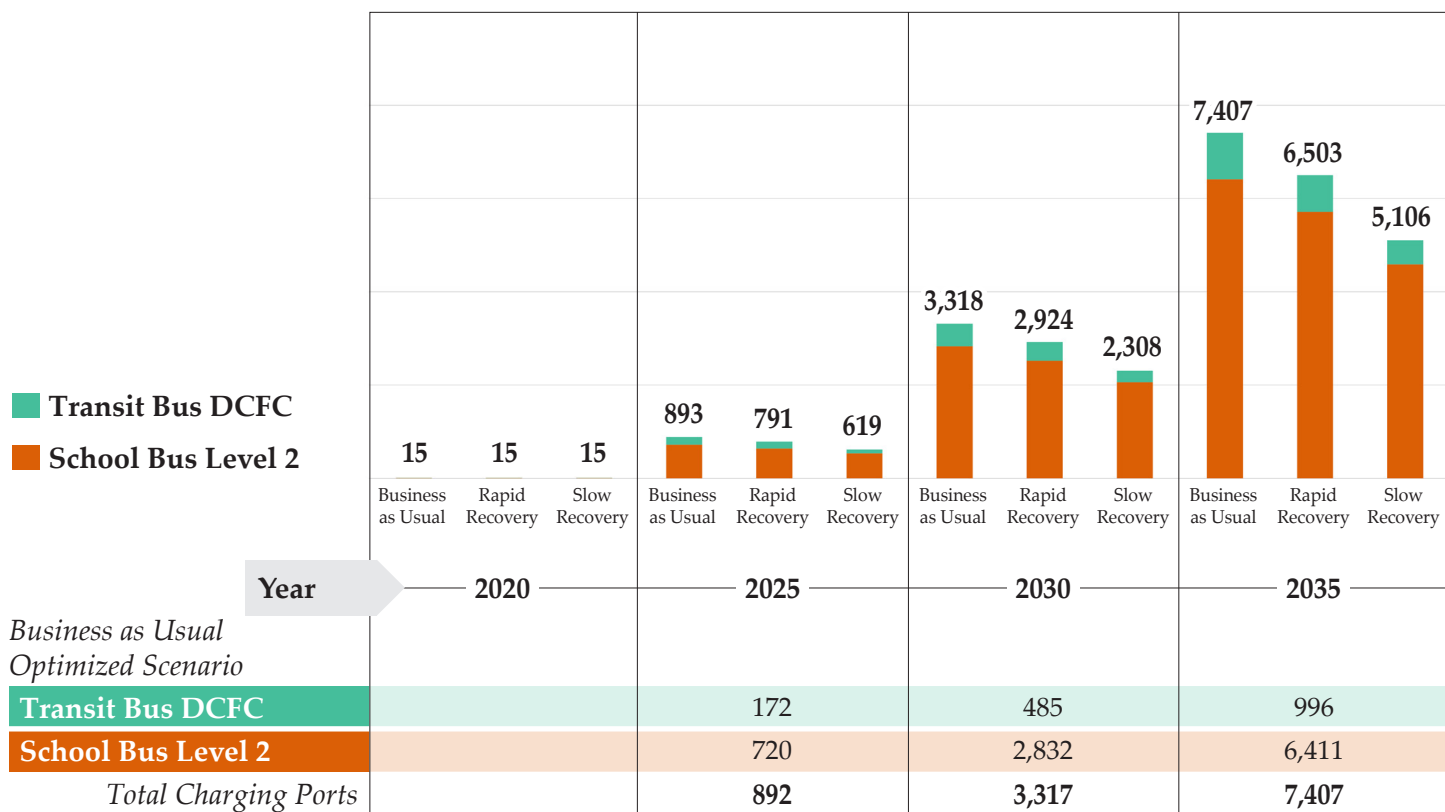


Figure 7. Total Number of Charging Ports for eBuses

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Transit and School Bus Charging

The following list identifies some of the key barriers posing challenges to Transit and School Bus charging. These barriers, along with the associated policy recommendations presented under “Policy Recommendations,” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Economics of installing and operating charging ports (upfront, demand charge costs)
- Need for fleet training on how best to operate and manage electric vehicle charging

Transportation Network Companies (TNCs)

TNCs—also known as ridehailing service providers such as Uber and Lyft—offer a particular set of challenges to electrify their fleets. TNC drivers may live in communities that are distant from the areas where most of the demand is for TNC services. Most TNC drivers visit nearby airports at least once a day, if not many times a day. Full-

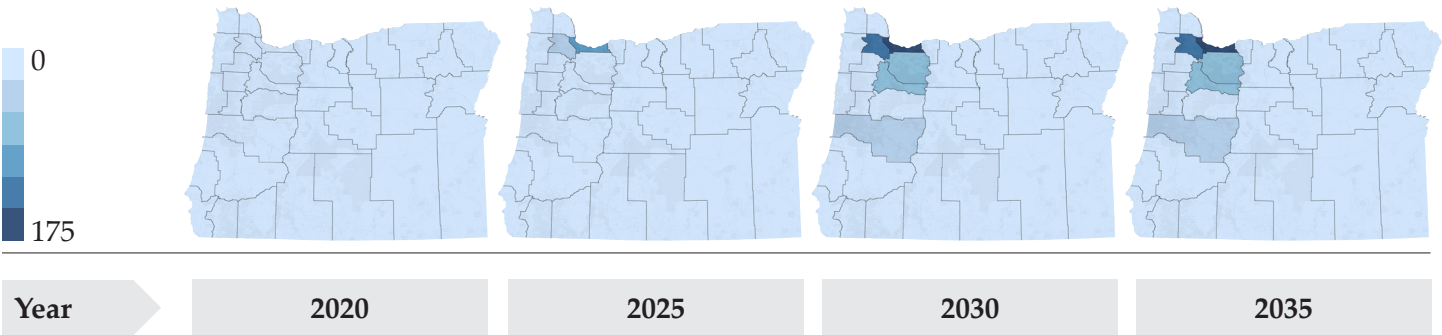
time TNC drivers routinely drive 250–300 miles a day, necessitating conveniently located high-speed charging ports so they can recharge with a minimum of down time. By 2035, it is possible that some of these services will use autonomous vehicles and become the preferred mode of travel for people who may become ex-drivers by 2035.

Key Takeaways

- In 2025, it’s estimated that 9% of TNC charging could be met by leveraging urban and rural LDV charging ports, corridor light-duty vehicle (LDV) charging ports, and the charging ports installed for local commercial and industrial vehicles. By 2035, this could grow to 18% while providing the same level of service. Thus, it’s critical (and advantageous) to consider integrating the needs of TNC charging when planning urban Direct Current Fast Charge (DCFC) charging.
- In 2025, an estimated 22% of TNC drivers will charge solely at home; by 2035, 44% of TNC drivers will charge at home, reflecting increasing deployment of home charging ports over the forecast period. This growing reliance and demand for home charging (generally much less costly than public DCFC)—especially with demand side management capability—should be a near-term priority.

DCFC Charging Ports Needed in the TNC Use Case

Business as Usual Optimized Scenario



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

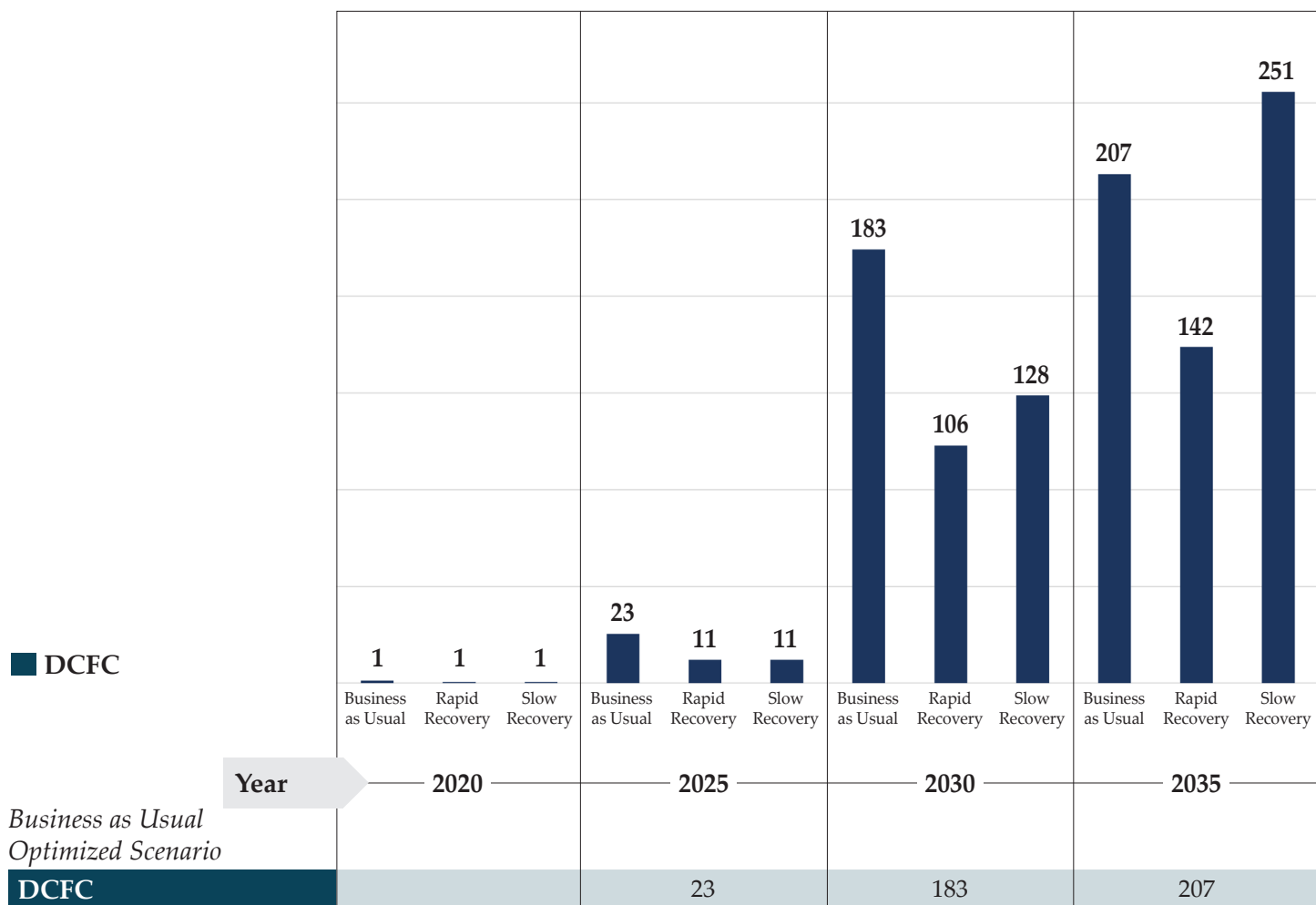


Figure 8. Total Number of Charging Ports for eTNCs

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Transportation Network Company (TNC) Charging

The following list identifies some of the key barriers posing challenges to TNC charging. These barriers, along with the associated policy recommendations presented under “Policy Recommendations” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Inconsistent fees and/or rates for public charging
- Economics of installing and operating charging ports (upfront, demand charge costs)
- Need for Direct Current Fast Charge charging in specific areas of high TNC use, driver’s home

Long-Haul Trucking

Long-haul trucking with Class 8 electric vehicles is still a nascent sector. That said, it is extremely likely that there will be significant numbers of electric trucks on the road over the modeling period, particularly now that the California Air Resources Board has passed a rule requiring most new trucks in the state be zero emission vehicles (ZEVs) by 2035. Oregon has signaled its intention

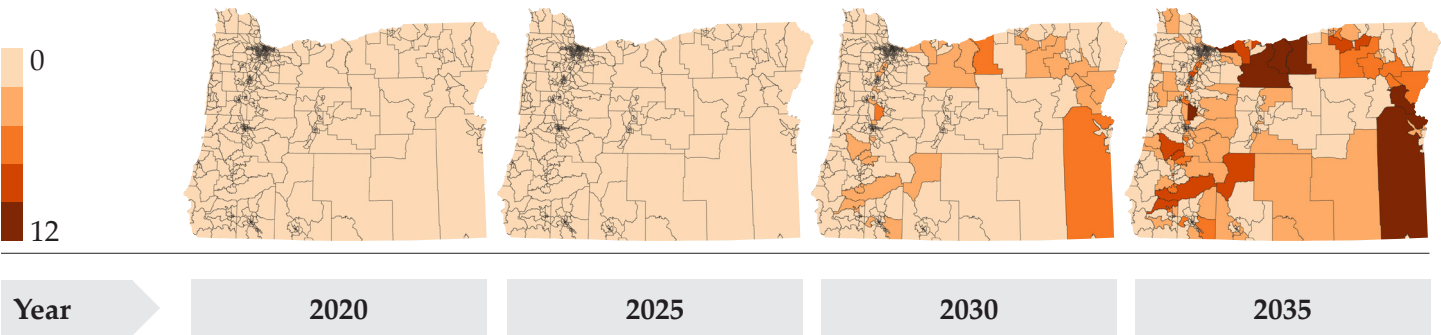
to adopt a similar rule within two years. These vehicles require power supplies that are at least an order of magnitude larger per vehicle than some of today’s light-duty vehicles (LDVs), and have very stringent requirements for duty cycles, dictated by federal rules governing driver working hours and the demands of the supply chains served.

Key Takeaways

- The heat maps indicate significant Direct Current Fast Charge (DCFC) long-haul growth begins to appear after 2025, later than the other sectors.
- In Oregon, one-third of long-haul trucking vehicle miles traveled (VMT) comes from out-of-state, thus the demand for long-haul trucking charging based on trucks from California should form a core part of Oregon’s infrastructure planning strategy.

DCFC Charging Ports Needed in Long-Haul Trucking Use Case

Business as Usual Optimized Scenario



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

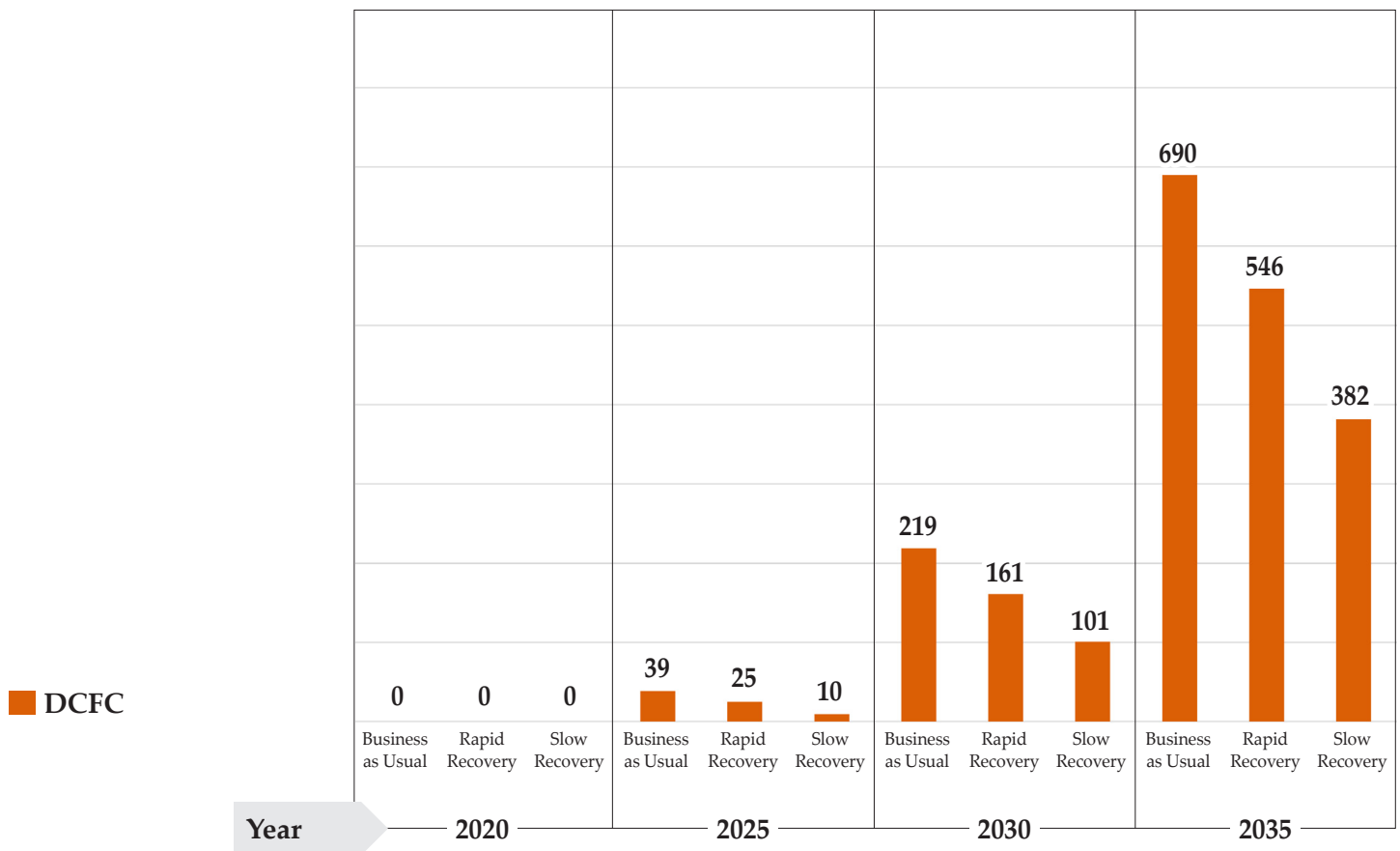


Figure 9. Total Number of Charging Ports for Long-Haul Trucking

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Long-Haul Trucking Charging

The following list identifies some of the key barriers posing challenges to charging for Long-Haul Trucking. These barriers, along with the associated policy recommendations presented under “Policy Recommendations,” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Uncertainty about charging standards, platforms for medium-duty commercial vehicles (MDVs)/ heavy-duty vehicles (HDVs)
- Significant, complex electricity infrastructure upgrades necessary for MDVs/HDVs
- Need for easy-access driver amenities and overnight idling space for public HDVs

Micromobility

Micromobility is a rapidly growing sector, particularly as an adaptation strategy during the pandemic. Micromobility comprises a

suite of electrified personal mobility devices, including bicycles, scooters, skateboards, one-wheels, unicycles, and more.

Key Takeaways

- The study assumes that micromobility will be far more prevalent in urban areas than in rural areas.
- Micromobility is expected to grow from 3% of urban trips in 2020 up to 25% in 2035; in rural areas micromobility is expected to grow more modestly from 0% of trips in 2020 up to 5% in 2035.
- The study assumes that micromobility is served by 110V outlets primarily at home locations, but that broader adoption will require a visible presence of charging opportunities at work locations and at public destinations, including parks, beaches, museums, etc.

Significant growth in micromobility (led largely by Portland’s long-term goal of meeting 25% of commuting trips with bikes) is expected to offset vehicle miles traveled (VMT) in the light-duty vehicle (LDV) sector (more so in the urban LDV case than in the rural LDV case) if micromobility accounts for 25% of urban trips and 5% of rural trips by 2035, 9,400 fewer public charging ports for the LDV sector (workplace, Level 2 public, DCFC) will be needed statewide as shown in **Figure 10**. The analysis of micromobility adoption considers a definition of urban/rural that is based on county, compared to the LDV use cases which used a definition of urban/rural that was census tract specific.

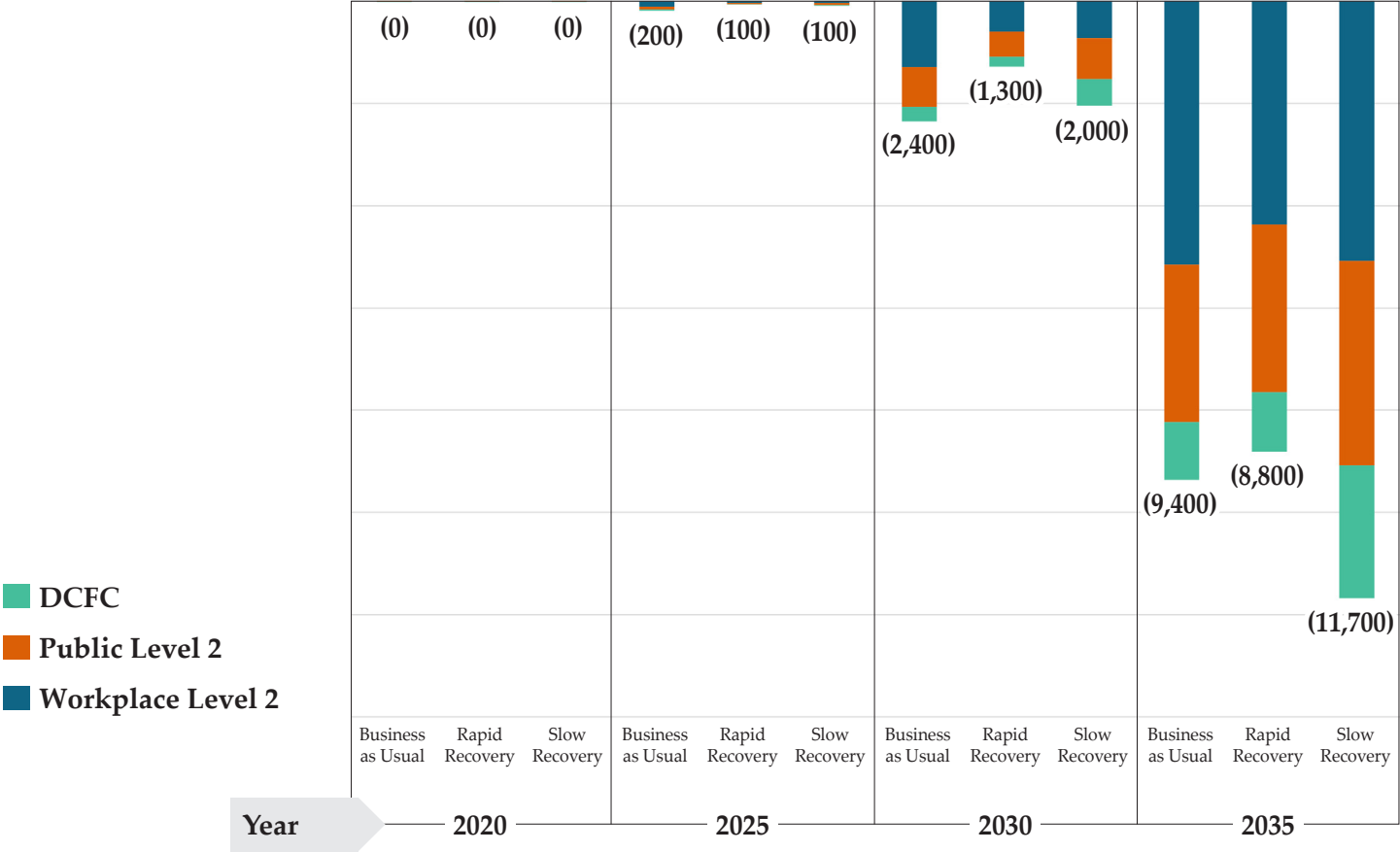


Figure 10. Reduction in Number of Required Charging Ports Due to Micromobility

Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Micromobility Charging

The following list identifies a key infrastructure barrier posing challenges to micromobility charging. This barrier, along with the associated policy recommendations presented under “Policy Recommendations,” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

-
- Limited public venues, access, and payment for public 110 volt charging
-

Disadvantaged Communities

Drivers in disadvantaged communities are more likely to need fast charging stations for two reasons. First, these drivers often live in multi-unit dwellings (MUDs) without dedicated parking where they can access a reliable slow charge overnight. Second, many drivers for transportation network companies (TNCs like Uber and Lyft), live in these communities, and TNC drivers need to be able to charge quickly to maximize their driving time. However, private charging networks often do not prioritize locations

in disadvantaged communities for deployments. Thus, these charging stations may be candidates to be built and operated by utilities or other municipal agencies. Some MUDs may be reasonably anticipated to build overnight charging facilities on site for their residents, and those need to be considered as well.

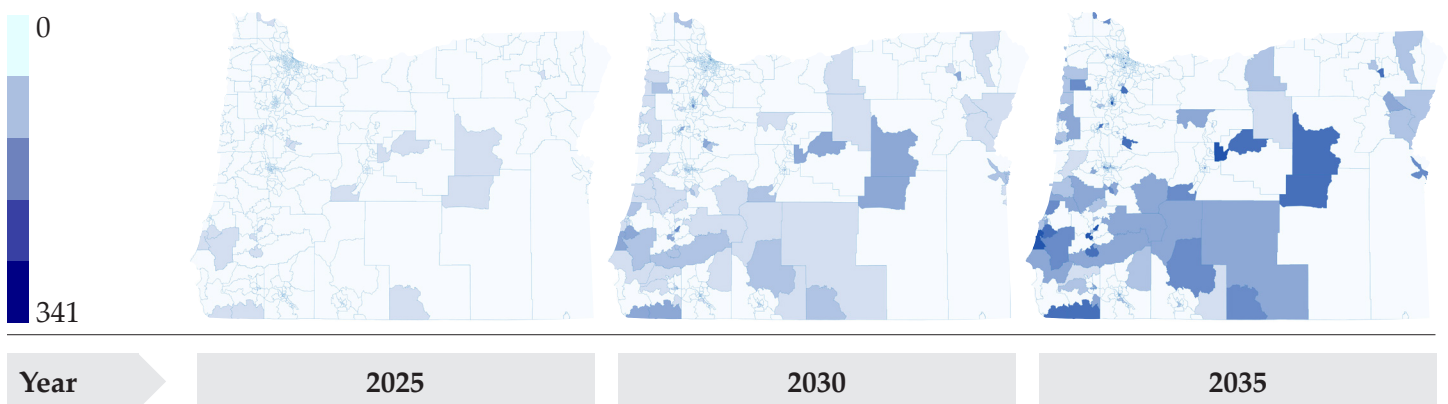
The modeling for disadvantaged communities essentially consists of adjustments to the Urban and Rural use cases.

Key Takeaways

- Analysis shows that vehicle registrations in Oregon are currently 11% lower in disadvantaged communities than non-disadvantaged communities. Because the model allocates charging ports to counties or census tracts based on their share of vehicle registrations, it's inherently biased to allocate fewer charging ports to disadvantaged communities.
- To compensate for this, the number of charging ports in the disadvantaged communities was increased by various factors for each scenario. This helps to compensate for the fact that residents in disadvantaged communities have less access to home charging because many of them live in MUDs. With these adjustments, by 2035 the model results for disadvantaged communities obtains the same number of charging ports per capita as in other non-disadvantaged communities, which levels the playing field and makes EV more accessible.
- As a significant portion (~40%) of TNC trips begin or end in low-income communities, a key priority will be to plan for TNCs as anchor tenants of Direct Current Fast Charge (DCFC) hubs in urban communities (2021 RMI report) to serve both TNC drivers and TNC customers.

Total Urban/Rural LDV DCFC Charging Ports Needed in Disadvantaged Communities (with DAC Adjustment Applied)

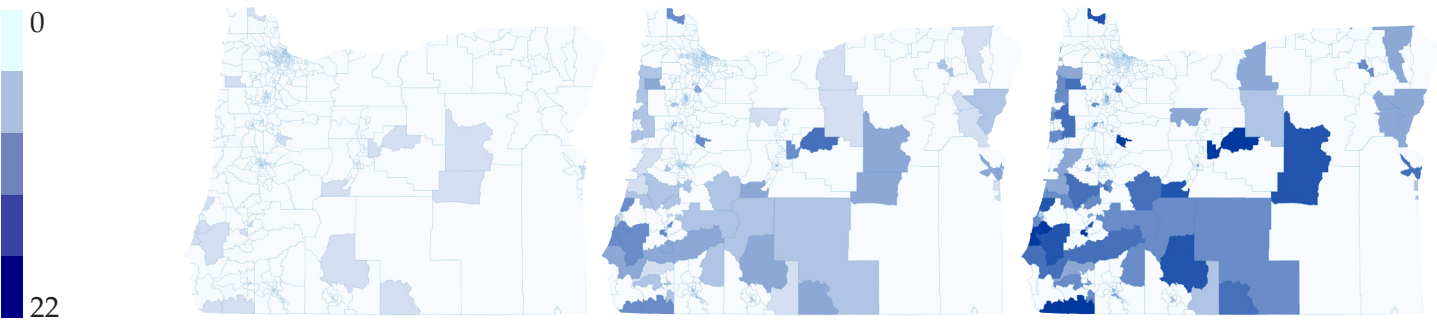
Business as Usual Optimized Scenario



Note: These heatmaps include net additional charging ports. Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Additional DCFC Charging Ports Needed in Disadvantaged Communities (Adjustment Applied for Urban/Rural LDV)

Business as Usual Optimized Scenario



Year	2025	2030	2035
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Note: These charging ports are included in the heatmaps on the previous page. Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

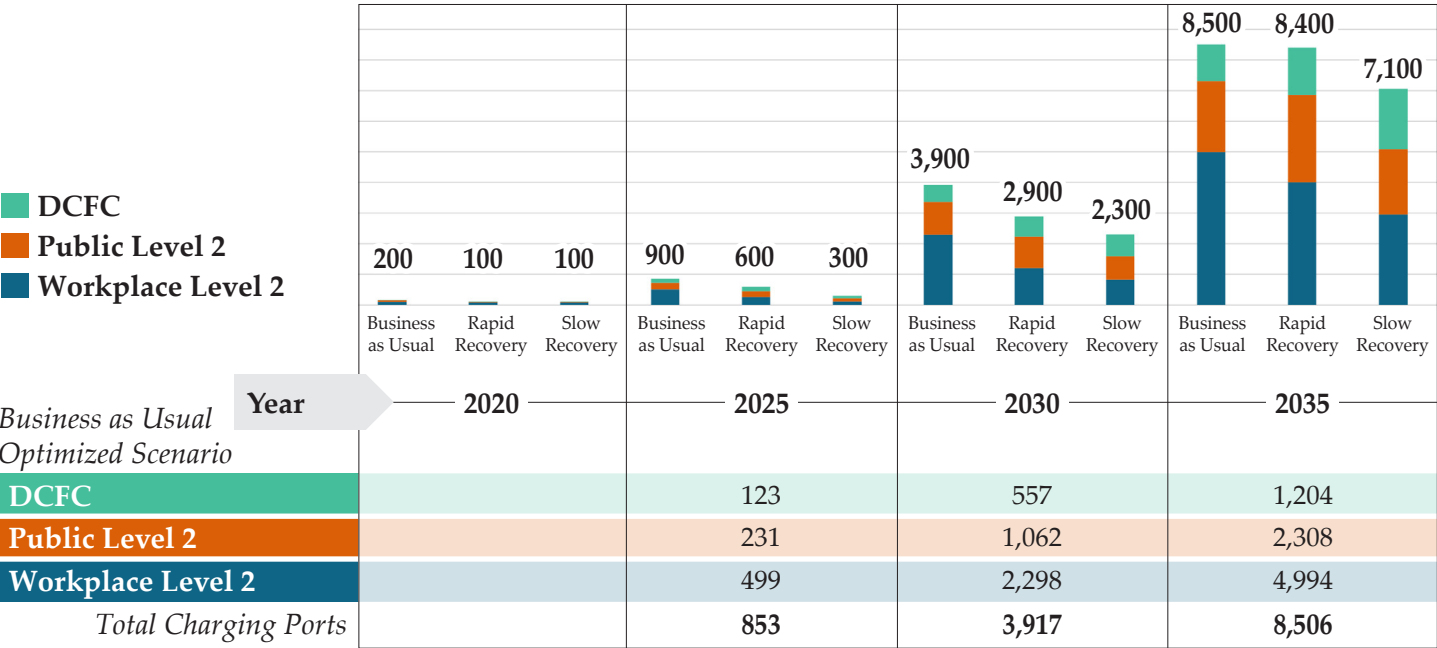


Figure 11. Additional Charging Ports Needed in Disadvantaged Communities (Applied to Urban/Rural LDV)
 Note: Modeling assumes 50,000 electric vehicles in 2020.

Barriers that pose challenges to Disadvantaged Communities Charging

The following list identifies some of the key infrastructure barriers posing challenges to charging in Disadvantaged Communities. These barriers, along with the associated policy recommendations presented under “Policy Recommendations,” will be considered in the development of the infrastructure deployment strategy that will follow the Transportation Electrification Infrastructure Needs Analysis study.

- Inconsistent fees and/or rates for public charging
- Limited multi-unit dwelling and workplace charging
- Limited electric vehicle focused government planning, programs, policies, and resources
- Demand charges and low utilization that reduce cost effectiveness
- Need for Direct Current Fast Charge (DCFC) charging in areas of high transportation network company use, driver’s homes
- Economics of installing and operating charging ports (upfront, demand charge costs)

4. Stakeholder Listening Sessions

The project team held twelve virtual listening sessions in January and February to gather stakeholders' perspectives on issues related to transportation electrification, including charging infrastructure and electric vehicle (EV) adoption in Oregon. See Appendix C for a list of all listening session topics, number of participants, and meeting dates. While the listening session participants provided a broad spectrum of input related to the goals of this study, there were five key themes that were shared across all or most of the listening sessions:



Upfront Costs

Individuals, agencies, municipalities, and businesses must make a financial investment to adopt EVs. The costs associated with purchasing the vehicles, electrical upgrades, and charging ports can be a barrier to adoption. For individuals who can charge at home on an existing outlet, savings may come immediately through more affordable lease terms and lower fuel costs. For others, like property managers or those who manage electric fleets, cost expended for electrical infrastructure upgrades and charging ports may not have a positive return on investment in the foreseeable future. Incentives for vehicle and charging port purchases and infrastructure upgrades play an important role in making EV adoption financially feasible. Incentives directed toward lower-income communities are also important to cultivate and promote.



Charging at Multi-Unit Dwellings

Participants at every listening session stressed widespread adoption of EV is linked to providing at-home charging to residents of multi-unit dwellings (MUDs). Residents need to experience the benefits of convenient, reliable, and affordable charging to spur adoption. Landlords and property owners of current developments face high infrastructure installation costs with limited options to recoup their investments, and community Direct Current Fast Charge hubs may offer an alternative charging opportunity. Building codes addressing new development will help EV-readiness over time, but retrofitting existing buildings remains a challenge. Access to workplace charging will continue to be important to EV drivers who live in MUDs without at-home charging. Some participants emphasized workplace charging should not be considered the ultimate solution.



Public Charging Network

A functional statewide public charging network combined with well-defined, visible charging signage will create awareness of charging locations, make longer trips possible, help combat range anxiety, and accelerate EV adoption. Participants raised the need to expand public charging options across the state. In urban areas, drivers often experience queues. Additional charging ports are needed at convenient locations like grocery stores and outlying areas where people recreate. The distance between charging stations in rural areas makes traveling between communities challenging. Corridor and off-corridor charging options will make driving EV for both personal and business use viable.



Public Charging User Experience

Creating a more positive and equitable user experience at public charging stations is important to many EV users. Ideally, charging stations are:

- Well maintained and reliable; the importance cannot be overemphasized of robust maintenance combined with quick repair times within a sustainable and well-organized maintenance-and-repair program.
- Safe and well-lit
- Interoperable and open access
- Located with other services, like bathrooms
- Following a code of conduct to avoid cars parked longer than needed
- Accepting credit cards to charge rather than relying solely on proprietary cards or smartphones apps
- Charging on a per kWh basis, as older vehicles charge more slowly



Availability of Vehicles and Equipment

Transit agencies, school districts, farmers, and freight operators are unable to exclusively adopt electric vehicles (EVs) now due to lack of or limited supply. When stock is readily available (many new vehicles are being piloted), these industries will have infrastructure costs, fleet vehicle costs, and charging logistics to consider before making the decision to go electric. However, participants in these industries did see beneficial applications for EVs and equipment, starting on a smaller scale.

In addition to the overall key themes, **Table 3** highlights key takeaways from each individual listening session.

Table 3. Key Takeaway Messages from Listening Sessions

EV Drivers and Advocates	<ul style="list-style-type: none"> • <i>Address range anxiety</i> by installing clearer signage and engaging in greater public education. • Implement a <i>standardized charging/user experience</i> so that all users, regardless of EV type, will have the same experience while charging.
Transit Agencies and Providers	<ul style="list-style-type: none"> • There is a <i>lack of equipment</i> available for transit agencies. • The equipment and infrastructure that are currently available come at <i>high upfront costs</i>, so making initial investments is challenging.
EV Service Providers	<ul style="list-style-type: none"> • <i>Streamline permitting processes</i> so that charging ports can be installed more expeditiously. • It is difficult to install charging ports at multi-unit dwellings (MUDs).
Micromobility Company Representatives	<ul style="list-style-type: none"> • <i>Safe road conditions</i> are vital to micromobility adoption, so policies supporting road safety should be developed in conjunction with EV infrastructure. • People need <i>secure parking and storage</i> options for Micromobility vehicles like eBikes.
Rural Representatives	<ul style="list-style-type: none"> • EV need to be able to <i>travel long distances</i> to be useful for rural environments where trips generally require greater distances than urban trips. • There are <i>not many EV trucks and Sport Utility Vehicles</i> available, which are used more heavily in rural environments.
Workplace Charging Venues	<ul style="list-style-type: none"> • Keeping up with charging demand is challenging, but <i>future need is uncertain</i> due to current work-at-home situations. • Many employees <i>use charging ports longer than needed</i>, thus precluding other employees from using the charging ports.

Transportation Networking Companies

- There are frequently *issues at charging stations*, such as broken charging ports, faulty card readers, and queues.
- *More charging ports are needed where people gather*, such as retail, grocery stores, or recreation activities.

Freight/Delivery Representatives

- *Charging times and power capacity are challenging* for larger delivery vehicles, so electrified routes are generally kept to smaller more urban routes.
- The equipment and infrastructure that are currently available come at *high upfront costs*, so making investments becomes challenging.

Historically Underserved Community Representatives

- Charging is not accessible for multi-unit dwelling (MUD) residents.
- Many communities would benefit from a *better understanding* of electric vehicle (EV) cost savings, incentives, and climate benefits.

Developers, MUD Owners, Property Managers

- Retrofitting buildings with EV charging infrastructure is generally *quite expensive*, as is installing new charging infrastructure.
- *Developers need EV-ready incentives* to make EV infrastructure installation financially feasible.

Farming/ Ranching Representatives

- EVs and farming equipment need to be *reliable* and have a *short charge time*.
- It is *expensive to install charging infrastructure*, partly due to the necessity of running electrical power to rural locations.

Original Equipment Manufacturers and EV Dealers

- Incentives and rebates are vital to increasing EV adoption.
- *Address range anxiety* by installing clearer signage, engaging in greater public education, and equipping salespeople with proper knowledge about EV ranges.

5. Policy Recommendations

Vision

In order to meet Oregon’s goals for electric vehicle (EV) adoption through 2035, expansive development of an EV fueling infrastructure is needed to provide Oregonians with confidence that EV charging is as ubiquitous and convenient as fueling with gasoline.

Six goals critical to the achievement of this vision were identified through this study to meet the directives of Senate Bill 1044 and to aid in reducing greenhouse gas emissions. Recommended policies to support each goal are proposed below. To frame what’s needed next, EV charging infrastructure implementation priorities and approaches are highlighted in the subsequent chapter. A much more detailed assessment of the policy recommendations is contained in Appendix E of this report.

Overall Infrastructure Goals

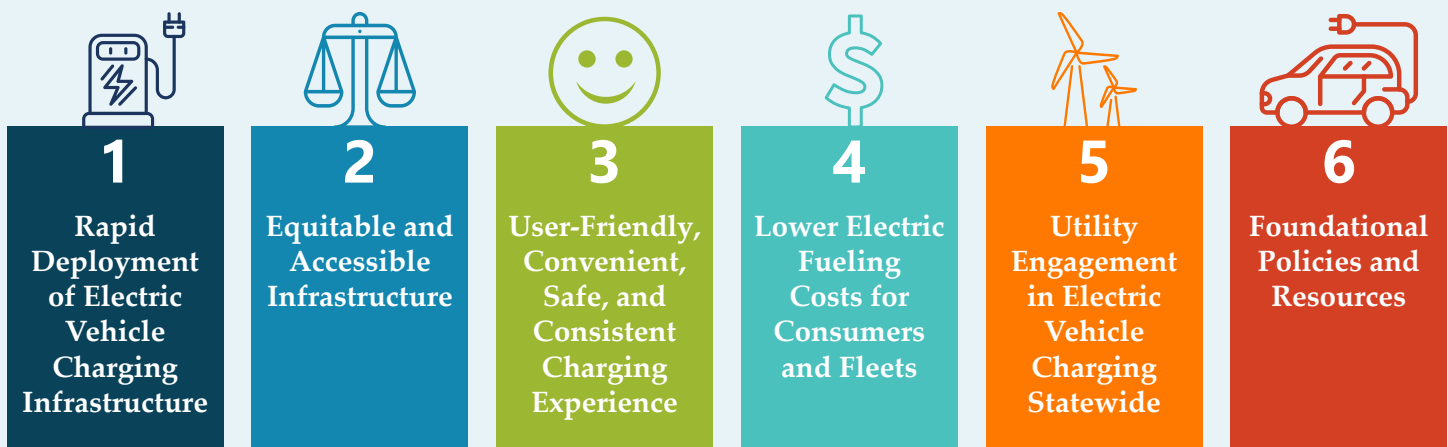


Figure 12. Overall Infrastructure Goals

Recommended Policies and Initiatives to Accomplish Infrastructure Goals

1

Support rapid deployment of EV charging infrastructure in homes, along travel corridors, at work and fleet depots, at travel destinations, and in multi-unit dwellings.

- Leveraging TEINA findings, develop a Statewide Zero Emission Vehicle (ZEV) Charging Infrastructure Deployment Strategy (2–5 year horizon) that establishes near-term implementation actions and priorities to meet the state’s EV goals.
 - *Prioritize deployment actions by the ability to enable increased ZEV adoption (e.g., high residential density, near major employers, public transit access, rural and underserved communities)*
 - *Identify leads for priority actions and develop processes to ensure that those leads (e.g., state agencies, utilities, local jurisdictions, non-governmental organizations, private sector entities, other stakeholders) will implement those actions.*

2



Ensure electric vehicles (EV) charging infrastructure is equitable and accessible to all Oregonians (including all communities, income levels, and geographic locations).

- Adopt measures—using state-sponsored grants, low/no interest financing, Clean Fuels Programs funding, utility guidance and utility investment—to increase *EV charging investments in low-income, black, indigenous, and people of color (BIPOC), rural, and disadvantaged communities.*
- *Set standards to guide EV charging investments defining “EV Charging Deserts” with geographic, emissions exposure, and other metrics to determine low-income, BIPOC, rural, and disadvantaged communities and needs.*
- *For medium- and heavy-duty uses, charging infrastructure that is funded by public/private partnerships should be prioritized in highly polluted areas like ports, railroads, depots, and other industry that disproportionately affect the health of low-income and BIPOC communities.*
- *Investigate ways to coordinate and ensure charging access and affordability for those eligible for the Charge Ahead rebate.*
- *Lead by example and deploy electric vehicle service equipment (EVSE) at all state-owned properties, including state buildings and offices and state parks.*
- *Collaborate with federal agencies administering federally-owned lands in Oregon (e.g., national parks, national forests, interstate rest areas) to deploy EVSE.*

3



Ensure the public charging experience is user-friendly, convenient, safe, and consistent.

- *Lead a public process to identify EV charging needs and standards to create a more consistent EV charging experience; address all items of consistency, including transparency in rates, multiple payment methods, open access, roaming, interoperability, reliability, redundancy (i.e., multiple charging ports per station), resiliency, Americans with Disabilities Act (ADA) compliance, and safety/lighting. Build upon standards proposed by the Western Governors Association’s EV Roadmap Initiative, Regional Electric Vehicle (REV) West, Pacific Coast Collaborative, Northeast States for Coordinated Air Use Management (NESCAUM), Georgetown Climate Center, and others.*
- *Engage with national, regional, and other multi-state actors, as well as private sector charging providers, to harmonize the EV charging experience. Leverage Oregon Governor Kate Brown’s Western Governors Association EV Roadmap Initiative, and efforts of regional stakeholders.*
- *Require infrastructure development to meet certain standards for user experience, including interoperability and reporting requirements, in order to qualify for incentive funding.*
- *Ensure consistent signage and labeling for EV fueling.*



Ensure that electric vehicles (EV) charging offers all consumers and fleets the benefit of lower electric fueling costs.

- *Establish a working group of utilities, electric vehicle service providers (EVSP), and other stakeholders, led by ODOT, Oregon Department of Energy (ODOE), and Public Utility Commission (PUC) to identify the barriers and opportunities to address the cost of EV charging, including rate design, demand charges, and costs driven by the installation process; ensure these efforts consider rural communities, and the price-sensitivities of low-income communities and multi-unit dwelling (MUD) residents who may have no access to home charging and must rely on public charging. Explore best practices, convening experts to share insights, particularly highlighting successful strategies for consumer owned utilities (COUs).*
- *Consider incentives that drive infrastructure development (both Level 2 and Direct Current Fast Charge) across the entire transportation landscape, including at single-family homes, MUDs, public and private fleets, businesses, and public charging locations. Such incentives might include grants, low/no interest financing, tax credits, Clean Fuels Programs opportunities, on-bill financing, and non-financial incentives such as parking privileges, High Occupancy Vehicle (HOV) lane access, curbside loading/unloading privileges, and green zones.*
- *Explore tax breaks to incentivize employers to install charging infrastructure at workplaces, in turn encouraging employers to incentivize EV drivers.*
- *Encourage appropriate rates for distinct EV charging activities depending on charging profiles, charging port types, and user groups. Utilities should be encouraged to explore, create, and pilot specific rate schedules for distinct types of EV charging. Convene work groups to identify and share best practices, with particular focus on COU success strategies.*
- *Pursue and leverage federal funding to implement EV charging deployment priorities.*
- *Encourage Transportation Network Companies (TNCs, also known as ridehailing service providers such as Uber and Lyft) to partner with local jurisdictions to identify and help fund charging stations in communities where a high percentage of TNC trips begin and end.*
- *Ensure the installation of EV charging is efficient, cost-effective, and speedy. Consider convening a work group to identify rapid pathways to accomplish goals.*
 - *Ensure all state, local, and utility processes involved in EVSE installations (e.g., site planning, permitting, and utility interconnections) are streamlined to reduce overall installation time and costs.*
 - *Measure, track, and report on best practices.*
- *Streamline EVSE permitting at local jurisdictions.*
 - *Develop and adopt streamlined permitting guidelines for EVSE installation permitting, with target timeframes.*
 - *Develop and adopt “model” expedited and streamlined EVSE installation permitting processes (including website resources offering online electronic applications, checklists, and other information).*



Ensure utilities are positioned for rapid expansion of electric vehicles (EV) charging statewide.

- *Utilities must plan for and supply the increasing demand for electricity as a transportation fuel and support the charging needs of electric light-duty, medium-duty, and heavy-duty vehicles and electric micromobility.*
- *Utilities need to accelerate make-ready* investments for light-duty vehicle (LDV) public charging (including urban hubs, corridors, workplaces, multi-unit dwellings, fleet depots, destinations) and plan to initiate make-ready investments for medium-duty vehicle and heavy-duty vehicle commercial applications, including transit and school buses. The provision of funding is key, and resources/mechanisms will need to be identified to support and fairly cover the costs of make-ready investments. In certain low-income housing or identified underserved communities, utilities could explore the own-and-operate model to support deployment of electric vehicle service equipment at such communities. Support and incentives from the Public Utility Commission and Consumer Owned Utilities' (COUs) governing bodies will be necessary.*
- *Explore and develop programs that support EV adoption while supporting utility grid management needs, reducing greenhouse gas emissions from the transportation sector, and balancing charging demand needs.*
- *Assess best practices and innovative load management strategies, including rate designs and smart/managed charging, and consider how best to facilitate efficient and effective grid integration to create Level 2 and Direct Current Fast Charge (DCFC) rate schedules to support downward pressure on rates for all utility customers and mitigate the impact of demand charges to the deployment of charging. Share best practices of rate design principles and broader load management strategies, including smart/managed charging that have been met with success among COUs and investor-owned utilities (IOUs).*
- *Convene a workgroup of utilities and key stakeholders (including Travel Oregon, among others) to identify optimal locations with available grid capacity for DCFC stations. Plan for and assess the potential charging impacts on future grid capacity and other grid integration issues over the next 15 years when substantial EV adoption is underway. Develop recommendations to increase overall system resiliency as EV adoption takes off, potentially through battery storage or load management, and help mitigate the effects of power outages. Consider other options to avoid need for expansive transmission line installations, such as micro hubs for onsite renewable generation.*

* Make-ready means the pre-wiring of electrical infrastructure at a specific location to facilitate easy and cost-efficient future installation of electric vehicle service equipment such as charging ports.






Develop foundational policies and provide resources to support citizens, businesses, local governments, tribes, and communities to build and benefit from a zero emission vehicle (ZEV) future.

- *Ensure educational and technical resources are available* to support all stakeholder groups seeking to pursue electric vehicle (EV) charging and installation.
 - Develop and fund a *statewide educational and technical assistance program* for charging.
 - Create fact sheets, technical resource documents, and website content, with separate, targeted materials for unique audiences.
 - Create a proactive outreach program that is comprehensive and hands-on, that targets high priority/underserved markets. Such outreach efforts should be coordinated through local community-based organizations and should be conducted in multiple languages.
 - Serve as an initial point of contact, referring individuals to utilities and other resources.
- *Ensure EV charging is available in new residential and commercial buildings, existing buildings are upgraded, and parking sites become increasingly EV ready. Adopt EV-ready building codes and parking ordinances, enabling local jurisdictions to adopt more stringent reach codes.*
 - Building Codes Division to establish EV charging requirements for new structures and make recommendations about how to phase in requirements to retrofit existing buildings.
 - Provide model code language to local jurisdictions (urban and rural) to set more stringent and enforceable building EV requirements and EV parking ordinances.
 - Ensure effective enforcement mechanisms.
 - In keeping with equity principles, investigate ways to protect renters to avoid displacement or major rent increases due to installation costs in multi-unit dwellings (MUDs) and other dwellings.
- *Grow a skilled, local workforce to build and maintain EV infrastructure and expand economic opportunities stemming from EV infrastructure expansion, leveraging community colleges to ensure broad geographic coverage.*
 - Assess best practices in EV workforce development to guide investments.
 - Focus investment in community college programs and other venues to build needed workforce skills.
- *Encourage public charging options for electric micromobility*
 - Encourage addition of 110-volt outlets at public charging stations, especially if charging sites are supported via public funding.
 - Encourage State and local jurisdictions to collaborate to develop public-private partnerships, advancing opportunities for charging for electric bikes and scooters.
 - Study how best to encourage eBike, eScooter, e-commerce trike adoption, exploring charging in the context of a broader evaluation of actions needed to support adoption of these electric mobility modes. Aspects to be considered include micromobility infrastructure needs, more industry standardization, commercial technology solutions for payment, connections to mass transit, and better bicycle infrastructure overall (e.g., more and better bike lanes).
- *Align transportation electrification goals with broader regional transportation conversations, including Road User Charges and tolling/congestion pricing.*

The change needed in electric vehicle (EV) charging infrastructure will require the broad mix of policies outlined previously. Of particular note are several near-term policies that are deemed priority initiatives. **Table 4** shows the near-term policy priorities and the corresponding goals they play a part in achieving.

Table 4. Near-term Priority Policy Initiatives

Near-Term Policy Priorities

Zero emission vehicle infrastructure deployment strategy—2 to 5 year focus, including opportunities for targeted state investment		1 	
Target equity in charging	<ul style="list-style-type: none">Ensure charging access for those eligible for Charge Ahead rebate.Incentivize workplace charging at employers, emphasizing women and minority-owned businesses and similar groups.Incentivize investment in charging deserts in rural areas.	2 	4 
		5 	
		Update Oregon’s building codes and parking ordinances to make them electric vehicle ready	
		6 	
Develop and fund a statewide educational and technical assistance program for charging	<ul style="list-style-type: none">Develop fact sheets, technical resource documents, and website content.Create proactive outreach program that is comprehensive, is hands-on, and targets high priority markets.Serve as an initial point of contact, referring individuals to utilities and other resources.Provide guidelines and model processes for streamlining permitting.	3 	4 
		6 	
		Lead by example: install charging at state buildings and offices for employees and visitors	
		2 	5 

6. Infrastructure Deployment

Priority Actions

The Transportation Electrification Infrastructure Needs Analysis (TEINA) study can help illuminate where to focus electric vehicle (EV) charging deployment efforts. An overall near-term priority focus is needed to deploy EV charging across a broad spectrum of light-duty EV use cases: corridor light-duty vehicle (LDV) charging (including rural and key destinations), rural LDV charging, and urban LDV (including transportation network company (TNC)/ridehailing and multi-unit dwelling (MUD) charging). Additionally, support for fleet conversion to EV is needed by encouraging private fleet depot charging for light-duty fleets, pilots of medium-duty/local commercial and delivery vehicle private depot charging, and pilots of long-haul truck private depot charging. Planning and support for longer-term public charging needs for medium- and heavy-duty zero emissions vehicle (ZEV) public charging should be initiated.

Key Infrastructure Implementation Priorities



Figure 13. Key Infrastructure Implementation Priorities

Building on the policy recommendations above, this chapter outlines a number of key infrastructure implementation priorities that are needed to create a robust statewide charging network. Infrastructure deployment strategies are aggregated into broad use cases, based on those identified in this report.

Corridor Long Distance Travel

- Expand Oregon's corridor Direct Current Fast Charge (DCFC) network across all federal and state highways, considering rural and black, indigenous, and people of color (BIPOC) access to long-distance travel.
 - Phase 1 short-term (as practicable): Ensure 25–50-mile maximum distance between charging stations: I-5, I-84, I-82, US 20, US 26, US 97, US 101; Ensure 75–100-mile maximum distance between charging stations along remaining rural highways
 - Phase 2 mid-term (as practicable): Ensure 15–25-mile maximum distance between charging stations: I-5, I-84, I-82, US 20, US 26, US 97, US 101
- Ensure 25–50-mile maximum distance between charging stations along remaining rural highways. Ideally *locate stations within 0.2 miles of highway exit* (maximum 0.5 miles).
- Prioritize the *near-term improvement of the West Coast Electric Highway*, encouraging installation of highly redundant Society of Automotive Engineers (SAE) Combined Charging System (CCS) DCFC charging ports for LDVs at each site (minimum 2 DCFC, goal of 4–8 DCFC).
- Consider *charging port redundancy* (minimum 4–8 charging ports) at corridor stations to allow multiple EVs to charge simultaneously and anticipate charging port failures. See examples of Electrify America and Tesla highway charging stations.

Rural

- Address rural charging deserts by prioritizing rural corridor, tourism, destination, and public Level 2 charging.
 - *Prioritize Direct Current Fast Charge (DCFC) on key corridors supporting tourism and key destinations as well as travel between rural communities.*
 - *Address low utilization and how to overcome this business case challenge (convening workgroups with utilities, electric vehicle service providers, state agencies, and other stakeholders to address rates, demand charges, Make Readies, other strategies).*
 - *Refine definition of charging deserts to guide priority installations.*
- *Focus on Level 2 charging ports within rural communities and at key tourism sites/destinations:*
 - *Promote ‘charge and shop’ in support of local tourism.*
 - *Locate public charging ports on federal, state, county, and city property, with existing power capacity to accommodate charging infrastructure. In particular, focus on low-income, black, indigenous, and people of color (BIPOC), and disadvantaged communities and equitable access to public charging by residents of multi-unit dwellings (MUDs).*

Urban

- *Consider shared Level 1 and Level 2 community charging sites that provide a more affordable, longer duration charging alternative for residents without access to reliable, overnight charging at home, including MUD residents (as well as micromobility needs). Consider school and church parking lots, urban plazas, and other day-use parking lots with overnight capability as well as right-of-way charging on utility poles and street lights.*
- *Locate Level 2 and DCFC public charging ports on federal, state, county, and city property with existing power capacity to accommodate charging infrastructure; consider in particular low-income, BIPOC, and disadvantaged communities.*
- *Prioritize workplace charging at large and women/minority-owned employers; develop and distribute technical guidance for employers; consider tax incentives and other incentives to encourage employer investment.*
- *Address urban charging deserts by prioritizing urban DCFC hubs that serve multiple use cases, including transportation network companies (TNCs)/ridehailing, MUDs, and other residents without access to reliable, overnight charging; co-locate multiple charging ports together to promote awareness and ensure better availability, redundancy, and reliability of the charging sites. Study and develop incentives for utility/Clean Fuels Programs/state programs:*
 - *Plan for TNCs as anchor tenants of DCFC hubs: TNCs can drive much-needed station utilization and significantly improve station economics. Furthermore, a significant portion of TNC trips begin or end in low-income communities, so locate DCFC directly within these communities (and consider proximity to high-density MUDs).*
 - *Consider and address the cost to charge at a public DCFC charging site vs. charging at home (assuming residential electricity rates) for the residents of MUDs or low-income, BIPOC, and disadvantaged communities. Options for addressing costs may include special utility rates or programs as well as pre-paid cards funded by public/non-governmental organizations with state oversight.*

Fleet Charging: Private and Public Light-, Medium- and Heavy-Duty Vehicles

Light-Duty Vehicles (LDV) Fleet

- Empower public and private LDV fleets to accelerate adoption of zero emission vehicles (ZEVs) by incentivizing private fleet charging, via utility programs, Clean Fuels Programs, and other mechanisms.
 - Ensure that charging meets standards for interoperability and user experience.
 - Encourage opportunities, where feasible, for fleet charging to be accessible on weekends or during daytime for workplace charging, community charging access.
 - Encourage opportunities for redundancy, resiliency, and renewable power.

Local Commercial & Delivery

- In the short-term, study and develop incentives/utility programs/Clean Fuels Programs that focus on larger urban fleets with shorter route distances; expect much of this charging will be at private fleet depots; survey public and private fleets to determine the need for public charging in the near-, mid-, and long-term.
- In the short-term, begin to plan for shorter-range regional medium/heavy-duty trucking between major urban centers along key corridors via working groups with utilities, state agencies; survey private fleets to determine the need for public charging, and time frame.

Transit and School Buses

- In the short-term, expect much of this charging will be at fleet depots; study and develop incentives/utility programs/Clean Fuels Programs that support transit and school bus transition to electric vehicles; survey public transit and school fleets to determine the need, if any, for public charging in the near-, mid-, and long-term.
- Broker partnerships between public transportation agencies and utilities (and potentially electric vehicle service providers) to enable planning and installation of transit fleet electrification with particular attention on total cost of operation, available funds, and the need for resiliency in the event of power outages.
- Produce and provide educational and technical resources to transit and school bus fleet operators to ensure they have access to the information required to electrify their fleets, install charging infrastructure and leverage available financial incentives (federal, state, local, utility).

Long-Haul Trucking

- In the short term, continue to watch the market evolve and work with manufacturers and freight carriers on timelines for long-haul trucking deployment, particularly between major urban centers.
- In the mid-term, study and develop incentives/utility programs/Clean Fuels Programs to initiate a medium/heavy-duty West Coast Electric Highway on major corridors to build out fast-charge stations along Oregon's Interstate Highways (I-5 and I-84).

Transportation Electrification Infrastructure Needs Analysis (TEINA) clearly identifies Oregon's urgent need to increase electric vehicle (EV) charging infrastructure to meet the state's goals for extraordinary growth in EVs, which in turn will create an unprecedented shift in the way Oregonians fuel their vehicles. TEINA sets out EV infrastructure goals to provide Oregonians with confidence that EV charging will be as ubiquitous and convenient as fueling with gasoline, and recommends policies to achieve these goals.

Looking forward, TEINA points to priorities for both for policies and implementation actions to achieve these goals. A series of next steps is needed, to turn the recommendations identified by TEINA into realizable results.

To implement TEINA's findings, a statewide zero emission vehicle (ZEV) charging infrastructure deployment strategy is being developed, with a 2 – 5 year focus, to fine tune and prioritize specific infrastructure actions needed to accelerate ZEV adoption – incorporating concerns for equity and geographic balance. In addition, three areas of study will be pursued: (1) A supplemental inquiry into the refueling needs of hydrogen fuel cell ZEVs; (2) An assessment of the barriers impeding accelerated adoption of electric micromobility (e.g., eBikes, eScooters, eTrikes), including concerns beyond charging infrastructure; and (3) Addendums to TEINA to facilitate stakeholder planning. These next steps will keep Oregon charging ahead, preparing for an electric future.

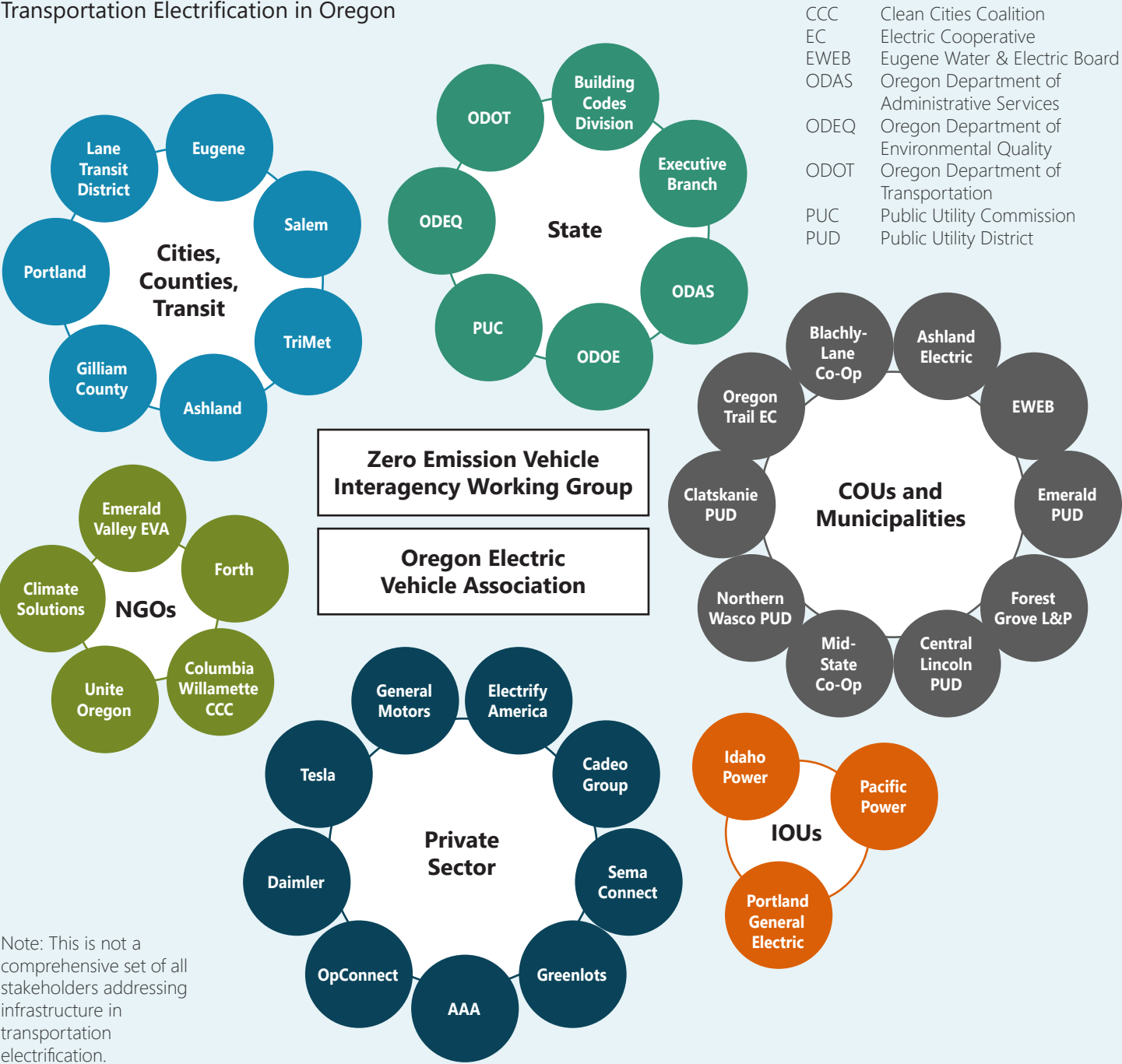
Conclusion

Exponential growth of EV charging ports throughout Oregon is needed to meet the ZEV adoption goals set forth in Senate Bill 1044. There is no magic wand to solve the challenges of Oregon's electric transportation infrastructure deployment. This effort will require a vigorous set of targeted approaches for different vehicle use cases in different parts of the state. It will also require flexibility to adapt to a potentially changing marketplace over time. For example, EVs enable storage and vehicle-to-grid solutions that may prove increasingly important as the use of variable renewable energy sources grow on the grid. There may be a much quicker (or slower) move to higher speed charging rates that drive changes to the hardware installed above the ground at charging sites. Or there could be new trends in individual car ownership that may pave the way for the increasing use of transit, TNCs, and micromobility. These trends can impact future scenarios in ways the Business as Usual scenario does not today comprehend.

In addition, this isn't a challenge that can be overcome by a single actor or entity. As the saying goes, it will take a village to achieve the deployment goals outlined in this report.

As shown in **Figure 14**, a broad spectrum of key stakeholders will be needed to make Oregon EV ready, including state agencies, the Oregon legislature, utilities and their governing bodies, private sector charging providers, tribal governments, and other advocates and interested parties across the state. All relevant stakeholders will need to take focused actions and coordinate with each other to build a robust statewide charging network and rapidly deploy the EV charging infrastructure needed to push transportation in Oregon toward an electric and zero emission future.

Figure 14. Key Stakeholders Engaged in Transportation Electrification in Oregon



Policy Recommendations and Barriers Addressed by Use Case

In the portion of the report addressing modeling results, each use case is identified, and barriers that impede progress toward electric vehicle (EV) charging infrastructure for that use case are identified. To better frame how the six infrastructure goals and their recommended policies address barriers encountered in each use case, summary matrices are presented. The matrices on the following pages are grouped according to each of the six infrastructure goals. Under the heading of each infrastructure goal are listed all previously-identified barriers (and associated use cases) constituting existing challenges, which are then linked to the relevant policy recommendations that are expected to have a positive effect in addressing these challenges. The matrices omit the first infrastructure goal, (Support rapid deployment of EV charging infrastructure in homes, along travel corridors, at work and fleet depots, at travel destinations, and in multi-unit dwellings) which calls for the development of a zero emission vehicle (ZEV) Infrastructure Deployment Strategy, as this deployment strategy is intended to address virtually all the barriers for all use cases, at some level.



Ensure electric vehicles (EV) charging infrastructure is equitable and accessible to all Oregonians (including all communities, income levels, and geographic locations).

Barriers	Use Case(s) Impacted	Recommended Policies				
		Adopt measures to increase EV charging investments in low-income, BIPOC, rural, and other disadvantaged communities	Set standards to guide EV charging investments to address charging deserts	Investigate ways to coordinate and ensure charging access and affordability for those eligible for Charge Ahead rebate	Lead by example and deploy EV charging ports at all state-owned properties	Collaborate with federal agencies administering federally owned lands in Oregon to deploy EV charging ports
Cost of electric power upgrades and charging port installation (conduit, trenching)	Urban Light-Duty Vehicles (LDVs), Disadvantaged Communities (DAC)	●	●			●
Inconsistent fees and/or rates for public charging	Urban LDV, Rural LDV, Corridor LDV, Transportation Network Companies (TNCs), DAC	●	●			
Limited multi-unit dwelling and workplace charging	Urban LDV, DAC	●	●	●	●	
Limited EV-focused government planning, programs, policies, and resources	Urban LDV, Rural LDV, Local Commercial and Industrial, DAC	●	●	●	●	●
Limited access to venues that can support power, safety and amenities	Rural LDV, Corridor LDV, DAC	●	●		●	●
Increased need for Direct Current Fast Charge (DCFC), multi-use medium-duty vehicles and heavy-duty vehicles (MDVs/HDVs) & travel destination charging	Rural LDV, Corridor LDV	●	●			●



Recommended Policies

Barriers	Use Case(s) Impacted	Recommended Policies				
		Adopt measures to increase EV charging investments in low-income, BIPOC, rural, and other disadvantaged communities	Set standards to guide EV charging investments to address charging deserts	Investigate ways to coordinate and ensure charging access and affordability for those eligible for Charge Ahead rebate	Lead by example and deploy EV charging ports at all state-owned properties	Collaborate with federal agencies administering federally owned lands in Oregon to deploy EV charging ports
Demand charges and low utilization that reduce cost effectiveness	Rural LDV, Corridor LDV, DAC	●		●		
Confusing and inconsistent user charging experience (payment systems, connectors)	Corridor LDV	●	●			
Economics of installing and operating charging ports (upfront, demand charge costs)	Local Commercial and Industrial, Transit and School Buses, TNCs, DAC	●	●			
Need for fleet training on how best to operate and manage EV charging	Local Commercial and Industrial, Transit and School Buses				●	
Need for publicly available charging for MDV/HDV EVs	Local Commercial and Industrial, Long-Haul Trucking		●			
Uncertainty re plug-types, compatibility for MDV/HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking		●			
Need for DCFC charging in areas of high TNC use, driver's homes	TNCs, DAC	●	●			



Recommended Policies

Barriers	Use Case(s) Impacted	Recommended Policies				
		Adopt measures to increase EV charging investments in low-income, BIPOC, rural, and other disadvantaged communities	Set standards to guide EV charging investments to address charging deserts	Investigate ways to coordinate and ensure charging access and affordability for those eligible for Charge Ahead rebate	Lead by example and deploy EV charging ports at all state-owned properties	Collaborate with federal agencies administering federally owned lands in Oregon to deploy EV charging ports
Uncertainty about charging standards, platforms for MDVs/HDVs	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking		●			
Significant, complex electricity infrastructure upgrades for MDV/HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking	●	●			
Need for easy-access driver amenities and overnight idling space for public HDVs	Long-Haul Trucking		●			
Limited public venues/access/payment for 100 volt charging	Micromobility	●	●			



Ensure the public charging experience is user-friendly, convenient, safe, and consistent.

Barriers	Use Case(s) Impacted	Recommended Policies			
		Lead a public process to identify EV charging port needs and standards to create a more consistent EV charging experience	Engage with national, regional, other multi-state actors to harmonize the EV charging experience	Require all incentive funding for infrastructure development to meet certain standards for user experience.	Ensure consistent signage and labeling for EV fueling
Inconsistent fees and/or rates for public charging	Light-Duty Vehicles (LDV) Urban, Rural LDV, Corridor LDV, Transportation Network Companies (TNCs), Disadvantaged Communities (DAC)	●	●	●	
Limited multi-unit dwelling and workplace charging	Urban LDV, DAC	●			
Limited electric vehicle (EV) focused government planning, programs, policies, and resources	Urban LDV, Rural LDV, Local Commercial and Industrial, DAC	●	●	●	●
Limited access to venues that can support power, safety and amenities	Rural LDV, Corridor LDV, DAC	●		●	
Increased need for Direct Current Fast Charge (DCFC), multi-use medium-duty vehicles and heavy-duty vehicles (MDVs/HDVs) & travel destination charging	Rural LDV, Corridor LDV	●			●



Recommended Policies

Barriers	Use Case(s) Impacted	Recommended Policies			
		Lead a public process to identify EV charging port needs and standards to create a more consistent EV charging experience	Engage with national, regional, other multi-state actors to harmonize the EV charging experience	Require all incentive funding for infrastructure development to meet certain standards for user experience.	Ensure consistent signage and labeling for EV fueling
Demand charges and low utilization that reduce cost effectiveness	Rural LDV, Corridor LDV, DAC	●	●		
Confusing and inconsistent user charging experience (payment systems, connectors)	Corridor LDV	●	●	●	
Need for publicly available charging for MDV/HDV EVs	Local Commercial and Industrial, Long-Haul Trucking	●	●		●
Uncertainty re plug-types, compatibility for MDV/HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking	●	●	●	
Need for DCFC charging in areas of high TNC use, driver's homes	TNCs, DAC	●	●		●
Uncertainty about charging standards, platforms for MDVs/HDVs	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking	●	●	●	
Need for easy-access driver amenities and overnight idling space for public HDVs	Long-Haul Trucking	●	●	●	●
Limited public venues/access/payment for 100 volt charging	Micromobility	●	●	●	



Ensure that electric vehicles (EV) charging offers all consumers and fleets the benefit of lower electric fueling costs.

Barriers	Use Case(s) Impacted	Recommended Policies						
		Establish a working group to identify the barriers and opportunities to address the cost of EV charging ports	Consider incentives that drive infrastructure development across the entire transportation landscape	Explore tax breaks to incentivize employers to install charging infrastructure at workplaces	Encourage appropriate rates for distinct EV charging profiles, charging ports types, and user groups	Pursue and leverage federal funding to implement EV charging deployment priorities	Ensure the installation of EV charging is efficient, cost-effective, and speedy.	Streamline permitting at local jurisdictions
Cost of electric power upgrades and charging port installation (conduit, trenching)	Urban Light-Duty Vehicles (LDVs), Disadvantaged Communities (DAC)		●	●				
Inconsistent fees and/or rates for public charging	Urban LDV, Rural LDV, Corridor LDV, Transportation Network Companies (TNCs), DAC	●			●			
Limited multi-unit dwelling and workplace charging	LDV Urban, DAC		●	●	●		●	●
Limited EV-focused government planning, programs, policies, and resources	Urban LDV, Rural LDV, Local Commercial and Industrial, DAC	●	●	●	●	●	●	●
Limited access to venues that can support power, safety and amenities	Rural LDV, Corridor LDV, DAC		●	●				



Barriers	Use Case(s) Impacted	Recommended Policies						
		Establish a working group to identify the barriers and opportunities to address the cost of EV charging ports	Consider incentives that drive infrastructure development across the entire transportation landscape	Explore tax breaks to incentivize employers to install charging infrastructure at workplaces	Encourage appropriate rates for distinct EV charging profiles, charging ports types, and user groups	Pursue and leverage federal funding to implement EV charging deployment priorities	Ensure the installation of EV charging is efficient, cost-effective, and speedy.	Streamline permitting at local jurisdictions
Increased need for Direct Current Fast Charge (DCFC), multi-use medium-duty vehicles and heavy-duty vehicles (MDVs/ HDVs) & travel destination charging	Rural LDV, Corridor LDV		●	●			●	●
Demand charges and low utilization that reduce cost effectiveness	Rural LDV, Corridor LDV, DAC	●			●			
Confusing and inconsistent user charging experience (payment systems, connectors)	Corridor LDV	●						
Economics of installing and operating charging ports (upfront, demand charge costs)	Local Commercial and Industrial, Transit and School Buses, TNCs, DAC		●	●				
Need for publicly available charging for MDV/ HDV EVs	Local Commercial and Industrial, Long-Haul Trucking		●	●			●	●



Barriers	Use Case(s) Impacted	Recommended Policies						
		Establish a working group to identify the barriers and opportunities to address the cost of EV charging ports	Consider incentives that drive infrastructure development across the entire transportation landscape	Explore tax breaks to incentivize employers to install charging infrastructure at workplaces	Encourage appropriate rates for distinct EV charging profiles, charging ports types, and user groups	Pursue and leverage federal funding to implement EV charging deployment priorities	Ensure the installation of EV charging is efficient, cost-effective, and speedy.	Streamline permitting at local jurisdictions
Uncertainty re plug-types, compatibility for MDV/ HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking							
Need for DCFC charging in areas of high TNC use, driver's homes	TNCs, DAC		●				●	●
Significant, complex electricity infrastructure upgrades for MDVs/ HDVs public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking						●	●
Need for easy-access driver amenities and overnight idling space for public HDVs	Long-Haul Trucking		●					
Limited public venues/ access/ payment for 100 volt charging	Micromobility		●	●		●		



Ensure utilities are positioned for rapid expansion of electric vehicles (EV) charging statewide.

Barriers	Use Case(s) Impacted	Recommended Policies			
		Accelerate utility make-ready investments for LDV public charging	Assess innovative rate designs and consider DCFC rate schedules that mitigate the impact of demand charges on deployment	Convene a workgroup to identify optimal locations with available grid capacity for DCFC stations and assess impacts on future grid capacity	Explore and develop programs that support EV adoption while supporting utility grid management needs, reduce greenhouse gas emissions, and balance demand charging needs
Cost of electric power upgrades and charging port installation (conduit, trenching)	Urban Light-Duty Vehicles (LDVs), Disadvantaged Communities (DAC)	●		●	●
Inconsistent fees and/or rates for public charging	Urban LDV, Rural LDV, Corridor LDV, Transportation Network Companies (TNCs), DAC		●		●
Limited multi-unit dwelling and workplace charging	Urban LDV, DAC	●		●	●
Limited EV-focused government planning, programs, policies, and resources	Urban LDV, Rural LDV, Local Commercial and Industrial, DAC			●	●
Limited access to venues that can support power, safety and amenities	Rural LDV, Corridor LDV, DAC	●		●	●
Increased need for Direct Current Fast Charge (DCFC), multi-use medium-duty vehicles and heavy-duty vehicles (MDVs/HDVs) & travel destination charging	Rural LDV, Corridor LDV	●	●	●	●



Recommended Policies

Barriers	Use Case(s) Impacted	Accelerate utility make-ready investments for LDV public charging	Assess innovative rate designs and consider DCFC rate schedules that mitigate the impact of demand charges on deployment	Convene a workgroup to identify optimal locations with available grid capacity for DCFC stations and assess impacts on future grid capacity	Explore and develop programs that support EV adoption while supporting utility grid management needs, reduce greenhouse gas emissions, and balance demand charging needs
Demand charges and low utilization that reduce cost effectiveness	Rural LDV, Corridor LDV, DAC	●	●		●
Confusing and inconsistent user charging experience (payment systems, connectors)	Corridor LDV				●
Economics of installing and operating charging ports (upfront, demand charge costs)	Local Commercial and Industrial, Transit and School Buses, TNCs, DAC	●	●	●	●
Need for fleet training on how best to operate and manage EV charging	Local Commercial and Industrial, Transit and School Buses				●
Need for publicly available charging for MDV/HDV EVs	Local Commercial and Industrial, Long- Haul Trucking	●		●	●
Uncertainty re plug-types, compatibility for MDV/HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking				●
Need for DCFC charging in areas of high TNC use, driver's homes	TNCs, DAC	●		●	●



		Recommended Policies			
Barriers	Use Case(s) Impacted	Accelerate utility make-ready investments for LDV public charging	Assess innovative rate designs and consider DCFC rate schedules that mitigate the impact of demand charges on deployment	Convene a workgroup to identify optimal locations with available grid capacity for DCFC stations and assess impacts on future grid capacity	Explore and develop programs that support EV adoption while supporting utility grid management needs, reduce greenhouse gas emissions, and balance demand charging needs
Uncertainty about charging standards, platforms for MDVs/HDVs	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking				●
Significant, complex electricity infrastructure upgrades for MDV/HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking	●			●
Need for easy-access driver amenities and overnight idling space for public HDVs	Long-Haul Trucking			●	●
Limited public venues/access/payment for 100 volt charging	Micromobility			●	



Develop foundational policies and provide resources to support citizens, businesses, local governments, tribes, and communities to build and benefit from a zero emission vehicle (ZEV) future.

Barriers	Use Case(s) Impacted	Recommended Policies			
		Ensure educational and technical resources are available to support all stakeholder groups seeking to pursue EV charging and installation	Ensure EV charging is available in new residential and commercial buildings, existing buildings are upgraded, and parking sites become increasingly EV-ready.	Grow a skilled, local workforce to build and maintain EV infrastructure and expand economic opportunities stemming from EV infrastructure expansion, leveraging community colleges to ensure broad geographic coverage	Encourage public charging options for electric micromobility
Cost of electric power upgrades and charging port installation (conduit, trenching)	Urban Light-Duty Vehicles (LDVs), Disadvantaged Communities (DAC)		●	●	
Limited multi-unit dwelling and workplace charging	Urban LDV, DAC	●	●	●	
Limited electric vehicles (EV) focused government planning, programs, policies, and resources	Urban LDV, Rural LDV, Local Commercial and Industrial, DAC	●	●		
Limited access to venues that can support power, safety and amenities	Rural LDV, Corridor LDV, DAC		●	●	
Increased need for Direct Current Fast Charge (DCFC), multi-use medium-duty vehicles and heavy-duty vehicles (MDVs/HDVs) & travel destination charging	Rural LDV, Corridor LDV	●	●	●	



Recommended Policies

Barriers	Use Case(s) Impacted	Recommended Policies			
		Ensure educational and technical resources are available to support all stakeholder groups seeking to pursue EV charging and installation	Ensure EV charging is available in new residential and commercial buildings, existing buildings are upgraded, and parking sites become increasingly EV-ready.	Grow a skilled, local workforce to build and maintain EV infrastructure and expand economic opportunities stemming from EV infrastructure expansion, leveraging community colleges to ensure broad geographic coverage	Encourage public charging options for electric micromobility
Confusing and inconsistent user charging experience (payment systems, connectors)	Corridor LDV	●		●	
Economics of installing and operating charging ports (upfront, demand charge costs)	Local Commercial and Industrial, Transit and School Buses, Transportation Network Companies (TNCs), DAC		●	●	
Need for fleet training on how best to operate and manage EV charging	Local Commercial and Industrial, Transit and School Buses	●		●	
Need for publicly available charging for MDV/HDV EVs	Local Commercial and Industrial, Long-Haul Trucking	●	●	●	
Uncertainty re plug-types, compatibility for MDV/HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking	●		●	
Need for DCFC charging in areas of high TNC use, driver's homes	TNCs, DAC		●	●	



		Recommended Policies			
Barriers	Use Case(s) Impacted	Ensure educational and technical resources are available to support all stakeholder groups seeking to pursue EV charging and installation	Ensure EV charging is available in new residential and commercial buildings, existing buildings are upgraded, and parking sites become increasingly EV-ready.	Grow a skilled, local workforce to build and maintain EV infrastructure and expand economic opportunities stemming from EV infrastructure expansion, leveraging community colleges to ensure broad geographic coverage	Encourage public charging options for electric micromobility
Uncertainty about charging standards, platforms for MDVs/HDV	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking	●		●	
Significant, complex electricity infrastructure upgrades for MDV/HDV public charging	Local Commercial and Industrial, Transit and School Buses, Long-Haul Trucking		●	●	
Need for easy-access driver amenities and overnight idling space for public HDVs	Long-Haul Trucking		●		
Limited public venues/access/payment for 100 volt charging	Micromobility				●

Appendices

The Appendices are ordered in general accordance with the manner in which the study was completed:

Appendix A: Existing Conditions

Provides a summary of the project's initial efforts to review, inventory, and understand existing geographic and zero emission vehicle (ZEV) charging port distribution characteristics in Oregon. It was important to complete this work early in the project so that base conditions could be established for use in subsequent analyses.

Appendix B: Literature Review

Summarizes the results of a nationwide literature review that was conducted in parallel with the assessment of existing conditions in Oregon. The literature review provided important insights into how Oregon's situation compares with other efforts across the country. In addition to this nationwide overview, the literature review included a more in-depth review of activities within three states (Colorado, New York, and California) that are providing national leadership and could serve as models for Oregon to emulate.

Appendix C: Stakeholder Engagement

Summarizes important project input regarding insights and activities of the many different entities that are actively engaged in promoting the planning, design, and implementation of transportation electrification infrastructure in Oregon. Input was received from several sources, including (1) a 17-member Advisory Group that reviewed and critiqued activities and findings throughout the project duration; (2) 12 separate Listening Sessions, each of which focused on a particular use case; and (3) public comments, which were received throughout the life of the project via a website and as part of four public meetings.

Appendix D: Infrastructure Needs Assessment

Describes the modeling analysis and findings regarding infrastructure needs in Oregon. Three bookend scenarios were used to establish a range of expected infrastructure needs across three target dates (2025, 2030, and 2035) for each of nine use cases as well as an optimized condition that considered all use cases in combination.

Appendix E: Policy Recommendations

Summarizes the study's policy recommendations, which result from the information obtained during the study and summarized in the previous chapters. The recommendations (in the body of the report) are presented in several different ways to enhance their usability and understanding, including (1) in the context of overall infrastructure goals, (2) in accordance with infrastructure priorities and approach by major use case, and (3) as a list of top five recommended priorities to support Oregon's future plan for a ZEV charging infrastructure development strategy.



Appendix A: Existing Conditions

About this Appendix

Appendix A contains results from a review of existing conditions that the project team performed in December 2020. RMI staff are the primary authors of Appendix A. The findings presented in Appendix A rely upon publicly available information about the assessment of existing charging infrastructure needs in Oregon, such as Oregon Department of Transportation databases, Oregon utility filings, local news, press releases, and multiple initiative proposals.

This Existing Conditions assessment considers efforts within Oregon, whereas Appendix B (“Literature Review”) focuses on efforts outside of Oregon.

There are two main parts to Appendix A:

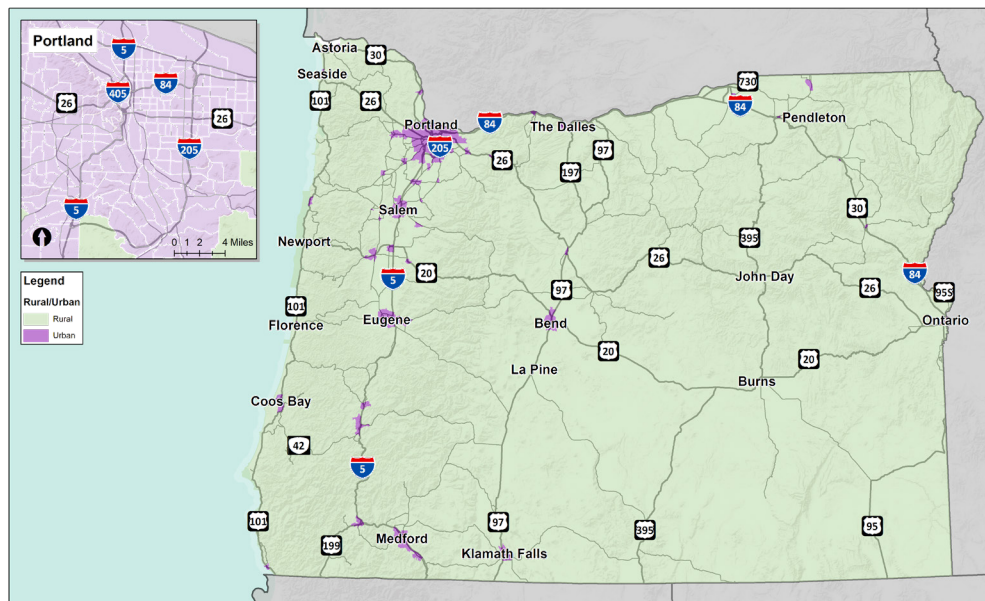
- Section 1: Geographic characteristics and zero emission vehicle charging ports distributions.
- Section 2: Research relevant to each of the nine use cases that are modeled for the Transportation Electrification Infrastructure Needs Analysis project.

Section 1: Geographic Characteristics and ZEV/Charging Ports Distributions

Key Takeaways from Figure A1

- Urban Populations:
 - ~2.9M residents (70%)
 - ~2.4M light duty vehicles (64%)
- Rural Populations:
 - ~1.3M residents (30%)
 - ~1.4M light duty vehicles (36%)

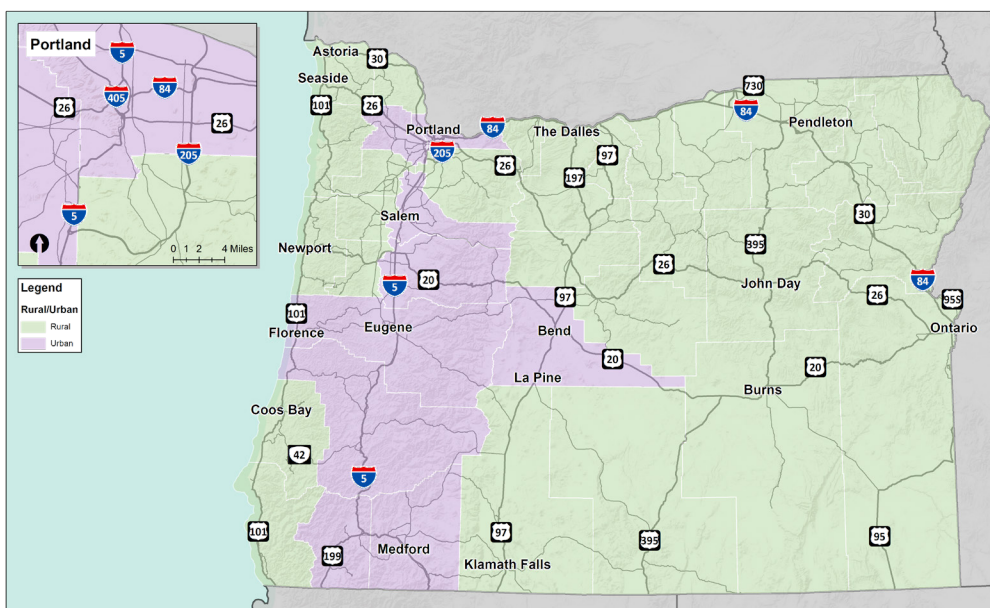
Figure A1. Definition of Census Tracts and Counties as Urban or Rural



Urban/Rural by Census Tract

0 50 100 Miles

- **Census Tracts** are defined as urban if the population density of the census tract is at least 500 people per square mile or the employment density of the census tract is at least 750 jobs per square mile. 548 of Oregon's 828 census tracts are defined as urban. Urban census tracts contain about 70% of Oregon's population and cover about 2% of Oregon's area. The Urban/Rural LDV use cases considers a definition of urban/rural that is based on census tracts. The figure shows the definition of each census tract as urban or rural.



Urban/Rural by County

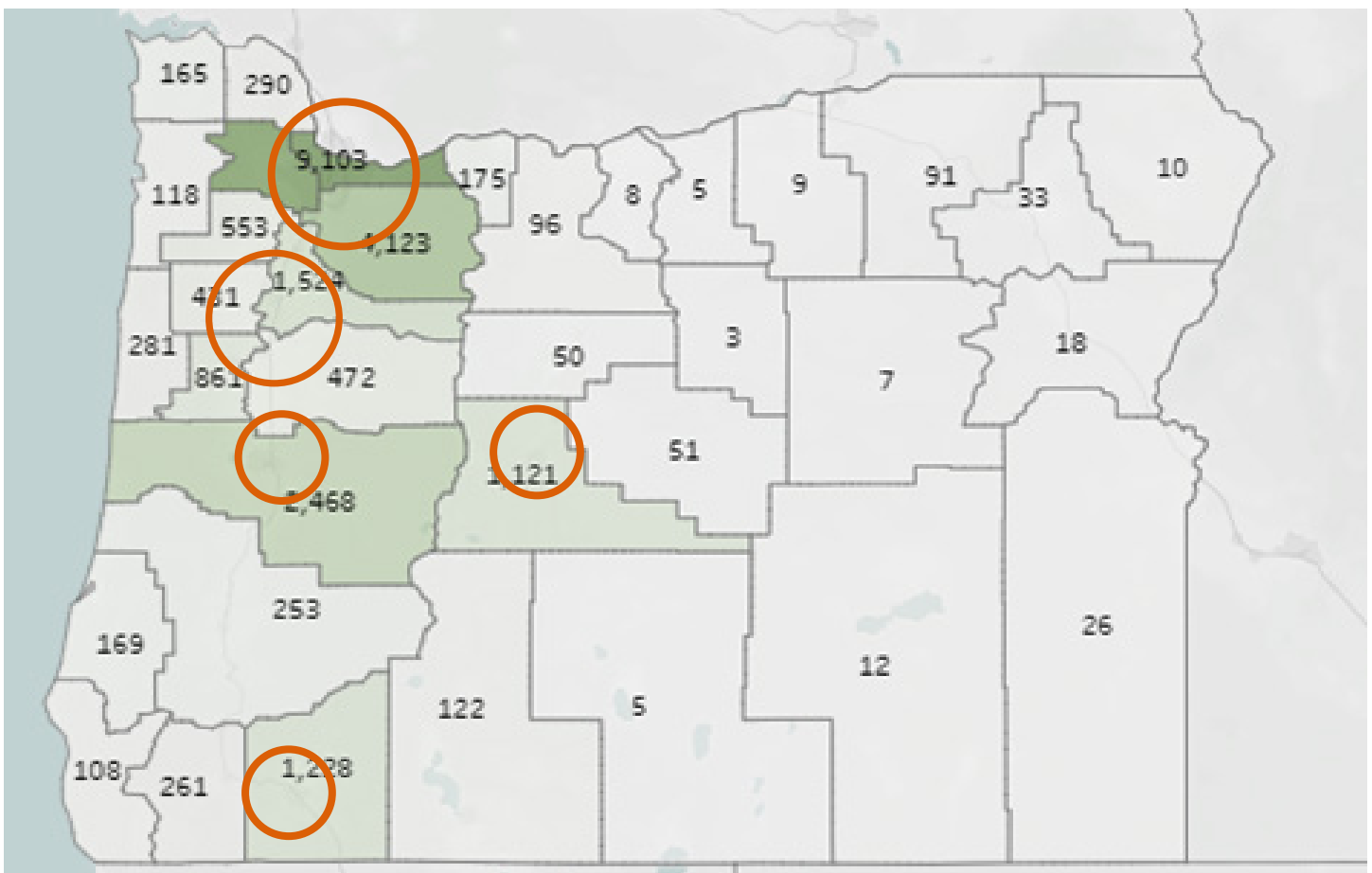
0 50 100 Miles

- The Micromobility use case, considers a definition of urban/rural that is based on county, rather than at the census tract level. The figure shows the definition of each county as urban or rural.

Key Takeaways from Figure A2

- Total number of zero emission vehicles (ZEVs): 32,000
- Battery electric vehicles: 67%
- Plug-in hybrid electric vehicles: 33%
- Concentrated in urban areas
- Statewide LDVs, electric vehicle (EV) and internal combustion engine (ICE): ~3.2 M
- Currently 1% electrification level
- Electrification Goals (Senate Bill 1044):
 - 2020: 1.15% (50,000 registered motor vehicles will be ZEVs)
 - 2025: 8% (250,000 registered motor vehicles will be ZEVs)
 - 2030: 25% of registered motor vehicles and at least 50% of new motor vehicles sold annually will be ZEVs (800,000+ ZEVs, and a cumulative total of 1.1 million registered ZEVs)
 - 2035: 90% of new motor vehicles sold annually will be ZEVs (accounting for a cumulative total of 2.5 million registered ZEVs)

Figure A2. Distribution of ZEV Registrations in Oregon

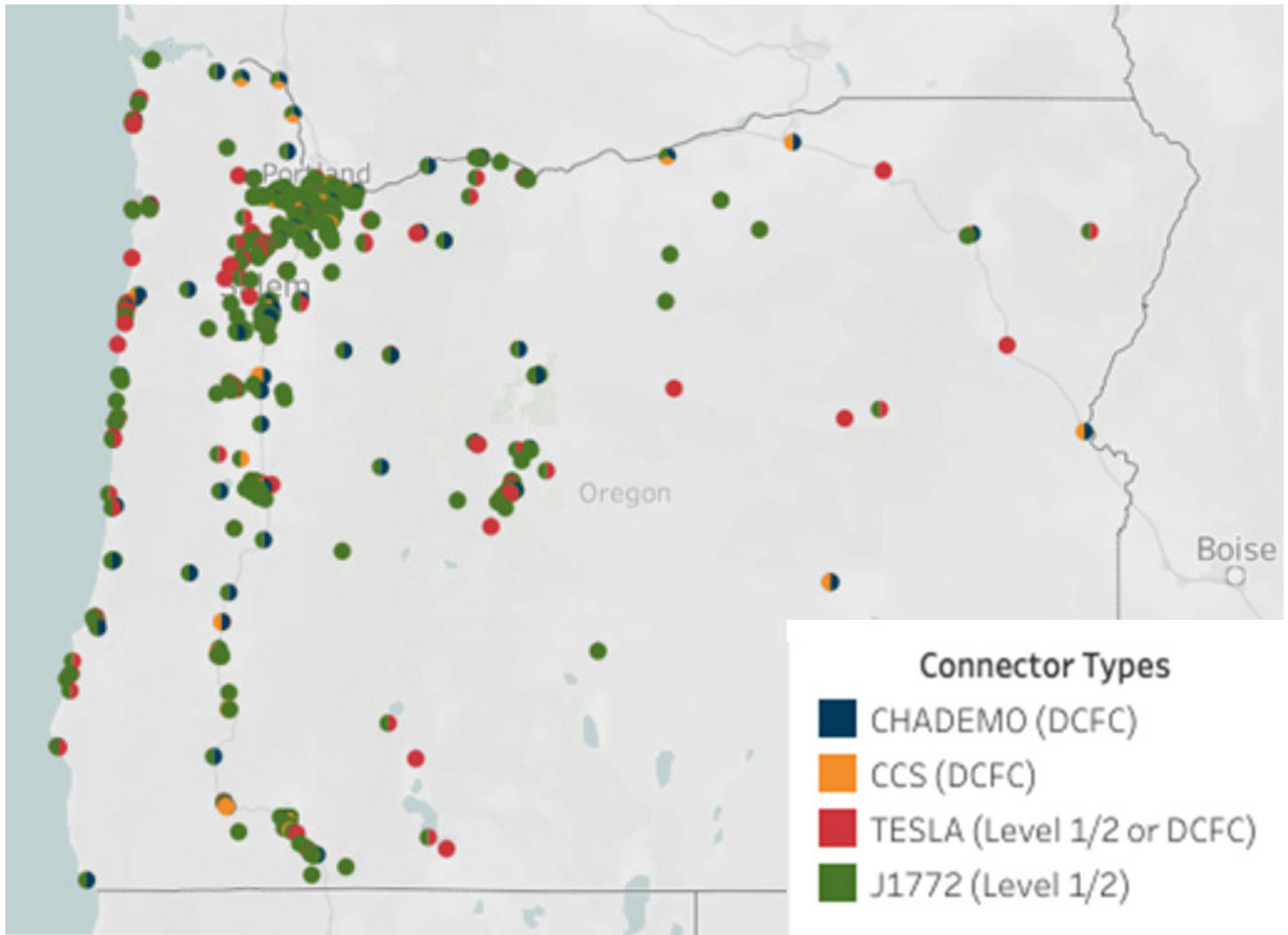


Note: Displayed information is for the period through July 31, 2020³⁷ (32,000 ZEVs with 3,200,000 LDV's in Oregon is equivalent to 1% electrification)

Key Takeaways from Figure A3

- Total number of public charging ports: 2,300
- Level 2 charging ports: 75%
- Direct Current Fast Charge charging ports: 23%
- Concentrated in urban areas
- Distributed along the major corridors and coast

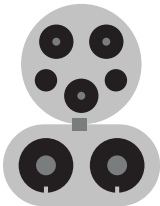


Figure A3. Distribution of Charging Ports in Oregon



Key Takeaways from Figure A4

The Direct Current Fast Charge (DCFC) charging ports available to each electric vehicle (EV) driver are even less than the total number of available charging ports because EVs today rely on three different charging port types for DCFC: EV manufactured by European, North American, and some Asian auto manufacturers use the Society of Automotive Engineers (SAE) Combined Charging System (CCS) connector; several Japanese auto manufacturers use the CHAdeMO connector; and Tesla uses its own proprietary connector for fast charging. Across Oregon, each of these connectors accounts for roughly 1/3 of the available DCFC charging ports, where the SAE CCS and CHAdeMO charging ports are often available at the same stations.

Figure A4. Charging Port Types

DC Standard	Connector	Used By
SAE CCS		<ul style="list-style-type: none"> General Motors Ford Honda Kia Hyundai BMW Mercedes Porsche Audi VW
CHAdeMO		<ul style="list-style-type: none"> Nissan Mitsubishi
Tesla Supercharger		<ul style="list-style-type: none"> Tesla

Note: Different types of charging ports can only serve specific vehicle models⁴⁶

Source: Portland General Electric

Section 2: Summary of Existing Charging Infrastructure Conditions by Use Case

Note: The numbers in this section have been rounded for simplicity.

Urban Light-Duty Vehicles (LDV)

Portland General Electric (PGE) is the key representative. Public utilities and cooperatives also host charging ports.

- Over 60% of current electric vehicles (EVs) are registered in the PGE service area.
- Existing³⁷
 - Urban Population: 2.9 million
 - Electric LDVs: 24,000 (about 80% of statewide Electric LDVs)
 - Charging ports: 700 Stations and 1,800 charging ports (Level 2: 1,500 charging ports; Direct Current Fast Charge (DCFC): 300 charging ports)
 - People per EV: 120 people/EV (~1% fleet penetration)
 - People per charging port:
 - Level 2: 2,000 people/port
 - DCFC: 9,000 people/port
 - Electric LDV per charging port:
 - Level 2: 20 EVs/port
 - DCFC: 70 EVs/port
 - *Finding: the most outstanding issue is a lack of sufficient electric vehicle supply equipment (EVSE)*
- Near future
 - Electrify America: the Volkswagen Group of America, Inc. subsidiary has committed to two rounds of investment in Oregon. Electrify America plans to deploy two more charging stations soon in urban areas (Portland and Bend).
 - PGE: Electric Avenue Pilot
 - Upgrade existing stations
 - Six new sites
 - 12 Level 2 ports, 40 DCFC charging ports

Table A1. Portland General Electric Transportation Electrification Activity Outlook by Vehicle Class

This table summarizes Portland General Electric's transportation electrification outlook by vehicle class (passenger vehicle and fleet), by offering type (rates, infrastructure, and consumer programs), and by time frame (in flight, on the horizon, and long-term considerations). This is consistent with how the remainder of the section is outlined.

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

Source: Portland General Electric

Rural Light-Duty Vehicles (LDV)⁴³

- Pacific Power is the key representative. Public utilities and cooperatives also host charging ports.
 - Large rural service area
 - 88% of Pacific Power charging ports are in non-metropolitan areas
 - Over 20% of current electric vehicles (EVs) are registered in its service area
- As of 2020, Pacific Power has contributed funds to 43 total charging stations, with 38 as customer owned charging stations and an additional 5 stations to be owned and operated by Pacific Power. Of the 43 charging stations, 88 percent are located in non-metropolitan areas. These sites will assist Oregon in building out its EV infrastructure in rural and coastal communities across the state.
- Existing³⁷
 - Population: 1.3 million
 - Electric LDV: 5,400 (about 20% of statewide Electric LDVs)
 - Charging ports: 300 Stations, 500 charging ports, 400 Level 2 charging ports, 100 Direct Current Fast Charge (DCFC) charging ports
 - People per electric LDV: 200 people per electric LDV (~0.5% fleet penetration)
 - Electric LDV per charging port: 10 electric LDVs per Level 2 charging port and 40 electric LDVs per DCFC port
 - People per charging port: 3,000 people per Level 2 charging port and 10,000 people per DCFC port
 - *Finding: the most outstanding issue is a lack of EV adoption*
- Near future
 - Electrify America: the Volkswagen Group of America, Inc. subsidiary has committed to two rounds of investment in Oregon. Electrify America plans to deploy two more DCFC stations soon in Newport and Warrenton.

Corridor LDV

- Existing
 - The West Coast Electric Highway⁴⁰ (WCEH) is an extensive network of EV DCFC stations located every 25 to 50 miles along I-5, US 99, and other major roadways in British Columbia, Washington, Oregon, and California. Oregon's portion of the WCEH operates as a public-private partnership, with 44 EV charging locations along I-5, parts of I-84, US 101, and routes into Central Oregon. It continues to serve as a critical link for EV travel throughout the state. Oregon's WCEH has dispensed more than 1.3 million kWh of charging and has powered about 4 million miles of all-electric driving via more than 130,000 charging events since its inception.
 - Utility Providers:³⁹ About 40% of WCEH sites are served by investor-owned utilities (IOUs) while 60% of sites are served by publicly-owned utilities (POUs). Nineteen of the sites are serviced by one of the two IOUs operating in Oregon: Portland General Electric Company (8) and PacifiCorp (11). The remaining 25 sites are serviced by 19 different providers: Electric co-op (11), Municipal utility (5), and Peoples' Utility District (9)
 - Each Oregon WCEH⁴² original EV station site currently consists of only a 50kW CHAdeMO DCFC and a 7.2kW Level 2 charging port. No SAE Combined Charging System (CCS) DCFC are currently available at these original sites. These original sites were initiated in 2012 and only equipped with CHAdeMO DCFC prior to the adoption of the CCS DCFC standard. To better serve all makes and models of plug-in electric vehicles, Oregon is pursuing upgrades to original WCEH locations through competitive funding opportunities to replace CHAdeMO-only stations with dual protocol DCFC.⁴⁰
 - Oregon published a request for proposals to accomplish these upgrades in February 2021. About \$4 million is available to replace and upgrade charging equipment to accommodate the CCS DCFC standard, enhance each of Oregon's 44 WCEH sites, and maintain and operate the network over time.

Figure A5. Oregon West Coast Electric Highway Map



Disadvantaged Communities

- Existing
 - Low-to-moderate income (LMI) customers.
 - Oregon offers Standard and Charge Ahead rebates; income qualified enables rebates for used electric vehicles (EVs).
 - Portland General Electric (PGE) and Pacific Power are using Clean Fuels Program funds for equity-centered projects.
 - Many disadvantaged community residents live in multi-unit dwellings.
 - Many pilot infrastructure programs are not in disadvantaged communities.
 - Utilities are increasingly aware of disadvantaged communities in the decision-making process. Utilities are building frameworks to promote transportation diversity, equity, and inclusion.
 - PGE 2021 electric school bus project is addressing underserved communities.
- Near Future
 - Pacific Power:⁴³ Current and near-term actions are already underway. The company is involved in several initiatives that improve the economics of charging infrastructure for customers.
 - The competitive electric vehicle service equipment (EVSE) grant program has reduced the cost of installations for 32 non-residential grant projects at the end of 2020.
 - The Electric Mobility Grant funded through Clean Fuels Program credits is designed to target funds for nonprofit and public entities for projects that benefit residential customers in underserved communities. In 2020, the company awarded \$1.3 million of grant awards for a total of 11 projects.

Local Commercial and Industrial Vehicles

- Existing
 - The development of commercial and industrial electric vehicles is still in an early stage.
 - Volkswagen/Diesel Emissions Reduction Act funds may be used for some medium-duty vehicles (MDVs) or heavy-duty vehicles (HDVs), but no specific MDV/HDV zero emission vehicle (ZEV) purchase incentives are available today (vs. Standard and Charge Ahead rebates for light-duty vehicles)
- Near Future⁵⁷
 - PGE and Daimler Trucks North America (DTNA) announced the co-development of “Electric Island,” a large public charging site for medium- and heavy-duty electric commercial vehicles. The charging site is the first of its kind in the United States. Electric Island will help accelerate the development, testing, and deployment of zero emissions (tank-to-wheel) commercial vehicles.
 - The site opened April 21, 2021 near DTNA headquarters in Portland and is designed to support up to nine vehicle charging stations with charging levels of up to one megawatt by spring of 2021. Electric Island will provide DTNA, PGE, and the public with the opportunity to charge light-, medium-, and heavy-duty vehicles. Plans for more charging ports, on-site energy storage, solar power generation, and a product and technology showcase building are currently being finalized.

- The site will be greenhouse gas emissions-free, including all vehicle charging.
- The site will utilize vehicle charging ports featuring power delivery of over 1 megawatt (over 4 times faster than today's fastest light-duty vehicle charging ports), enabling Portland General Electric (PGE) and Daimler Trucks North America (DTNA) to develop best practices for cost-effective future deployments.
- The project will integrate heavy-duty charging technology into PGE's Smart Grid, such as vehicle-to-grid technologies, second-life use of DTNA's battery packs, and onsite energy generation.⁴⁷ Other benefits include testing information technology opportunities, like fleet and energy management by captive solutions and services.

Transit and School Buses

- Existing⁴⁶
 - Tri-County Metropolitan Transportation District of Oregon (TriMet): TriMet's first electric bus line (Line 62) has been operational since April 2019. This line is comprised of five battery electric buses that run between the Sunset Transit Center and Washington Square. Electricity for Line 62 is served by a combination of en-route and depot charging solutions.
 - Today, PGE sponsored electric school bus pilots are just beginning to operate on Oregon roads, with the first one starting up in Beaverton, Oregon, in February 2021.
 - South Metro Area Regional Transit (SMART), Wilsonville, Oregon: Since June 2019, two eBuses with depot charging ports have been in service
 - Josephine Community Transit: Since November 2019, two eBuses with depot inductive charging ports have been in service
- Near Future²²
 - Lane Transit District: 11 eBuses will be operating in 2021 with multiple depot charging ports
 - In 2021, PGE and Oregon Clean Fuels Program funds will support eBuses for five Oregon school districts (Beaverton, Newberg, Portland, Reynolds, and Salem-Keizer)

Transportation Network Companies (TNCs)

- Existing⁴⁶
 - There are no significant infrastructure investments dedicated to TNC use, nor specific incentives in place to support TNC electrification.
- Other relevant information
 - Portland General Electric (PGE) has developed a subscription-based model that reduces cost for TNC drivers
 - In Oregon, most stakeholders assume TNC demand is part of the public charging demand, so no TNC dedicated stations have been announced

Long-Haul Trucking

- Existing³
 - The development of electric long-haul trucking is still in an early stage
 - Truck charging requires greater electrical upgrades and planning due to larger charging capacity
 - No medium-duty vehicle (MDV)/heavy-duty vehicle (HDV) specific incentives are in place in Oregon
- Near future:⁸ West Coast Clean Transit Corridor Initiative
 - This is an effort to plan and design charging sites for medium- and heavy-duty electric trucks along I-5
 - The initiative proposes to develop 27 charging sites to support medium-duty electric trucks by 2025. Oregon will operate eight of them
 - The initiative proposes expanding 14 of those sites to accommodate heavy-duty electric trucks by 2030

Micromobility

- Existing
 - Pacific Power's \$1.3 million Clean Fuels Program grants fund innovative clean transportation projects for a range of community-driven electric transportation projects, including the projects that may offer users the ability to purchase eBikes with instant rebates
 - Nike Biketown program: 1,500 eBikes at 180 stations across Portland
 - B-line eTrike urban delivery program in Portland
- Near Future⁴⁶
 - PGE was planning to lead the design of a mobility hub in inner southeast Portland. This hub will include active modes of new transportation (e.g., scooters, eBikes, electric car share, etc.). COVID-19 challenges may have shifted timelines on this project.
 - PGE is working closely with the City, County, TriMet, and local businesses to identify transportation priorities in the future. Such a project can help Oregon better understand the long-term system impacts of micromobility, facilitate adoption of electricity as a transportation fuel for customers who do not or cannot drive, and support Oregon communities in transitioning to multimodal and active transportation options. This first deployment is expected to be exploratory and designed to inform how to engage with micromobility in the future.



Appendix B: Literature Review

About this Appendix

Appendix B represents the results of a literature review performed in December 2020. RMI is the primary author of Appendix B. It presents comparable research, studies, and policies advancing Transportation Electrification (TE) infrastructure, including state, regional, and national studies as well as collaborative and public-private efforts designed to inform Oregon's charging infrastructure needs assessment.

This Literature Review focuses on efforts outside of Oregon. Appendix A ("Existing Conditions") focuses on efforts within Oregon.

There are three main parts to Appendix B:

- Section 1: Summary vignettes of three leading states in transportation electrification
- Section 2: Summary of national data on electric vehicles registrations, charging infrastructure, and multi-state initiatives
- Section 3: Research on states outside of Oregon relevant to each of the nine use cases that are modeled for the Transportation Electrification Infrastructure Needs Analysis project

Section 1: Summary Vignettes of Three Leading States

California, New York, and Colorado were selected as three states that are leading the nation in their transportation electrification activities and that also have aspirational goals similar to those of Oregon. A vignette-type overview is provided in the following sections for existing conditions in each of these three states.

California

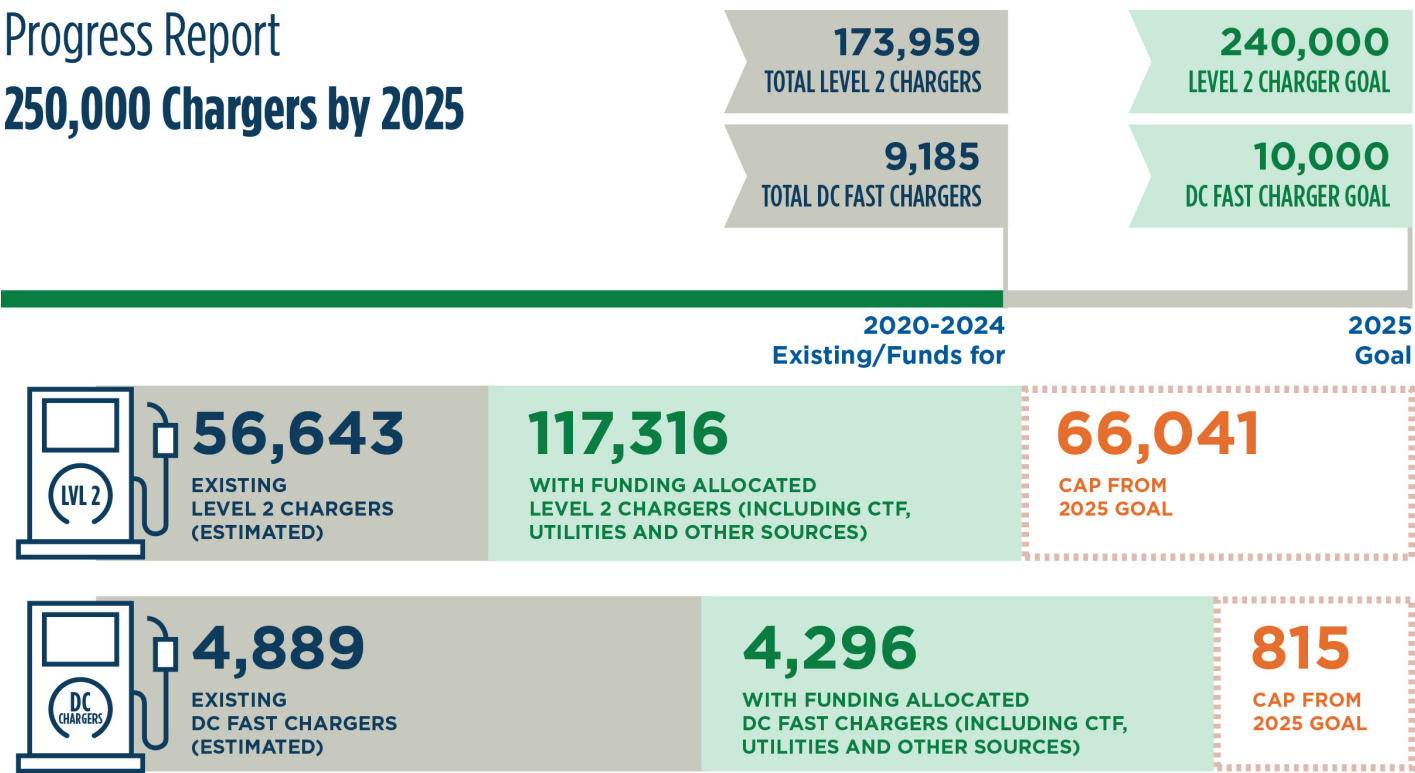
Currently, there are roughly 26 million automobiles and 6 million trucks registered in California, of which about 726,000 are ZEVs, including about 422,000 Battery Electric Vehicles (BEVs), about 300,000 Plug-in Hybrid Electric Vehicles (PHEVs), and about 8,000 fuel-cell vehicles (FCVs)²⁵. California has about half the nation’s EVs.

California’s current goals call for 1.5 million EVs by 2025 and 3 million by 2030. In September 2020, California Governor Gavin Newsom announced a new goal, instructing the California Air Resources Board (CARB) to establish rules for phasing out internal combustion engine vehicles in the state by 2035. CARB is expected

to develop regulations to require every new passenger car and light-duty truck sold in the state to be electric or “zero emissions” by 2035.

As shown in the **Figure B1**, California has an estimated 57,000 Level 2 charging ports and 4,900 direct-current fast charging ports (DCFC) today, according to California Energy Commission (CEC) data. Current funding plans from the CEC and utilities are expected to add another 117,000 Level 2 charging ports and 4,300 DCFC by 2025 — short of the goal of 240,000 Level 2 charging ports and 10,000 DCFC by mid-decade that was set by former California Governor Jerry Brown in 2018.

Figure B1. California Charging Ports Summary Report



California's 2020-2023 Clean Transportation Program² has the following elements:

- A "down payment" of \$384 million over the next three years on the electric-vehicle charging and zero emission vehicle infrastructure needed to meet California Governor Gavin Newsom's pledge to end sales of new gasoline-powered cars by 2035.
- \$133 million electric vehicle (EV) charging systems for light-duty vehicles (LDVs)
- \$130 million for infrastructure for zero emission medium-duty vehicles (MDVs)/ heavy-duty vehicles (HDVs), most of it electric charging.
- \$70 million will go toward hydrogen refueling infrastructure. Hydrogen fueling has received about \$156 million in California Energy Commission (CEC) funding and has seen only 44 fueling stations deployed to date. Another 128 are expected to be built with new funding over the next five years, leaving the state 28 stations short of its goal of 200 by 2025.
- \$25 million will go toward "zero- and near-zero carbon fuel production and supply" to meet the need for alternatives to battery-powered vehicles.

The CEC has already invested about \$900 million into clean transportation, including EV charging and compressed natural gas over the past 13 years, with an additional \$880 million in matched funding. CEC's previous \$375 million in electric transportation program funding has brought 11,276 EV charging ports to the state to date.

California utilities are investing more than \$1 billion²⁵ into charging infrastructure, including the electrical system upgrades and interconnections needed to support EV charging ports and incentives for the businesses and institutions that host them.

- Southern California Edison will spend \$436 million to install 38,000 light-duty EV charging ports and \$356 million for at least 870 commercial charging stations for MDV and HDV.
- Pacific Gas & Electric's EV charging program will spend \$130 million to bring 7,500 Level 2 charging ports to its territory over the next few years
- San Diego Gas & Electric's \$100 million program will install about 3,000 MDV and HDV charging ports.

California has a wide variety of additional programs and incentives supporting transportation electrification.

- California's green building code (2019 California Green Building Standards Code, "CALGreen," Title 24, Part 11) requires new construction parking spots to include equipment to support electric vehicle charging.¹⁶
- California has a low carbon fuel standard.
- A dollar on all vehicle registrations funds alternate fuel efforts.
- The "Replace your Ride" program offers significant incentives to income-qualified residents/disadvantaged community residents to replace high-polluting old cars with newer, cleaner cars, with the greatest incentive given for electric cars.
- Other cost-reducing rebates are also available for both LDVs and MDVs/HDVs.
- Other non-monetary zero emission vehicle (ZEV) incentives, such as high occupancy vehicle lanes and free parking, have helped to foster ZEV adoption.

Colorado

Colorado has completed the Colorado EV Plan 2020 and, in November 2018, the Colorado Energy Office (CEO) awarded a \$10 million grant to ChargePoint to build direct current fast charging (DCFC) EV stations along six corridors across the state.

The Colorado EV Plan 2020¹⁰ has numerous objectives, with a long-term goal of fully electrifying all light-duty vehicles and making all MDVs and HDVs zero emissions. The plan has the following goals and objectives:

GOAL #1: Increase adoption of EVs in the light-duty sector to approximately 940,000 vehicles by 2030. Interim targets: 10,500 by June 30, 2020, and 23,500 by June 30, 2022

GOAL #2: Develop plans for transition to ZEV for MDV, HDV, and transit vehicles.

MDV/HDV: Colorado Energy Office (CEO), Colorado Department of Transportation (CDOT) and Regional Air Quality Council will work with industry, electric utilities, and other stakeholders to establish timelines, identify strategies, and

dedicate sufficient resources to develop a plan for the medium- and heavy-duty sector by July 2021.

Transit vehicles: Colorado Department of Transportation (CDOT), Regional Air Quality Council (RAQC) and Colorado Energy Office (CEO) will work with transit agencies, electric utilities, and other stakeholders by July 2021 to establish timelines, identify strategies, and dedicate sufficient resources for the conversion of the state transit fleet to 100 percent zero emission vehicles (ZEVs) no later than 2050, with an interim target of at least 1,000 ZEVs by 2030.

GOAL #3: CEO, working with state partners, will develop an electric vehicles (EV) infrastructure goal by undertaking a gap analysis to identify the type and number of charging stations needed across the state to meet the 2030 LDV, MDV, and HDV goals by 2022.

GOAL #4: State government agencies will meet their directives from the Executive Order D 2019 016 Amending and Replacing Executive Order D 2018 026 Concerning the Greening of State Government related to EV and:

- The state will increase the number of state agencies that offer workplace charging from five in January 2020 to 10 by the end of FY 2022.
- State agencies will prioritize purchase of ZEVs for light-duty applications, increasing the number of ZEVs in operation or on order from at least 200 by end of 2020 to 375 by January 2022, with a goal of electrifying all vehicles that have appropriate use cases by 2030.

GOAL #5: Develop a roadmap to full electrification of the light-duty vehicle fleet.

- As part of the development of the GHG Pollution Reduction Roadmap, the state will evaluate the necessary timeline for light-duty electrification to achieve the target of 90% emissions reductions by 2050.
- The state will analyze policy, programs and strategies to achieve this transition and will develop recommendations for administrative and legislative action.
- The state will participate in the development of emissions and ZEV standards for model years 2026 and after to support the changes needed to achieve full electrification of light-duty vehicles.

New York

Make-Ready Program*

In July 2020, the New York Public Service Commission (PSC) authorized investor-owned utilities to collect up to \$701 million from customers to fund a new “Make-Ready Program” of investment in electric vehicle charging infrastructure to enable development of thousands of public charging locations. The program aims to support development of more than 50,000 Level 2 charging ports and 1,500 public Direct Current Fast Charge (DCFC) stations by encouraging private investment.

The Make-Ready Program will provide incentives for the installation of light-duty EV Infrastructure for both Level 2 and DCFC stations. The Make-Ready Program will cover up to 90 percent of the eligible costs needed to prepare a site for EV charging (if all eligibility criteria are met) or 50 percent of the costs if the station does not meet the public accessibility or standardized connector eligibility requirements.

The PSC order³⁶ is part of a broader proceeding⁴⁹ on EV charging infrastructure and expands on a \$582 million investment that New York Department of Public Service staff proposed in a white paper²⁰ in January 2020⁵¹.

MHD, Fleet, Transit, and School Bus Electrification

In order to further accelerate the electrification of light-, medium-, and heavy-duty vehicle fleets, New York has entered into an memorandum of understanding ([MOU](#)) with 14 other states (including Oregon) and the District of Columbia to develop an action plan to ramp up electrification of buses and trucks. The goal of the MOU is to ensure that 100 percent of all new medium- and heavy-duty vehicle sales be zero emission vehicles by 2050, with an interim target of 30 percent zero emission vehicle sales in these categories of vehicles by 2030.

The PSC has also directed utilities to create a Fleet Assessment Service that includes site feasibility and rate analysis to help fleet owners identify cost- and time- saving measures.

** Make-ready means the pre-wiring of electrical infrastructure at a specific location to facilitate easy and cost-efficient future installation of Electric Vehicle Service Equipment, including charging ports.*

In addition to the Make-Ready Program funding from investor-owned utilities, the New York State Department of Environmental Conservation is allocating \$48.8 million from the Volkswagen diesel emissions settlement to transit bus and school bus operators and electric vehicle (EV) charging station owners to advance local growth of electric vehicle infrastructure, clean public transportation and transit options, and electric school buses.

The Make-Ready Program includes \$15 million for medium- and heavy-duty electric vehicles that will support a reduction of diesel emissions located in disadvantaged communities and directs \$10 million toward utilities partnering with transit authorities.

Long Island Power Authority (LIPA) Investing in Charging Stations on Long Island

The LIPA, with its service provider, PSEG Long Island, announced a goal to support 180,000 new EV on Long Island along with 4,650 new EV charging ports by 2025, beginning with a proposed 2021 investment of \$4.4 million in make-ready infrastructure.

NYPA Partnerships

As part of the New York Governor's State of the State commitment to electrify transit buses for five major transit operators across the state, the New York Power Authority (NYPA) and the New York State Energy Research and Development Authority (NYSERDA) will partner with these transit operators and provide up to \$1 million to study the challenges of zero emissions bus fleets and identify solutions for electrification, including bus options, charging needs, and other logistical challenges.

As part of the state's commitment to EV infrastructure, the New York State Department of State (NYDOS) is collaborating with NYPA to significantly expand deployment of Direct Current Fast Charge (DCFC) charging ports in downtown communities through New York Governor Andrew M. Cuomo's Downtown Revitalization Initiative (DRI).

NYDOS and NYPA will work with local governments and key stakeholders to identify communities participating in the DRI that may be interested in hosting public fast charging ports. The first downtown charging ports will be installed through this program in fall of 2021.

In addition, through its [EVoLve NY initiative](#), NYPA is building a network of 200 150kW DCFC charging ports at 50 locations (four charging ports per location, on average) by the end of 2021 to enable drivers to travel throughout New York State with confidence. The stations will be about 50 miles apart, with easy on/off access from highway exits and in key urban hubs. They will be located at shopping plazas, convenience stores, and supermarkets, with safe access to food, restrooms, and shelter. NYPA is also working with the New York State Thruway to upgrade its plaza charging stations.

Rate Design

Utilities are also offering innovative rate designs for home charging to promote off-peak charging. Further rate design modifications will be reviewed as the EV initiative moves forward.

Equity Considerations

The PSC's Make-Ready Program allocates \$206 million toward "equitable access and benefits for lower-socio-economic and disadvantaged communities." Those communities will also be eligible for a higher incentive, supporting up to 100% of the costs to make a site ready for EV charging.

The PSC has also directed NYSERDA to propose an integrated competition, with up to \$85 million of the EV make-ready total budget, designed to directly address emissions, equity, and electrification in communities near high-density and congested streets and public highways. Three prize areas will focus on supporting clean transportation options that benefit lower socio-economic and environmental justice communities.

Other Initiatives and Programs

Other initiatives and programs designed to achieve New York Governor Andrew M. Cuomo's Charge New York goal of 10,000 EV charging stations by the end of 2021 and 850,000 zero emission vehicles by 2025 are already underway.

Under NYSERDA's Drive Clean Rebate program, more than \$35 million in rebates have now resulted in over 25,000 electric vehicle purchases as of June 2020.⁴⁴

Section 2: National Conditions

The following sections provide a brief overview of the current national status of the following important indicators of transportation electrification activity:

- Electric vehicle (EV) registrations by state
- Charging infrastructure
- Carbon intensity data
- Transportation emission incentives
- Zero emission vehicle (ZEV) states

EV Registrations

EV registration data is highly variable from source to source. There is no publicly available standard data for EV registrations by state for the whole nation. Most data sources report sales, not registrations. Additionally, public data sources do not cleanly differentiate vehicle registrations across light-duty vehicles (LDVs, electric vehicles (EVs), plug-in hybrid electric vehicles (PHEVs), and battery electric vehicles (BEVs) for recent years. Most of the publicly available data is only available through 2018. The best current national source for sales data is Atlas EV Hub, which reports data from IHS Markit, which purchased the previous authoritative

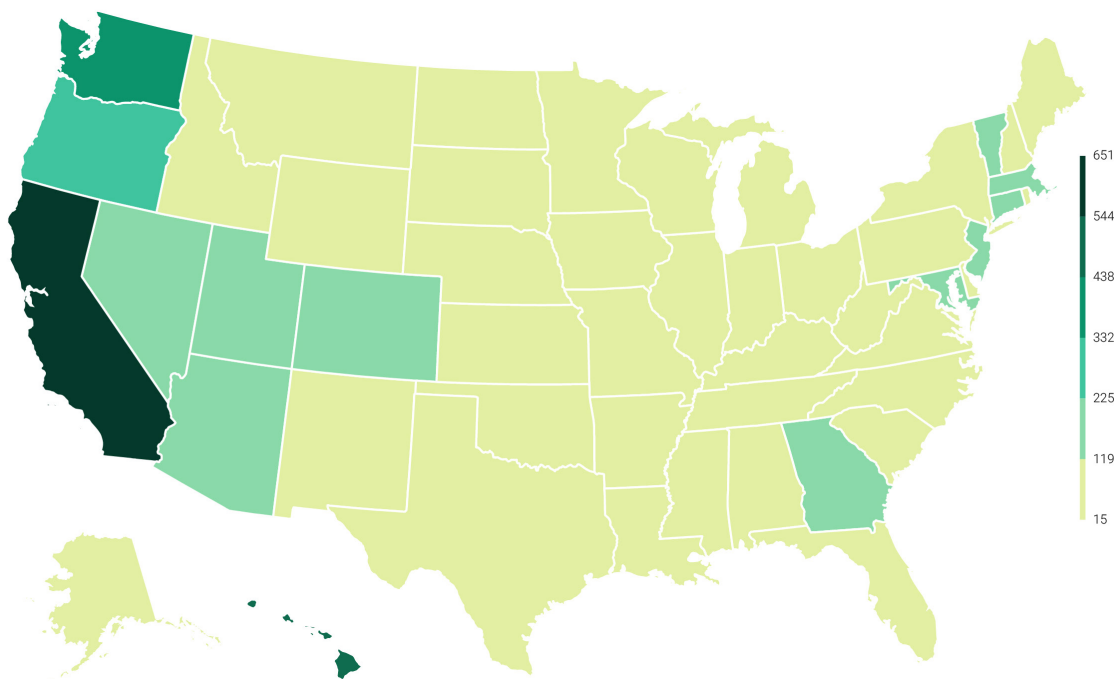
source, Polk, in 2013. The best source of registration data in Oregon comes from Oregon Department of Energy's Oregon Electric Vehicle Dashboard³⁸, which publishes ZEV registration data developed by the Oregon Department of Transportation.

Available data sources indicate that the market share of EVs sold in the United States is:

- 56% BEVs
- 44% PHEVs
- 0.5% Hydrogen Fuel Cell Electric Vehicles

The following graphic provides a visual representation of EV registrations by state.

Figure B2. EV Registrations Per 100,000 Residents (2018)



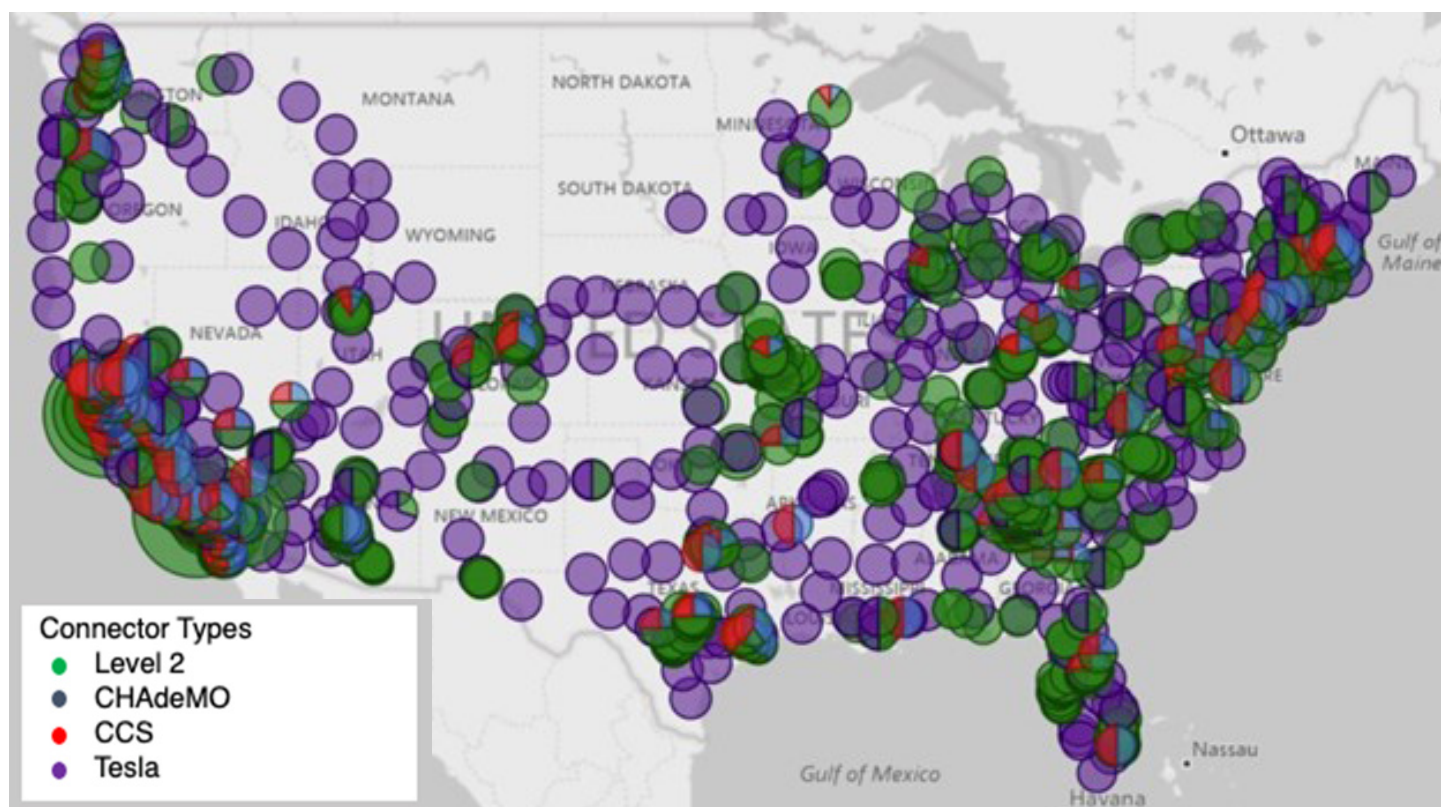
Source: Compiled from a variety of sources^{4, 24, 51}

Charging Infrastructure

There are currently about 106,009 charging ports nationwide.²⁵ Nationwide charging ports are shown in **Figure B3**.

- 86,576 Level 2 ports (82%)
- 19,398 DCFC charging ports (18%), subdivided into:
 - 4,434 CHAdeMO (4%)
 - 5,710 CCS Combo (5%)
 - 9,289 Tesla (9%)

Figure B3. Nationwide Distribution of Charging Ports



Carbon Intensity Data by State

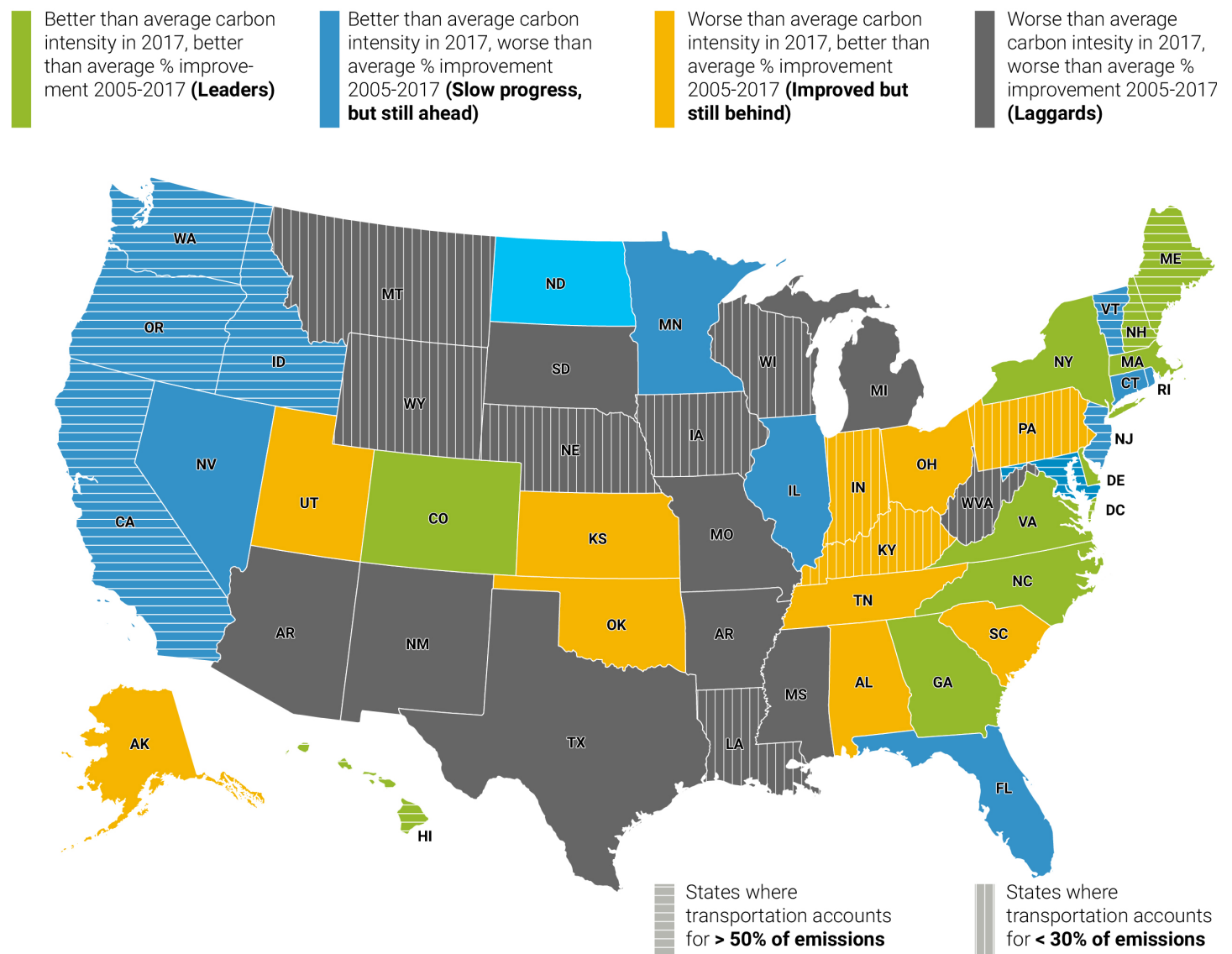
The transportation sector overtook power plants as the largest source of carbon dioxide emissions nationally in 2016, and the gap increased as transportation sector emissions grew by 7.4% between 2012 and 2019.²⁶ Light-duty vehicles are the largest source of transportation sector carbon dioxide emissions, responsible for 59% of US transportation sector greenhouse gas emissions in 2018.

California will require that all new passenger cars and trucks sold in the state be emissions free by 2035, the first state in the union to set such a requirement.

Six states are in the category of “Slow progress but still ahead,” and four are “Leaders.” These

states are characterized by little or no dependence on coal-fired electricity generation and smaller than average industrial sectors, leaving the transportation sector responsible for a majority of their emissions. Conversely, of the 11 states where the transportation sector accounted for less than 30% of total emissions, seven are “Laggards” and four are “Improved but still behind.” These states include the nation’s largest coal producing and consuming states as well as some of the largest oil producing states, resulting in higher than average carbon intensity and a lower than average share of emissions coming from the transportation sector. These states are identified in **Figure B4**.

Figure B4. Carbon Intensity Progress by State

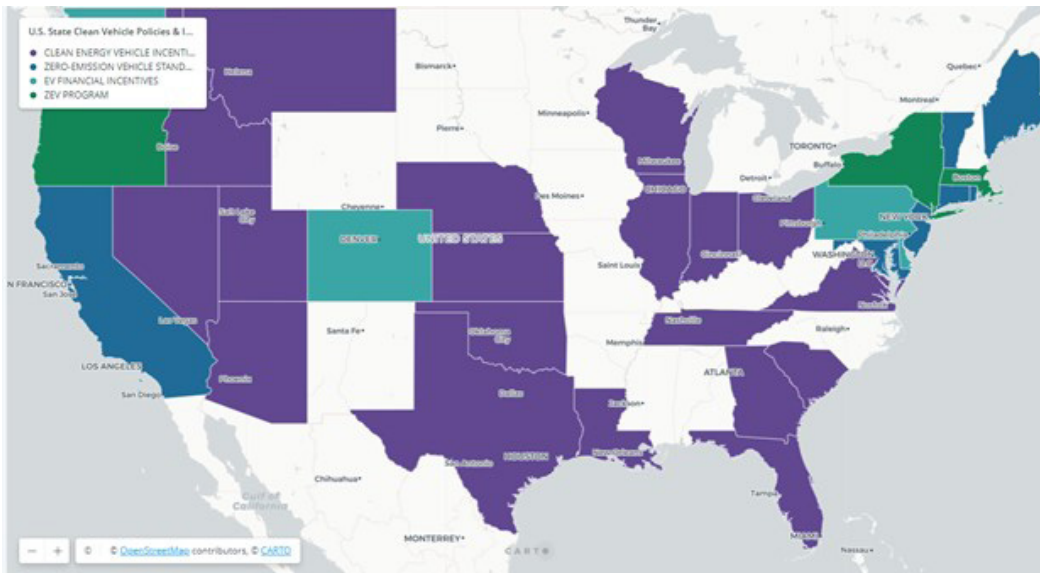


Source: World Resources Institute¹¹

Transportation Emissions Incentives

The following map shows transportation emission incentive programs by state throughout the United States.

Figure B5. Transportation Emission Incentive Programs by State



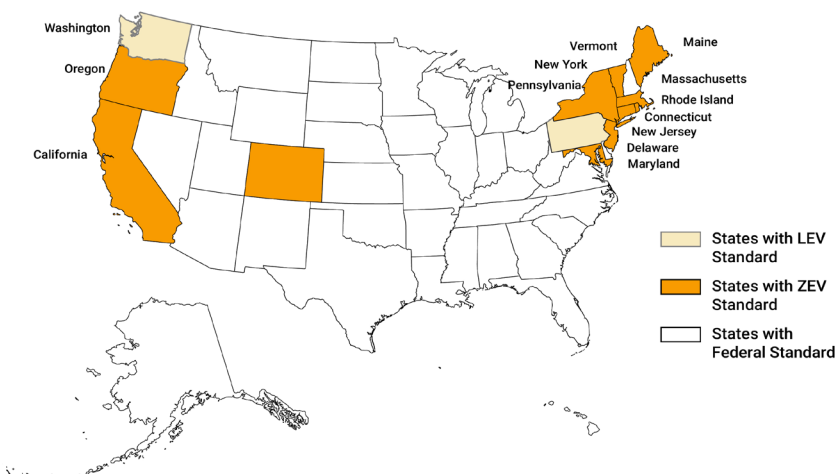
Source: Center for Climate and Energy Solutions²⁸

Zero Emission Vehicle (ZEV) States

The ZEV program is the nation's largest initiative promoting EVs, starting in California in 1990. The ZEV program was originally a part of the Clean Air Act and allowed other states to follow the same requirements that California adopted. Since then, 11 additional states, including Colorado, Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, Vermont, and Washington, have adopted a series of low

emission standards, including the ZEV standard, to encourage EV purchases, as shown in the **Figure B6**. The program is adopted by state governments and mandates that automakers sell a certain percentage of EVs, which varies by state. The goal of the Multi-State ZEV Task Force, which aligns these states, is to have 3.3 million EV operating in the states by 2025.¹⁹ Minnesota, Nevada, and New Mexico are also considering adopting the ZEV standard.

Figure B6. California Alternative Vehicle Standard Adoption in the United States



Source: Western Resources Advocates⁶²

Section 3: Use Cases

United States Nationwide Light-Duty Vehicles (LDV)

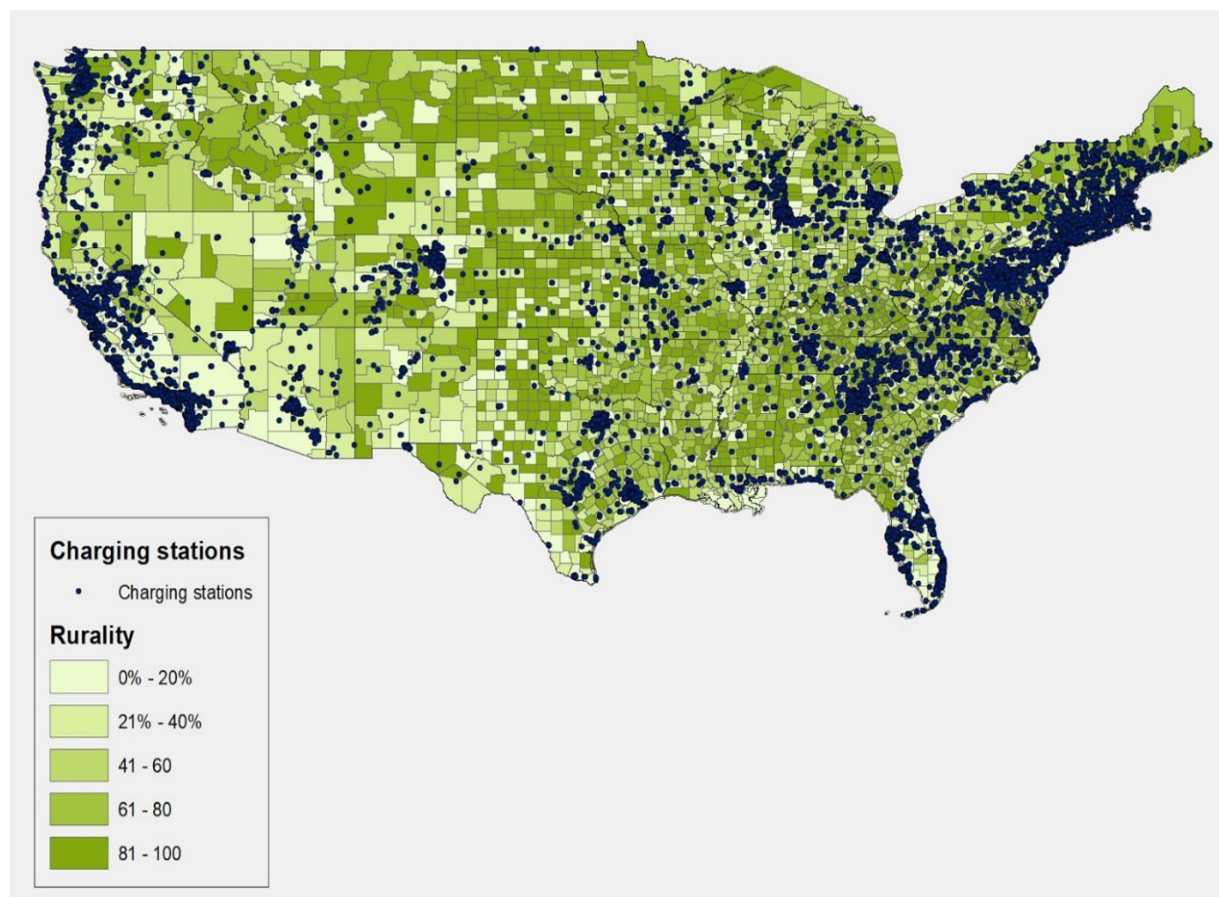
Although the use cases separately consider Urban, Rural, and Corridor LDVs, publications and data with a national focus do not usually use these same categories. This section considers national data from sources including United States Government agencies and Atlas EV Hub.

- United States Population: 331 million
- All LDVs: 251 million²⁹
- Electric LDVs, battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs):
 - 1.0 million registrations (0.4% of all LDVs)⁴⁵
 - 1.6 million sales since 2011 (0.6% of all LDVs)⁶
- Level 2 charging ports: 86,576⁴
- Direct Current Fast Charge (DCFC) charging ports: 19,398⁴
- People per electric vehicles (EVs): 325⁵¹
- People per Level 2 charging ports: 3,823
- People per DCFC charging ports: 17,033
- EV per Level 2 charging ports: 12
- EV per DCFC charging ports: 52

Rural

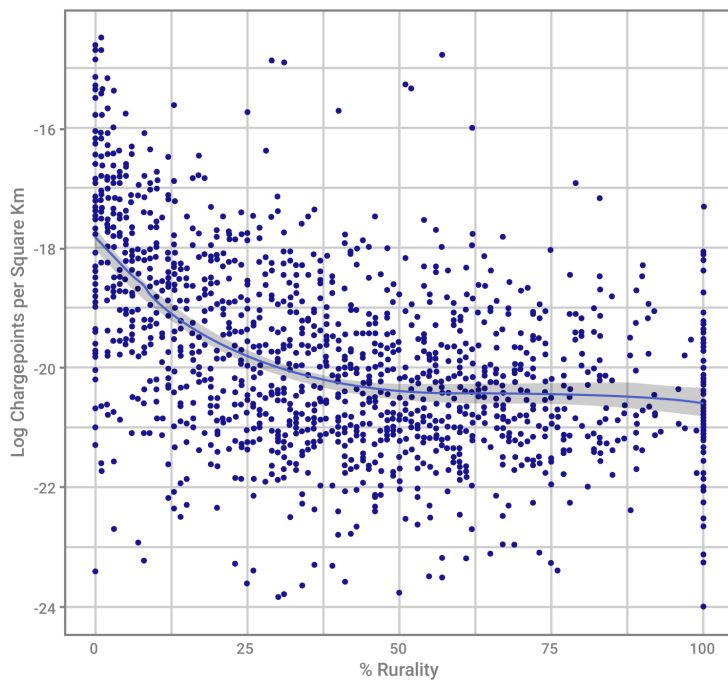
Research from UC Davis indicates that the more rural a location is, the fewer charging ports it typically has. The map in **Figure B7** summarizes this.

Figure B7. Rurality and EV Charging Stations in the United States



Source: UC Davis⁷

Figure B8. Charging Population Density vs. Rurality



Source: UC Davis⁷

Rural Charging Network Plan: ChargePoint and NATSO

Charging station operator ChargePoint and the National Association of Truck Stop Operators (NATSO) plan to add charging stations at 4,000 sites in the United States. While most charging infrastructure initiatives focus on heavily traveled corridors between major cities, ChargePoint and NATSO plan to focus on rural areas.

The agreement between ChargePoint and NATSO calls for charging stations to be installed at the 4,000 sites by 2030. At this point, the companies have only gone as far as signing a memorandum of understanding, so no actual work has started yet. ChargePoint and NATSO did not provide much information about where the charging stations would be located. A press release said stations would be placed along highways primarily in rural areas and that the network of new stations would connect with Federal Highway Administration-designated Alternative Fuel Corridors (also known as FAST Act corridors). These are stretches of highway targeted for construction of not only charging stations but also infrastructure for hydrogen fuel cell and natural gas vehicles. The exact number and location of these corridors is undetermined, as stretches of road must be nominated by state and local officials and then approved by the United States Department of Transportation, a process

that's still ongoing.⁵⁶ ChargePoint says: "Over the next decade, the Collaborative will leverage \$1 billion in capital to deploy charging at more than 4,000 travel plazas and fuel stops that serve highway travelers and rural communities."⁴⁸

Electric Farm Equipment

Electric farm equipment is now coming to market, which may change the way that farmers, ranchers, and other rural community members perceive electric vehicles. For example, the Monarch Tractor, which is due to start shipping in the fall of 2021, is fully electric, autonomous, and uses machine learning to become more accurate and self-guided over time. Starting at \$50,000, the manufacturer says it already has hundreds of farmers signed up to receive one.³⁴

Corridor Light-Duty Vehicles (LDV)

West Coast Clean Transit Corridor Initiative

Electric utilities in California, Oregon, and Washington completed a study that could lead to significant reductions of pollution from freight transportation up and down the Pacific Coast. The West Coast Clean Transit Corridor Initiative (WCCTCI), a study commissioned by an unprecedented collaboration among nine electric utilities and two agencies representing more than

two dozen municipal utilities, recommends adding electric vehicles (EV) charging for freight haulers and delivery trucks at 50-mile intervals along Interstate 5 and adjoining highways.⁶¹ The study proposes a phased approach for electrifying the I-5 corridor:

- In the first phase, 27 charging sites would be installed along I-5 at 50-mile intervals for medium-duty electric vehicles, such as delivery vans, by 2025.
- In the next phase, every other charging site (14 of the 27) would be expanded to accommodate charging for electric big rigs by 2030, when it is estimated that 8% of all trucks on the road in California could be electric.

Of the 27 proposed sites, 16 are in California, 5 are in Oregon, and 6 are in Washington, as shown in the **Figure B9**. An additional 41 sites on other highways that connect to I-5 are being proposed for electrification. Those highways include Interstates 8, 10, 80, 210, and 710 as well as state routes 60 and 99 in California; I-84 in Oregon; and I-90 in Washington.

Figure B9. Proposed Charging Sites Under the West Coast Clean Transit Corridor Initiative



Proposed Charging Sites Under the West Coast Clean Transit Corridor Initiative

Northeast Electric Vehicle Network

The Northeast Electric Vehicle Network (Network) is an effort to plan and deploy EV infrastructure throughout the Northeast and mid-Atlantic. The Network includes both the physical infrastructure required and the partnerships needed to transition to electric transportation. The Network is a project of the Transportation & Climate Initiative facilitated by Georgetown Climate Center.

West Coast Electric Highway

The West Coast Electric Highway is a network of charging stations located every 25 to 50 miles along I-5, US 99, and other major roadways in British Columbia, Washington, Oregon, and California. With building starting in 2011, the network currently consists of stations equipped with both 50kW CHAdeMO Direct current fast charge (DCFC) and 7.2kW J1772 Level 2 charging ports as well as thousands of other Level 2 charging ports.

The Oregon Legislature and the Oregon Transportation Commission are providing funding to upgrade and enhance Oregon's network of 44 WCEH charging stations with new, CCS Combo DCFC capability. The upgrades will allow fast charging using CHAdeMO or CCS connectors at each of the 44 sites.¹⁷

**Federal Highway Administration
(FHWA) Alternative Fuel Corridors**

Several corridors in Oregon and other states are proposed for FHWA's Alternative Fuels Corridor Deployment Plan, which offers the potential for federal funding. Oregon corridors currently designated for EV charging include I-5, I-84, I-82, US 101, US 97, US 20, and part of and US 26, and I-5 for Hydrogen refueling.

Disadvantaged Communities

Disadvantaged communities are disproportionately burdened by and vulnerable to multiple sources of pollution. Ensuring that these communities have equitable access to clean, electrified transportation is a key objective of most state and municipal programs.

California

In 2019, the California Public Utility Commission took several actions to advance the state's transportation electrification goals, including the adoption of a new rate design and authorizing the utilities to spend millions of dollars to support additional

electric vehicle (EV) charging infrastructure. These decisions included direction for the utilities to build charging infrastructure in disadvantaged communities. Short summaries follow.⁶³

[Decision \(D.19-08-026\)](#) (August 2019): San Diego Gas & Electric (SDG&E) is authorized to spend more than \$107 million to support the installation of charging infrastructure for medium- and heavy-duty electric vehicles. SDG&E must spend at least 30 percent of its program budget in disadvantaged communities.

[D.19-09-006](#) (September 2019): Pacific Gas and Electric Company (PG&E) is authorized to implement a program specifically targeting low-income residents. In D.19-09-006, the California Public Utilities Commission (PUC) authorized PG&E to spend up to \$4 million to provide rebates for charging infrastructure to low- to moderate-income customers in its service territory. The decision includes additional incentives for those customers, including a rebate to compensate for the purchase of a home EV charging port as well as for the panel upgrade often necessary for installation.

[D.19-11-017](#) (November 2019): As required by AB 1082 and AB 1083, the California PUC approved pilot programs for EV charging in parks, beaches, and schools for PG&E, SDG&E, Southern California Edison (SCE), and Liberty Utilities. The four utilities will spend a combined \$55 million to install up to 800 charging ports. Between 25 percent and 100 percent will be in disadvantaged communities, depending on the program.

Local Commercial and Industrial Vehicles

Multi-State Zero Emission Vehicle (ZEV) Task Force MOU

As of July 2020, 15 states (including Oregon) and the District of Columbia have signed onto a joint memorandum of understanding (MOU) (Multi-State Medium- and Heavy-duty ZEV MOU³³) to develop a multi-state Action Plan to identify barriers and propose solutions to support widespread electrification of medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs) (Zero Emission Medium- and Heavy-duty Vehicle Action Plan). It commits the signatories to work collaboratively to advance and accelerate the market for electric MDV/HDV, including large pickup trucks and vans, delivery trucks, box trucks, school and transit buses, and long-haul delivery trucks (big-rigs). The

objective of the MOU is to “foster a self-sustaining market for zero emission medium- and heavy-duty vehicles through the existing Multi-State ZEV Task Force.” The Action Plan will consider the need for a dozen programs and incentives to advance charging infrastructure for MDVs/HDVs and encourage ZEV adoption. The goal is to ensure that 100 percent of all new MDV/HDV sales be zero emission vehicles by 2050, with an interim target of 30 percent zero emission vehicle sales by 2030.

States signing the MOU are: California, Connecticut, Colorado, Hawaii, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, Rhode Island, Vermont, and Washington.¹

A primary focus is to accelerate the deployment of zero emission medium- and heavy-duty trucks and buses to benefit disadvantaged communities that have been historically burdened with higher levels of air pollution. One outcome of the MOU could be to adopt California’s Advanced Clean Trucks (ACT) Rule, which sets sales requirements for three vehicle class groups. Class 4-8 truck sales would have to be 50% zero emission by 2030, and 75% by 2035 (note that Oregon plans to adopt similar ACT regulations).

CARB Data on Trucks and Buses on the Market

Today, at least 70 electric truck and bus models are on the market, and manufacturers are expected to make many more new models commercially available over the next decade.

While trucks and buses only account for 4 percent of vehicles on the road, they are responsible for nearly 25 percent of total transportation sector greenhouse gas emissions. In fact, emissions from trucks are the fastest growing source of greenhouse gases, and the number of truck miles traveled on the nation’s roads is forecast to continue to grow significantly in the coming decades.

Truck and bus electrification also promises to deliver widespread health benefits, particularly in communities with heavy truck traffic that are burdened with higher levels of air pollution. Medium- and heavy-duty trucks are a major source of harmful smog-forming pollution, particulate matter, and air toxics. These emissions disproportionately impact low-income communities and communities of color often located near major trucking corridors, ports, and distribution hubs.¹

Transit and School Buses

The United States now has 650 electric buses deployed as of 2019, which is twice as many as the previous year. At least 1,600 are on order or grant-awarded in 45 states.⁵⁵ Together, the total (2,250 buses) represents only 3.2% of the 70,000 transit buses in the US. The vast majority are battery electric buses with fewer than 100 hydrogen fuel cell electric buses.²¹ **Table B1** summarizes the use of electric buses and commitment to electric buses for transit agencies throughout the nation.

Table B1. Transit Agency Electrification Activities in the United States

Transit Agency	City/State	Electric Buses in Operation and On Order	Commitment to Electric Buses
Antelope Valley Transit Authority	Lancaster, CA	49	88 by 2030
Foothill Transit	West Covina, CA	30	370 by 2030
Los Angeles County Metropolitan Transportation Authority	Los Angeles, CA	130	2,500 by 2030
King County	Seattle, WA	143	1,600 by 2034
Regional Transportation Commission of Washoe County	Reno, NV	21	70 by 2035
IndyGo - Indianapolis Public Transportation Corporation	Indianapolis, IN	31	170 by 2035
Metro Transit	Minneapolis, MN	9	40 by 2025 Last diesel purchase after 2022
Toronto Transit Commission	Toronto, ON	60	2,030 by 2040 Last Diesel purchase by 2025
Metropolitan Transportation Authority	New York City, NY	25	500 by 2024, 5,725 by 2040
NJ Transit - New Jersey Transit Corporation	Newark, NJ	8	3,000 by 2040
Southeastern Pennsylvania Transportation Authority	Philadelphia, PA	25	No commitment
Regional Transit District	Denver, CO	53	No commitment
TARC - Transit Authority of River City	Louisville, KY	15	No commitment
DDOT - District Department of Transportation	Washington DC	14	No commitment

Austin, Texas, Electric Transit Bus Hub

Austin's transit service, CapMetro, currently has 12 electric buses in service. CapMetro is currently building a new dedicated facility for its electric bus fleet. When finished, the facility will accommodate 214 buses, which amounts to more than half of the current fleet. Its infrastructure will support charging capacity for 187 battery electric buses. CapMetro operates on a 10-year fleet replacement schedule, under which zero emission electric vehicles will be purchased exclusively beginning in 2022.¹⁵

California School Bus Replacement Program

The California Energy Commission has established the School Bus Replacement Program to help schools transition from dirty diesel school buses to zero or low emissions buses. It includes \$75 million to purchase battery-electric school buses, and about \$14 million to provide the necessary charging infrastructure to operate the buses.² The funding is sufficient to buy 233 electric school buses plus \$60,000 for infrastructure per bus. All buses are expected to be delivered by October 2022.

More than 1,300 buses remain that need additional funding to be replaced. Fully funding the remaining buses would require an additional \$422 million as well as \$79 million in needed infrastructure.

Dominion Energy School Bus Pilot in Virginia

The largest school bus electrification program in the United States is Dominion Energy's pilot program in Virginia. Under the first phase of the program, 50 electric school buses will be delivered to school districts across the state starting in November 2020. Dominion will pay the premium cost of these electric buses over a standard \$100,000 diesel bus, and those costs will be covered by Dominion's base rate.¹³ Under phase two of the program, Dominion plans to deploy at least 1,000 more electric school buses by 2025. In phase three, half of all diesel bus replacements in Dominion Energy's footprint will be electric by 2025, and all will be by 2030. Dominion expects schools to save at least \$6,000 per bus per year, assuming that the buses are 60% cheaper to operate than standard diesel buses.²⁴

The Dominion program will also test grid integration of the buses with vehicle-to-grid (V2G) technology, but Dominion says, "getting this technology up and running requires a smarter grid, which we are working to build."¹³ Each electric school bus is equipped with bidirectional charging capabilities and can be charged within three to four hours. The buses would be charged overnight during off-peak times when electricity demand and prices are at their lowest. If scaled according to plan, 1,000 buses by 2025 would store enough energy to power 10,000 homes.²⁷

Other Notable Programs

Airports and university campuses have led the way with bus electrification over the past decade given their smaller fleet sizes and constrained circulator routes, which are not included in these counts. California is the leading state in bus electrification, with its mandate for all bus purchases to be zero emission by 2029. Los Angeles County is committed to a 100% zero emission fleet by 2030. Seattle is expected to have a zero emission fleet deployed by 2034, and New York City and New Jersey have committed to 100% zero emission by 2040.

Transportation Network Companies (TNCs)

For transportation network companies (TNCs) to transition to electric vehicles (EVs) and meet demand, many more public Direct Current Fast Charge (DCFC) charging stations may be needed.

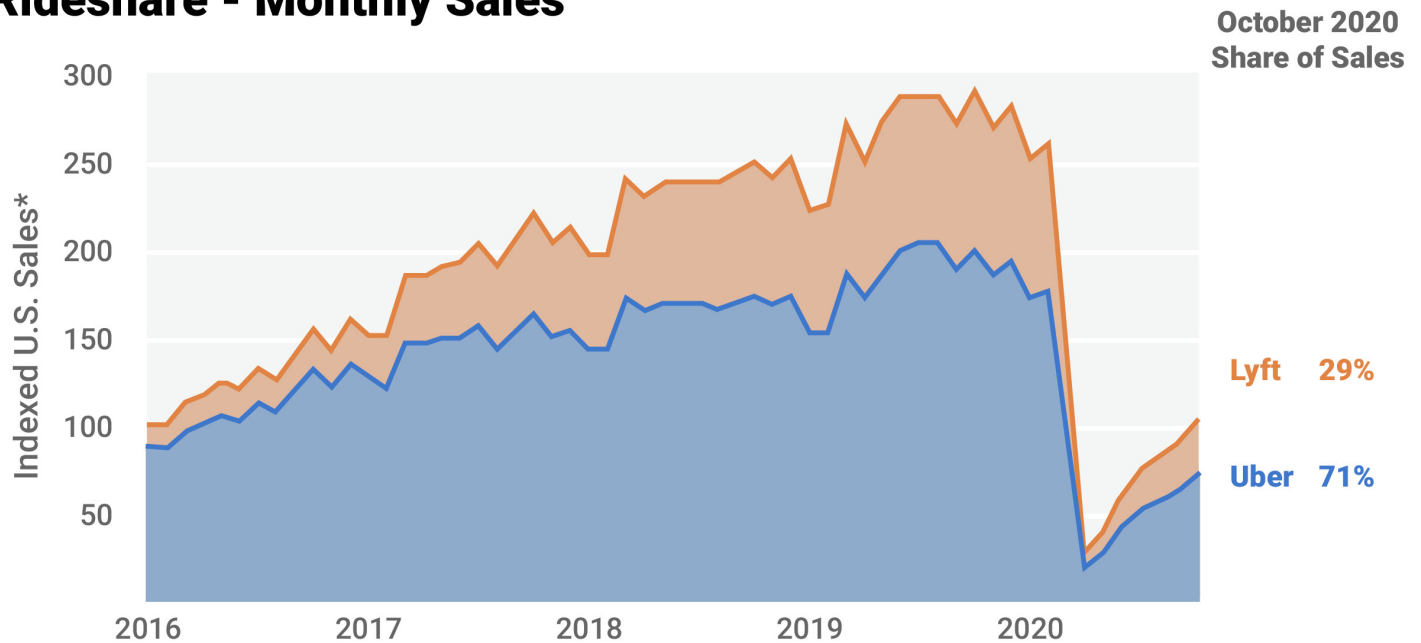
In June 2020, Lyft announced its commitment to reach 100% electric vehicles on the Lyft platform by 2030.³⁰

Uber is committing to become a fully zero emission platform by 2040, with 100% of rides taking place in zero emission vehicles, on public transit, or with micromobility. Uber has also set a goal to have 100% of rides take place in EVs in United States, Canadian, and European cities by 2030.¹²

As shown in **Figure B10**, Uber and Lyft experienced a sharp drop in usage as the COVID-19 pandemic lockdown began, but sales are gradually rebounding. As of October 2020, Uber sales were down 64 percent year-over-year, and Lyft sales were down 66 percent year-over-year.

Figure B10. Rideshare Activity - Monthly Sales

Rideshare - Monthly Sales



* Indexed to rideshare Jan 2016 sales (=100).

* Some Uber Eats sales are indistinguishable from Uber rides sales, especially in May-Aug, 2019. Corporate spending and purchases made with Uber Cash are not included.



Second Measure

Source: Second Measure³¹

Despite the statistics on the previous page, the outlook for TNCs is complicated by shifting regulations. In August, rideshare operators entered a standoff with regulators in California over how employees are classified and compensated. Both Uber and Lyft were on the brink of suspending operations before reaching an agreement with the state to continue service. In November, Uber and Lyft won a major victory when California voters approved Proposition 22, which will allow gig economy companies, such as Uber and Lyft, to continue classifying their drivers as independent contractors rather than employees.

Further business diversification, such as Uber's "Uber Eats" food delivery service, may offer a way for the services to expand even as the pandemic continues to depress travel and economic activity. Meal delivery services are thriving in the COVID-19 era.³¹

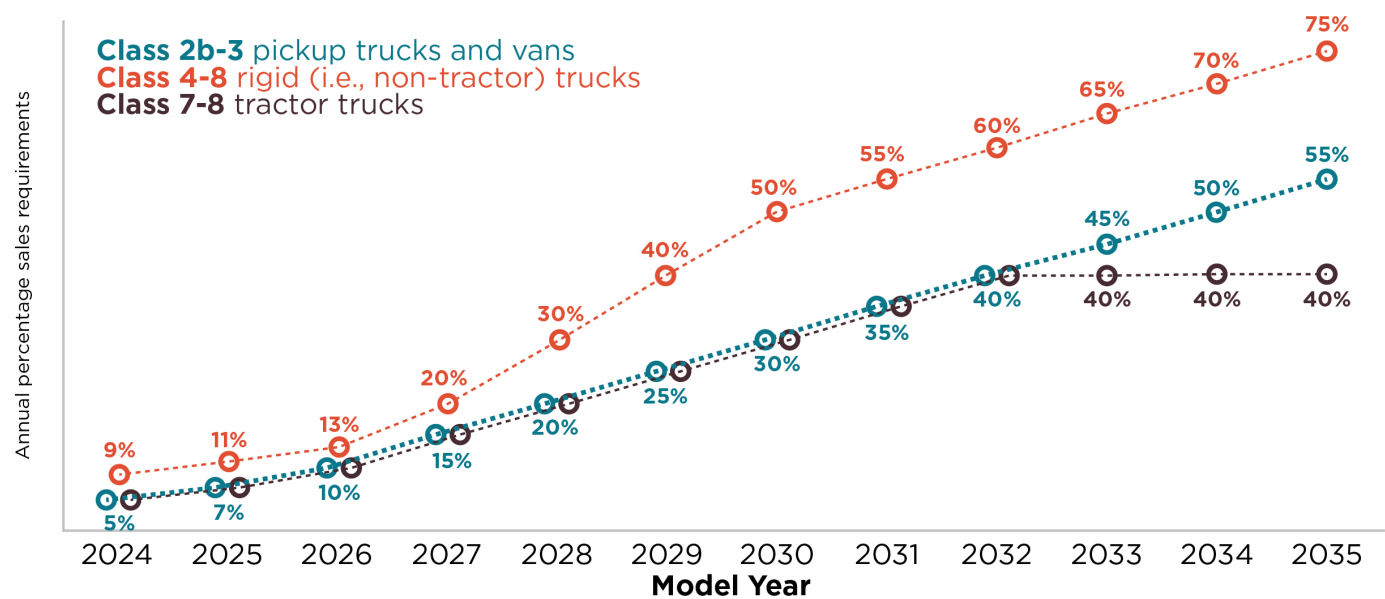
Long-Haul Trucking

ACT Rule

In June 2020, California set the world’s first zero emission truck sales requirement, the Advanced Clean Trucks (ACT) rule. It applies to all classes of trucks (Class 2b – Class 8). The ACT rule originated with a collaboration by a diverse coalition of stakeholders⁵⁴ and sets sales requirements for three vehicle class groups as shown in **Figure B11**. ACT will require new Class 7-8 semi-truck sales to be 30% zero emission by 2030 and 40% by 2035.

The sales requirements in the ACT are complemented by series of fleet purchase requirements, such as the Innovative Clean Transit rule for buses, which goes into effect in 2023 and requires 100% zero emission bus purchases by 2029.

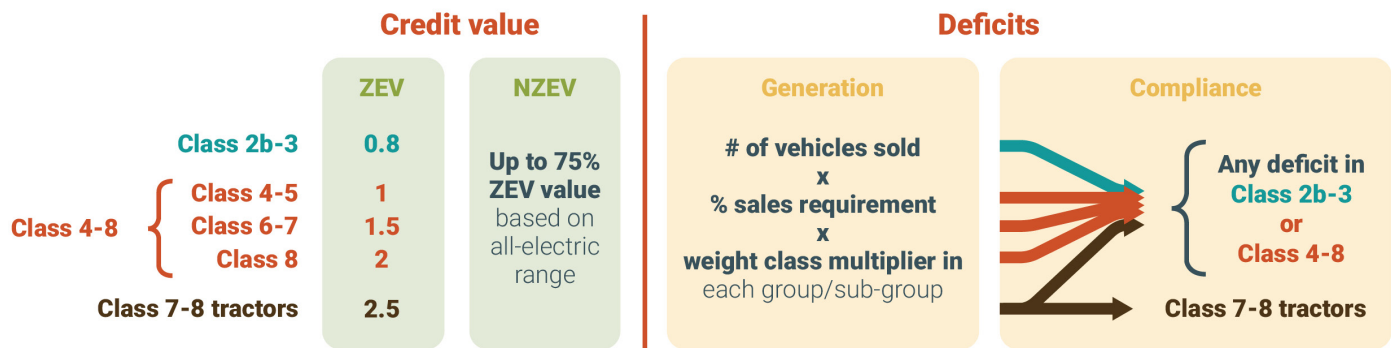
Figure B11. California ACT Sales by Year



Source: International Council on Clean Transportation⁹

The regulation is structured as a credit and deficit accounting system. A manufacturer accrues deficits based on the total volume of on-road heavy-duty truck sales within California, beginning with model year 2024 vehicles. These deficits must be offset with credits generated by the sale of zero emission vehicles (ZEVs) or near ZEVs starting in model year 2021, as shown in the **Figure B12**.

Figure B12. California’s Credit and Deficit Accounting System



Source: International Council on Clean Transportation⁹

Manufacturers must bank or generate enough credits in any given year to offset their deficits. Manufacturers selling 500 or fewer heavy-duty trucks (HDT) in California are exempt from the Advanced Clean Trucks (ACT) rule, but they may still generate zero emission vehicle (ZEV) and near ZEV credits to be banked, traded, or sold for those vehicles. ACT contains numerous other program details, restrictions, requirements, and exemptions not included here.

While the ACT rule only applies to trucks sold in California, the forthcoming Advanced Clean Truck Fleets regulations will affect any fleet that operates in California, including HDTs entering from neighboring states, Mexico, and Canada. Therefore, fleets that operate between Oregon and California will be subject to it. Additionally, Oregon has signalled its intent to adopt California's Advanced Clean Truck rule, with accompanying ZEV sales requirements.

West Coast Collaborative

The West Coast Collaborative (WCC) is a United States Environmental Protection Agency (EPA) led public-private partnership including representatives from federal, state, local, and tribal governments as well as the private sector, academia, and environmental groups—all with a stated goal to reduce diesel emissions.

In 2017, the WCC formed the Alternative Fuel Infrastructure Corridor Coalition (AFICC), a partnership committed to accelerating the modernization of West Coast transportation corridors by deploying alternative fuel infrastructure for medium-duty vehicles and heavy-duty vehicles (MDVs/HDVs).

The West Coast Collaborative Alternative Fuel Infrastructure Corridor Coalition (WCC AFICC) has developed a plan to provide medium and heavy-duty alternative fuel infrastructure across the entire West Coast, including California, Oregon, and Washington.

This plan includes 141 proposed stations of various size, throughput, and level of construction for targeted alternative fuel technologies. The network is intended to amount to a minimum viable network, covering “a small percentage of the full need for comprehensive MDV/HDV alternative fuel infrastructure access on the West Coast.” Nearly half of the proposed sites (62 of the 141) are for electric vehicle charging. Its total estimated cost is approximately \$374 million.⁴

California Incentives for Class 8

In June 2020, California Energy Commission (CEC) and California Air Resources Board (CARB) staff announced the development of the first-of-its-kind joint funding solicitation that will provide up to \$20 million from CARB's Fiscal Year 2019-20 Funding Plan for Clean Transportation Incentives for large-scale deployments of zero emission Class 8 trucks and up to \$20 million from the CEC's Clean Transportation Program funds for equipment and infrastructure to support those vehicles. The goal of this zero emission drayage truck and infrastructure pilot project is to fund large-scale deployments of 50 or more Class 8 zero emission trucks per fleet to assess the ability of vehicle manufacturers to produce large numbers of zero emission Class 8 trucks. The project would also assess the ability of fleets to recharge or refuel large numbers of trucks daily in regular use.²

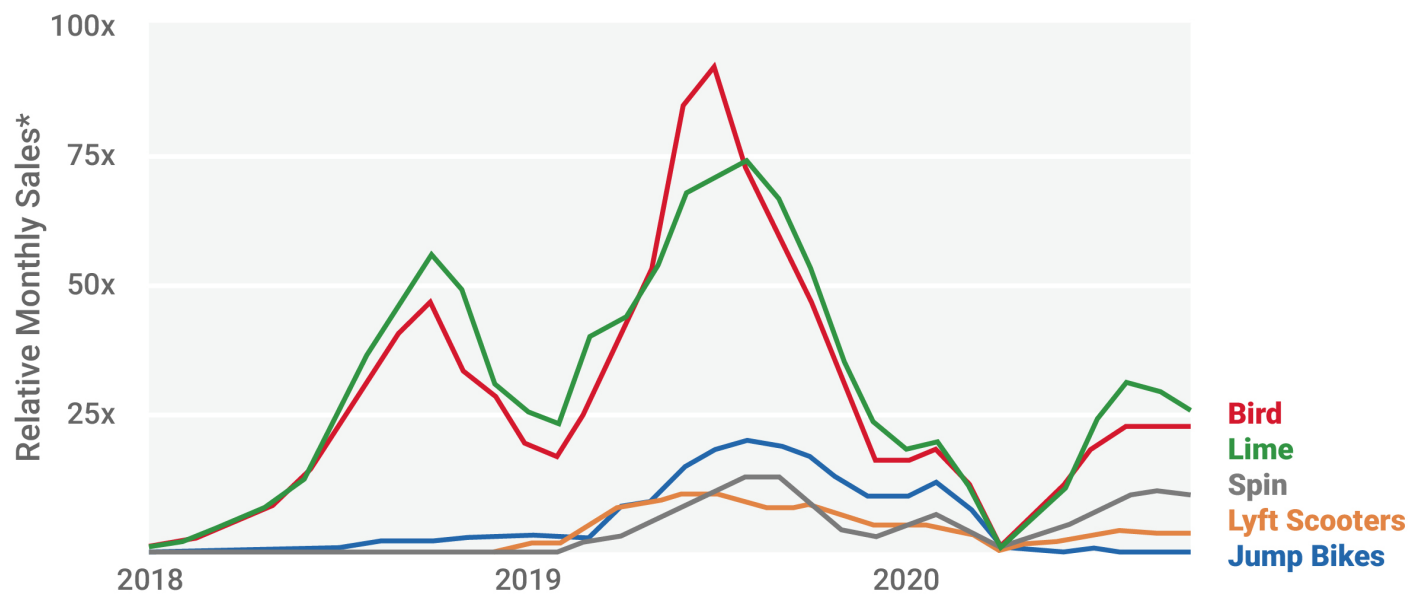
Micromobility

According to a September 2020 report from Guidehouse Insights, the global market for micromobility sharing services revenue is expected to grow from \$8.0 billion in 2020 to \$30.8 billion by 2030 at a compound annual growth rate (CAGR) of 14.4%. Shared electric kick scooters (such as the Lime and Bird scooters) and seated eScooters in North America, Europe, and pockets of Asia Pacific and Latin America are expected to represent most of the growth opportunities in shared micromobility services over the next 10 years.³²

The COVID-19 pandemic caused an initial surge in scooter usage, as many major cities around the world installed new bike- and scooter-friendly lanes and infrastructure. For example, New York City's Citi Bike program, which has thousands of eBikes, has reported a 67% increase in ridership in early March compared to the same time period in 2019. That was followed by declining usage and layoffs for some scooter operators.⁵² However, as shown in the **Figure B13**, Bird, Lime, and Spin scooters staged a modest recovery later in 2020, taking them back to roughly year-ago sales levels by November 2020.³¹

Figure B13. Sales of Dockless Bikes and Scooters

Dockless Bikes and Scooters - Sales



* Indexed to Bird Jan 2018 sales (=1x)

 **Second Measure**

The outlook for micromobility remains uncertain, but major cities seem likely to continue seeing strong adoption.⁵⁸ Major cities should plan for rising demand for these services, especially for first/last mile connections to transit. For example, Paris has allocated 2,500 micromobility parking spots for a planned 15,000 eScooter fleet provided by three operators.

Appendix C:

Listening Sessions

Table C1. Listening Session Topics

Group	Use Case(s)	Date	Participants
Electric Vehicle Drivers and Advocates	Corridor Light-Duty Vehicles, Urban, Rural	January 25, 2021	6
Transit Agencies and Providers	Transit and School Buses	January 25, 2021	6
Electric Vehicle Service Providers	All	January 27, 2021	8
Micromobility Company Representatives	Micromobility	January 28, 2021	10
Rural Representatives	Rural Light-Duty Vehicles	February 1, 2021	7
Workplace Charging Venues	Local Commercial and Industrial Vehicles	February 4, 2021	7
Transportation Networking Companies	Transportation Network Companies	February 4, 2021	2
Freight/Delivery Representatives	Local Commercial and Industrial Vehicles, Long-Haul Trucking	February 5, 2021	7
Historically Underserved Community Representatives	Disadvantaged Communities	February 9, 2021	2
Developers, Multi-unit dwelling Owners, Property Managers	Urban Light-Duty Vehicles, Rural Light-Duty Vehicles, Disadvantaged Communities	February 10, 2021	7
Farming/Ranching Representatives	Rural Light-Duty Vehicles, Corridor Light-Duty Vehicles, Local Commercial and Industrial Vehicles	February 11, 2021	4
Original Equipment Manufacturers and Electric Vehicle Dealers	All	February 11, 2021	4
<i>Total</i>			70

1. Introduction

The Oregon Department of Transportation Climate Office worked with state agencies, utilities, service providers, local jurisdictions, and other stakeholders on the Transportation Electrification Infrastructure Needs Analysis (TEINA). The study identified charging infrastructure gaps, needs, and opportunities statewide to support and accelerate zero emission vehicle (ZEV) adoption. I also suggested policies and actions that address charging needs for nine different use cases:

- Urban Light-Duty Vehicles
- Rural Light-Duty Vehicles
- Corridor Light-Duty Vehicles
- Local Commercial and Industrial Vehicles
- Transit and School Buses

- Transportation Network Companies
- Long-Haul Trucking
- Micromobility
- Disadvantaged Communities

This appendix summarizes twelve listening sessions conducted by the project team from January 2021 – February 2021, with approximately 70 different stakeholders.

Listening sessions gathered stakeholders' perspectives on issues related to transportation electrification, including charging infrastructure and electric vehicle (EV) adoption in Oregon. This feedback helped inform the study's recommended policies and actions.

Listening session topics, associated use case(s), dates, and number of participants in each session are included in Table 1.

Table 1. Listening Session Details

Group	Use Case(s)	Date	Participants
EV Drivers and Advocates	Urban Light-Duty Vehicles (LDVs), Rural, Corridor	January 25, 2021	6
Transit Agencies and Providers	Transit and School Buses	January 25, 2021	6
EV Service Providers	All	January 27, 2021	8
Micromobility Company Representatives	Rural LDV	February 1, 2021	10
Rural Representatives	Rural LDV	February 1, 2021	7
Workplace Charging Venues	Local Commercial and Industrial Vehicles	February 4, 2021	7
Transportation Networking Companies	Transportation Network Companies	February 4, 2021	2
Freight/Delivery Representatives	Local Commercial and Industrial Vehicles, Long-Haul Trucking	February 5, 2021	7
Historically Underserved Community Representatives	Disadvantaged Communities	February 9, 2021	2
Developers, Multi-unit Dwelling (MUD) Owners, Property Managers	Urban LDV, Rural LDV, Disadvantaged Communities	February 10, 2021	7
Farming/Ranching Representatives	Rural LDV, Corridor LDV, Local Commercial and Industrial Vehicles	February 11, 2021	4
Original Equipment Manufacturers and EV Dealers	All	February 11, 2021	4

2. Key Themes

Five key themes emerged across all listening sessions.

2.1 Upfront Costs

Individuals, agencies, municipalities, and businesses must make a financial investment to adopt electric vehicles (EV). The cost associated with the vehicles, electrical upgrades, and chargers can be a barrier to adoption. For individuals who can charge at home on an existing outlet, savings may come immediately through good lease terms and fuel savings. For others like property managers or those who

manage electric fleets, cost expended for electrical infrastructure upgrades and chargers may not have a positive return on investment in the foreseeable future. Incentives for vehicle and charger purchases and infrastructure upgrades play an important role in making EV adoption financially feasible. Incentives directed toward low-income communities are also important to cultivate and promote.

2.2 Charging at Multi-Unit Dwellings

Participants at every listening session stressed that widespread adoption of EV is linked to providing at-home charging to residents of multi-unit dwellings (MUDs). Residents need to experience the benefits of convenient, reliable, and affordable charging to spur adoption. Landlords and property owners of current developments face high infrastructure installation costs with limited options to recoup

their investments. Building codes addressing new development will help EV-readiness over time, but retrofitting existing buildings remains a challenge. Access to workplace charging will continue to be important to EV drivers who live in MUDs without at-home charging. Some participants emphasized workplace charging should not be considered the ultimate solution.

2.3 Public Charging Network

A functional statewide public charging network combined with well-defined, visible charging signage will create awareness of charging locations, make longer trips possible, help combat range anxiety, and accelerate EV adoption.

Participants raised the need to expand public charging options across the state. In urban areas,

drivers often experience queues. Additional chargers are needed at convenient locations like grocery stores and outlying areas where people recreate. The distance between charging stations in rural areas makes traveling between communities challenging. Corridor and off-corridor charging options will make driving EV for both personal and business use viable.

2.4 Public Charging User Experience

Creating a more positive and equitable user experience at public charging stations is important to many EV users. Ideally, charging stations are:

- Well maintained and reliable, like a gas station experience
- Safe and well-lit
- Interoperable and open access

- Located with other services, like bathrooms
- Following a code of conduct to avoid cars parked longer than needed
- Accepting credit cards to charge rather than relying solely on proprietary cards or smartphones apps
- Charging on a per kWh basis, as older vehicles charge more slowly

2.5 Availability of Vehicles and Equipment

Transit agencies, school districts, farmers, and freight operators are unable to exclusively adopt EV now due to lack of or limited supply. When stock is readily available (many new vehicles are being piloted), these industries will have infrastructure

costs, fleet vehicle costs, and charging logistics to weigh before making the decision to go electric. However, participants in these industries did see beneficial applications for electric vehicles and equipment, starting on a smaller scale.

3. Listening Sessions

3.1 Key Takeaways

Table 2 outlines the key takeaways from each of the twelve listening sessions.

Table 2. Listening Session Key Takeaways

Listening Session	Key Takeaways
EV Drivers and Advocates	<ul style="list-style-type: none"> • Address range anxiety by installing clearer signage and engaging in greater public education. • Implement a standardized charging/user experience so that all users, regardless of electric vehicle (EV) type, will have the same experience while charging.
Transit Agencies and Providers	<ul style="list-style-type: none"> • There is a lack of equipment available for transit agencies. • The equipment and infrastructure that are currently available come at high upfront costs, so making investments becomes challenging.
EV Service Providers	<ul style="list-style-type: none"> • Streamline permitting processes so that chargers can be installed more expeditiously. • It is difficult to install chargers at multi-unit dwellings (MUDs).
Micromobility Company Representatives	<ul style="list-style-type: none"> • Safe road conditions are vital to micromobility adoption, so policies supporting road safety should be developed in conjunction with EV infrastructure. • People need secure parking and storage options for micromobility vehicles like eBikes.
Rural Representatives	<ul style="list-style-type: none"> • EV need to be able to travel long distances to be useful for rural environments where trips generally require greater distances than urban trips. • There are not many EV trucks and sport utility vehicles available, which are used more heavily in rural environments.
Workplace Charging Venues	<ul style="list-style-type: none"> • Keeping up with charging demand is challenging, but the future need is uncertain due to current work-at-home situations. • Many employees use chargers longer than is needed, thus precluding other employees from using the chargers.
Transportation Networking Companies	<ul style="list-style-type: none"> • There are frequently issues at charging stations, such as broken chargers, faulty card readers, and queues. • More chargers are needed where people gather, like retail, grocery stores, or recreation activities.
Freight/Delivery Representatives	<ul style="list-style-type: none"> • Charging times and power capacity are challenging for larger delivery vehicles, so electrified routes are generally kept to smaller more urban routes. • The equipment and infrastructure that are currently available come at high upfront costs, so making investments becomes challenging.
Historically Underserved Community Representatives	<ul style="list-style-type: none"> • Charging is not accessible for MUD residents. • Many communities would benefit from a better understanding of EV cost savings, incentives, and climate benefits.
Developers, MUD Owners, Property Managers	<ul style="list-style-type: none"> • Retrofitting buildings with EV charging infrastructure is generally quite expensive, as is installing new charging infrastructure. • Developers need EV-ready incentives to make EV infrastructure installation financially feasible.

Farming/Ranching Representatives	Electric vehicles (EV) and farming equipment need to be reliable and have a short charge time. It is expensive to install charging infrastructure, partly due to the fact of needing to run electrical utilities to the rural locations.
Original Equipment Manufacturers and EV Dealers	Incentives and rebates are vital to increasing EV adoption. Address range anxiety by installing clearer signage, engaging in greater public education, and equipping salespeople with proper knowledge about EV ranges.

3.2 Listening Sessions Questions and Summary of Responses

Participants in twelve listening sessions were asked a unique series of questions. Questions and participant responses are summarized below.

3.2.1 EV Drivers and Advocates

Question: What needs to happen to make EV more accessible and functional for more Oregonians?

- Expand incentives to purchase EV.
- Significantly expand charging at multi-unit dwellings (MUDs); adoption will not grow until MUD residents can conveniently and inexpensively charge at home.
- Address range anxiety:
 - A strong network of chargers coupled with a comprehensive visible signage plan
 - More education and awareness of the longer range of newer vehicles (compared to first generation EV) and how it continues to improve
 - More charging infrastructure along corridors in rural areas between destinations
 - Infrastructure needed along non-corridor roadways
- Address charging anxiety and user experience:
 - Standardize the charging experience; like going to a gas station
 - EV charging signage should indicate the charging types available (Level 1, Level 2, Direct Current Fast Charging), or every charging station provide all three types of charging
 - Let people “test charge,” similar to taking a “test drive”
 - Use universal form of payment such as a credit card

- Maintain chargers for reliability; currently, many are not maintained and therefore are not functional. The state could require reporting and tracking of infrastructure status to help resolve the issue
- Address charging etiquette to reduce users leaving their cars plugged in at public charging stations
- Use the Tesla charging experience as a model

Question: What would make charging infrastructure equitable to everyone?

- Providing charging at MUD is critical to ensure that people who do not own their home do not pay more.
- Standardized rates and rate transparency:
 - Treat charging providers more like utilities in order to provide rate transparency
 - Charge on a per kWh basis (volumetric) instead of by the time spent using the public charger
 - Cost and fees associated with each charging session need to be clear
- Require payment in forms consistent across platforms that does not depend on a bank account or smart phone.
- The current proprietary charging networks pose a barrier to access, if membership in a proprietary network is required for access/payment.
- Locate other services at charging stations such as eBike charging, electrical outlets, and bathrooms.

- Electric vehicles (EV) incentives, infrastructure incentives, and assistance with EV registration fees. (California's Clean Cars for All program, through the California Air Resources Board, provides a good model.)
- Focus electrification on specific community needs; do not make assumptions.
 - Example: Vanpools or transit may be better than installing Level 2 chargers for communities that rely more heavily on transit than personal vehicles.
- High upfront costs of vehicles and infrastructure installation.
 - Cost of purchasing an electric transit vehicle is high
 - Cost of installing charging infrastructure is high, including utility upgrades and chargers
 - Only federal money is available right now, and there is not enough to go around
 - For providers that are not transit districts, funding is a big issue

Question: What are some challenges you see around charging infrastructure and getting it in the ground? Other EV-related challenges?

- Expand labor and workforce through programs to get infrastructure installed and training programs for electricians and mechanics operating on light-duty-, medium , and heavy-duty EV. California has good programs.
- Update building codes to require installation of electrical conduit necessary to support chargers in the future.
- Costs and profitability are barriers to charging infrastructure installation; electric utility demand charges need to be addressed in ways that allow fair and reasonable electricity costs to consumers while utility needs are met .
- Uncertainty around the future of electrification for transit use.
 - Other non-fossil fuel alternatives may be more readily available or feasible, like hydrogen fuel cells
 - Hybrid options might be better than full electric
 - Vulnerable to shifting priorities after making large investment into infrastructure and equipment
- Charging compatibility. Committing to the same manufacturer for vehicles and chargers minimizes issues with maintenance and compatibility.
- Trained technicians. It is easy to train drivers; however, electric bus repair is more difficult. Currently repairs are dependent on manufacturers.

3.2.2 Transit Agencies and Providers

Question: What are the current barriers to adopting EV for transit providers?

- Lack of available vehicles:
 - Vans and cutaways are not readily available or do not serve the needs of disabled or elderly populations requiring ramps
 - Proterra and Cummins are both working on vehicle options; however, timing is unclear
 - Not all vehicles are approved to be purchased with Federal Transit Authority funds
- Vehicle longevity and fuel diversity.
 - Diesel vehicles last much longer than current electric transit vehicles at a fraction of the cost
 - Not implementing fuel diversity is "operationally irresponsible"
- Range of charging models discussed:
 - Overnight depot charging with rotations throughout the night for short range buses
 - In-route charging
 - Sequential charging system at the depot
 - Inductive charging is expensive. Not every bus can accept the technology, causing an interoperability issue
 - Smaller transit providers often do not own the property where vehicles are parked
 - For vehicles without routine route service, it is hard to standardize when

traveling between communities with different utilities and service providers

- Charging is needed in maintenance facilities in addition to depots.

Question: How do you identify which routes to electrify first?

The group was split between prioritizing equity/accessibility and geographic feasibility. Feedback included:

- Geographic feasibility
 - Helpful to “stress test” the capabilities of electric buses during pilot programs along longer and hilly routes
 - Local routes close to the depot were best to allow unexpected charging when needed
 - Hills will hinder the capacity of electric buses until technology improves
- Equity/accessibility
 - Providing electric bus service to underserved communities can lower pollution and reduce noise
 - Equity will play a major role in the routes ultimately selected, a similar process to high-frequency route selection
 - One participant’s vision statement incorporates both a climate and equity lens to all work
 - As shuttle service is electrified, it will serve low-income communities
- Other considerations
 - Range for large buses is currently a problem for longer route vehicles
 - For smaller providers with limited routes, focus is on electrifying the busiest routes

3.2.3 EV Service Providers

Question: What are the biggest gaps in electric vehicles (EV) charging infrastructure in Oregon today? What are the needs and the barriers?

- US 20, US 26, and US 97 are known for infrastructure gaps.
- Coverage east of the Cascades is sparse; the west side has better coverage.

- Long-term alternatives to demand-charge-based rates:
 - Low utilization and high demand charges make it a challenge to fill the gaps in rural areas
 - Great Plains Institute (2019) report addresses Direct Current Fast Charge economics in rural areas
- Load balancing and management.
 - Amount of power needed for charging is an important consideration and can raise infrastructure cost
 - Software can help with load balancing, but that only addresses the current state of power v. future load growth
 - Load management and flexibility of charging units is important
- Infrastructure costs.
 - The cost for getting charging stations in the ground is not decreasing
 - Infrastructure installation is the highest cost, much higher than the charging units
- User experience.
 - Unreliable charging needs to be addressed before wider EV adoption
 - People need either home charging or a “refueling” experience that is reliable, comparable to going to a gas station
 - Solve the interoperability problem
- Skilled and knowledgeable workforce.
 - Many electricians do not understand how to install the chargers or pull the necessary permits
 - Installing EV charging infrastructure could become a great jobs program and employment opportunity
 - A good model for utilities to follow would be to establish a specific point of contact for EV service providers and have engineers dedicated to charger assistance

Question: Is the lack of long-term solutions for a viable financial model a significant barrier?

- Direct Current Fast Charge (DCFC) installation:
 - There is no business case for a site owner to install a DCFC in most areas
 - It is currently not a successful long-term business model. Last year a participant paid the equivalent of \$5.69 per gallon for investment; this cannot be passed on to consumers
 - It is difficult to see a positive return on investment in the foreseeable future
 - Utility make-ready programs for DCFC can be a big help, especially in rural areas
- Challenge to invest in states that do not address demand charges. Oregon needs to address this to attract investments. Maryland has a temporary program that can lead to longer term restructuring. New York is considering a bill.
- Role of utilities:
 - Utilities and electric vehicles (EV) services providers need to work together to develop a shared responsibility model where utilities are responsible for their side of the meter and EV service providers handle their side
 - Utilities are in the position to create new profit centers
 - Their role is variable depending on the state

Question: What kind of charging do you find easiest/hardest to sell and install? Why?

- Commercial properties and new construction are easiest to sell/install.
- Hardest to sell/install:
 - All charging is hard to sell and provides economic challenges
 - Harder to build in urban areas. Rural areas provide better topography and space, but can be a challenge with connectivity (Ethernet, cell signals, etc.)
 - Multi-unit dwellings:

- Condominiums
 - Selling chargers to condominiums is difficult because of the deeded parking spaces and limited panel capacity.
 - Some Homeowner Associations are attempting to un-deed the parking spaces.
 - Homeowner Associations are made up of volunteers, and decision-making can be a challenge.
- Apartments
 - Generally, there are no driveways or garages to utilize at-home charging options.
 - When one apartment complex offers an amenity like charging, others will follow.
 - Need building code regulations that facilitate installation of charging infrastructure.
 - Using common area parking has not been a success due to Americans with Disabilities Act (ADA) space needs, etc.

Question: When do potential sales slow down or fail?

- Many sales slow or fail when people receive the bid for electrical installation.
- Bids include cost of running conduit, trenching, etc., and these items lead to sticker shock.

Question: What programs or policies have you experienced that you feel did a good job of helping you install more charging?

- Helpful programs and policies:
 - Pacific Gas and Electric Company program in California
 - Charging Ahead program in Colorado
 - Do not shortchange future innovation/upgrade needs
 - Policies that build in cost-effectiveness and return on investment
 - Policies that are flexible in finding community-based solutions

- Policies that have a clear purpose and are not overreaching
- Programs and policies that could be improved:
 - Streamline permit requirements and loosen zoning requirements regarding permissible charging locations
 - Reduce the amount of costly data that some grants and policies require in order to utilize their funds or incentives
 - California's requirements on reporting and pre-registration of chargers, etc. go too far and are slowing down the process. Do not replicate that in Oregon

Question: How is your company addressing equity gaps in charging infrastructure? How can the state help improve equity gaps?

- Need credit card readers; do not require smartphones.
- Have a sponsorship program for education and outreach to community-based organizations to improve awareness.
- The state and municipalities can help with policies to provide affordable charging for everyone.
- Putting a stronger focus on incorporating vendors and installers that represent diverse communities. Need to find a way to encourage this.

3.2.4 Micromobility Companies

Question: What types of locations or communities are best suited for eMobility?

- Shared fleets are best suited in areas with a larger population. Bend is the smallest city in Oregon that would accommodate shared fleets.
- Privately owned equipment is viable in both urban and rural areas.
- Adaptive mobility is also important to consider in this discussion.

Question: How far do people typically travel on an eBike and eScooter?

- eBikes: 2-5 miles (and up to 10 miles roundtrip).
- eScooters: 1-5-mile trips (often to/from public transportation).

Question: What factors encourage and discourage eMobility use and adoption?

- Safe road conditions and infrastructure (bike/scooter lanes).
 - Streets need to be open and slow; surveys indicate this is the biggest component to increasing Micromobility use
 - eScooter riders worry about cars and street conditions
- Secure storage.
 - Transit hubs with secure storage are becoming more widely adopted
 - eBikes require new storage solutions; traditional bike storage often requires lifting bikes, and eBikes are too heavy
- High Costs.
 - High electric bike costs (ownership and annual membership fees (shared use) can be a barrier to many
 - State and federal assistance through incentives are needed to cover the high costs of installing shared fleets
 - The state should allow micromobility companies to apply for energy credits by showing a reduction in vehicle miles traveled to help offset high installation costs. Data from a Portland Bureau of Transportation study indicated that electric scooters have replaced about 38 percent of vehicle trips
 - Shared eBikes are a feasible alternative to ownership for some in urban areas, but not where density is low

Question: Where do micromobility users typically charge?

- Private owners primarily charge at home or at their workplace.
- Shared fleets:
 - The industry seems to be moving toward swappable batteries which can be changed on the spot, rather than transporting scooters or bikes to and from a charging location
 - Swappable batteries have reduced carbon footprints, but currently have safety issues due to lack of protection

- Bird makes batteries last longer by protecting them (and making them non-swappable)
- Lime is looking at using the same batteries for their scooters and eBikes
- A participant noted that the idea of having charging available in the public right-of-way does not currently have traction in the industry
- A participant shared the importance of ensuring that micromobility devices, their chargers, and storage are compatible with accessibility devices for people with disabilities.

Question: What policies could help expand micromobility?

- Clarity around who pays for the infrastructure and who pays for the electricity (Public Utility Commission (PUC) will not let utilities give electricity away for free).
- New requirements around providing specific space for eBikes like traditional bike parking.
- The state could help shared micromobility companies apply for energy credits.
- For multi-unit dwellings, storage is an issue. Need enough space to place eBikes and larger cargo bikes.
- Policies supporting safety.
- Building code changes to improve design conditions for eMobility; these changes can also create improvements for people with disabilities.
- State goals for eBikes like those for light-duty vehicles.

Question: What type of public infrastructure is needed to support privately owned eBikes?

- 110v outlets.
- Most riders do not carry their chargers with them, requiring specific plugs because they are not standardized.
- Universal batteries (and thus chargers) would help the battery capacity issue, but manufacturers have expressed little interest.
- It takes about 0.5 kWh to charge an eBike; eBikes cannot rapid charge.

Question: Anything else you would like the team to consider?

- Private companies can donate charging ports to create an “airport cell phone charging” experience at locations in the city.
- Move in the direction of equity, universal use, and reducing traffic congestion and fossil fuel use.
- Positive legislation is occurring around incentives in other states, but more is needed.
- Consider battery recycling as part of the overall strategy.
- Seek legislative interest in directing the PUC to allow utilities to make infrastructure investments.

3.2.5 Rural Representatives

Question: What needs to happen so that EV are successful and functional in your area?

- Ability to travel long distances.
 - Vehicles with long range batteries or mid-route charging stations
 - When only one charger at a station, people can wait hours to charge if it is in use. Need more stations running with multiple chargers per station
 - Rural communities experience areas with no charging stations or only Tesla charging stations
 - Example: There is not any Combined Charging System in Corvallis so people that travel between Newport and I-5 via Corvallis in non-Leaf vehicles are challenged
 - Example: No charging on US 97 between Bend and Klamath Falls
- Direct Current Fast Charge along corridors like I-5 is critical
- Need dependable stations with service support
- Safe charging stations in terms of locations and conditions.
- Education and awareness.
 - Provide opportunities to drive and experience electric vehicles

- Engage community leaders to help promote
- Multi-unit dwelling (MUD) charging stations.
 - Provide charging for low- and moderate-income individuals. Rural areas will have many used electric vehicles (EV) for sale in the future
 - Workplace charging may help fill a gap while inadequate charging at MUD, but it should not be considered a solution

Question: What are the average total miles per day you want to be able to travel?

- A minimum of 300 miles is needed. 90 miles per day or 15,000-20,000 miles per year is not uncommon.
- In Lincoln County, there is a huge travel range, from over 50 miles per day to under ten.
- Rural drivers can benefit significantly from electrification and fuel cost savings.
- Housing in rural areas is more likely to be single-family, providing the benefits of at-home charging.
- For a commuter transit service, the challenge is not how far, but the fact that routes are run 3–4 times per day. The fleet would need to double in size to allow one to charge while the other is operating.

Question: What is the general ratio of cars to SUVs and trucks in your area?

- All participants said vehicles in rural communities are mostly trucks and sport utility vehicles.
 - Currently, no electric trucks are available and limited electric sport utility vehicles are available
 - With General Motors announcing the phase out of internal combustion engine vehicles, it is likely that electric trucks will be available for sale soon
- Some rural residents have smaller vehicles as second cars used for commuting.

Question: Are you worried about the growth of transportation electrification in any way?

- Utility capacity.

- Potential electric utility capacity issues exist in central and eastern Oregon
- Putting all the region's energy needs into one basket is risky and may not be a sustainable option for some communities
- Reliability of infrastructure.
 - Current infrastructure on West Coast Electric Highway (WCEH) is in bad repair and undependable
 - Tesla offers the best charging support, which not everyone can afford
- Charging at MUD.
 - Have at least one Level 2 charging space available at all MUD
 - Level 2 chargers are a much lower investment than Direct Current Fast Charge
 - Landlords need to manage and monitor the Level 2 chargers to recoup costs
- State-run charging.
 - Address EV service providers' profitability issues by operating at the state level
 - Oregon Department of Transportation should buy back the Webasto WCEH chargers and start operating them

Question: Who would you turn to for advice about purchasing an EV?

- Forth knows the industry and brings excitement
- Oregon Transit Facebook Group
- Smart Energy Group
- Ride and Drive events
- EV owners and peers
- Some participants shared their dealership experiences and indicated there is incorrect information being shared about EV and sometimes salespeople dissuade interested customers from purchasing EV.

3.2.6 Workplace Charging Venues

Question: What needs to happen to spur electric vehicles (EV) adoption through workplace charging?

- Keeping up with demand is the big issue for employers who provide workplace charging.
 - Employees assume it is free or inexpensive to install more infrastructure
 - Employees overstaying their time at chargers is a problem; current measures to encourage employees to move cars only marginally successful
 - Dedicated two parking spaces for one charging port
 - One participant located chargers in the middle of the parking lot to charge four cars with one port, but not meeting demand; and issues with people not moving
 - At home charging at multi-unit dwellings (MUDs) would certainly lower workplace charging demand
- Small companies that do not own their office space but want to provide charging rely on flexible landlords.
- Charging is expanding to serve electric fleet and not just employees.

Question: How can charging access be equitably provided?

- Used EV have a much lower range, so making charging available at work is important, especially until MUD provide charging more widely.
- Envoy (electric car sharing service) is putting vehicles at low-income properties.
- Charging as a service; looking for vendors who bundle hardware/software/fuel into one monthly cost to electrify fleets.
- Fleet switching allows employees to drive to work and switch to their electric fleet vehicle.
- Portland General Electric (PGE) has time of use rates, with overnight rates being the lowest. Utilities should work with businesses to pair renewables during the day for lower rates.

Question: What are the barriers to adding more charges?

- High cost of installing new infrastructure; state incentives would help.

- Utility rates affect the cost of charging. They are often the highest during the day when people charge their EV at work.
- Parking logistics and etiquette; most employers do not have the capacity to monitor and enforce charging codes of conduct.

Question: Do you provide charging for eMobility? Do you charge for it?

- There is increased interest among employees around eMobility.
- Most participants provide secured bike storage rooms with electrical outlets and do not charge for electricity use.
- Promoting eBikes is a good option since EV still contribute to traffic congestion.

Question: What concerns you about charging infrastructure needs over the next 15 years?

- The uncertainty about employee behaviors and infrastructure needs post COVID-19. For example, the need for more chargers at workplaces may greatly reduce if many people continue to work from home long-term.
- Infrastructure costs will remain an issue as EV adoption increases.
- Fleet management.
- Equity around access to the infrastructure.

3.2.7 TNC Drivers

Question: What are the advantages of driving an EV?

- Fuel cost savings.
 - Before driving an EV, one driver spent about \$300 per week on gas. They now subscribe to PGE's Greenlots program, which only requires a low monthly fee to use Direct Current Fast Charge throughout the Portland metro area.
- Decreased maintenance.

Question: What issues do you experience as an EV driver?

- Faulty card readers.
 - Chargers need to accept credit cards through platforms like tap to pay or Apple Pay because sometimes credit card readers are not functional

- Broken chargers.
 - People mishandle the charger connectors or leave them on the ground after they have finished charging. This can break the charger connectors and leave them unusable
 - A station can be out of order for a month, which does not happen with gas stations
- Safety while charging.
 - Charging stations that are hidden or out-of-the-way can be unsafe, especially at night. They should be in visible, well-lit locations
- Charging wait times.
 - There are often waits at Portland Electric Avenue, often caused by people who leave their cars for hours after they are done charging
 - Free charging can have a negative outcome; it does not motivate people to move their car once charging is complete, creating queues and wait times

Question: How many miles do you drive per day and how low do you let the charge go before you start to prioritize charging?

- Before COVID-19, one driver drove 300 miles per day but currently drives about 200 miles per day. Range is reduced in the winter because the battery is less efficient in the cold.
- Do not like to go under 40 miles before recharging.
- Both participants fast charge 3–5 times per day.

Question: In your observations, how long does it typically take to repair broken chargers? What typically breaks?

- Heavy usage is a precursor to break downs; break down causes vary.
 - One charger would not take payment, but drivers could still charge their cars
 - Some chargers appear to have communication errors that could be related to software
 - Downtown chargers often have broken clips/connectors that will not plug into the car
 - Holsters can be broken and laying on the ground

Question: Where are additional charging stations needed?

- In and around downtown Portland.
- Grocery stores, libraries, retail locations and tourist attractions in outlying areas.
- Where people begin and end their trips (suburbs and downtown, for example).
- Apartment buildings. If you expect people to get into electric vehicles, charging needs to happen where they live and currently this is a barrier.

Question: What are the priority charging infrastructure needs or barriers over the next 15 years?

- More chargers in high-use areas. Can often wait up to an hour to charge downtown.
- Fast chargers needed along corridors and in outlying areas in order to reliably travel, recreate outdoors, etc.
- Make public charging affordable.
- Increase at-home charging at multi-unit dwellings.
- Serve equity communities, not just the wealthy.

3.2.8 Freight/Delivery Representatives

Question: What EV or electric equipment do you have?

- Forklifts and yard tractors
- No heavy-duty trucks are commercially available today, but are being piloted
- Shared staff vehicles
- Daimler is deploying eCascadia and step vans
- Portland International Airport
 - Current passenger bus fleet from the parking areas to the terminal is compressed natural gas, transitioning to renewable natural gas. Looking to transition to electric
 - Interested in working with airport partners on electrifying ground transportation vehicles

Question: What are the barriers and needs for going electric?

- Charging and power capacity.
 - Supporting large fleets will require a lot of power capacity. Utilities need to plan long-term to ensure the power is available when needed
 - Light- and medium-duty electric vehicles that operate during the day are best suited for electrification. They can charge in the depot and at night instead of charging mid-trip
 - Electrify classes 1–6 first; other fuels may be better for other classes
- High cost of vehicles and infrastructure.
 - Challenging for freight/delivery companies to invest in the infrastructure (vehicles, chargers, and any other upgrades) on their own
 - Retrofitting existing operations with the needed utilities is complex and costly
 - Cost of ownership is difficult for agencies like school districts looking to transition to electric buses. The miles driven, and thus the cost savings per mile, do not accumulate to enough savings to make the switch feasible
 - Freight companies may opt to lease electric trucks or utilize a shared equipment model rather than purchasing
 - Many trucking companies in Oregon are independently owned and operated by people from diverse backgrounds who many not have the resources to invest in electric trucks and chargers
 - Supply and incentives drive vehicle purchases. The Oregon credit is expiring and will limit ability to purchase vehicles
- Long duration of utility upgrades.
 - Fleet managers need to schedule appropriate installation times (18–24 months) with the proper power level. For example, planned upgrades may accommodate five trucks, but adding one more truck will trigger another upgrade
- Streamline permits for charging units.

- Design rates that incentivize certain charging times, like charging at night.
- More complex logistics.
 - Current trucking logistics are challenging; charging requirements will increase the complexity
 - Until there is infrastructure available that can support quick and easy charging, electrification does not seem feasible
- Corridor charging gaps.
- Other more suitable alternative fuel options, like hydrogen fuel cells.
- Lack of charging infrastructure for independent owner operators.
 - Look for shared charging opportunities
 - Engage truck stops
 - City/state shared pilot programs

3.2.9 Historically Underserved Communities

Question: How much awareness is there about electric vehicles (EV) and their benefits in your community? What are your ideas for increasing awareness?

- Current awareness and perception of EV:
 - Currently there is not widespread understanding of the capabilities of EV, including fuel cost savings and the distance EV can travel on a single charge
 - EV are not seen as an affordable solution; not considered mainstream or accessible
 - EV are perceived as luxury items
- Increasing awareness in the community:
 - Peer-to-peer connection will be most effective; engage community ambassadors and liaisons
 - Community-based education and awareness campaign. Co-create messaging with community members and provide information in language to avoid the language barriers that exist today
 - Providing rideshare EV and a charging station at local churches could familiarize the community with EV and the charging

- NAACP's new solar project is a good opportunity for ride & drive events and educational opportunities

Question: What are the potential barriers to electric vehicles (EV) in your community?

- Vehicle cost and financing.
 - Purchase will be more realistic when used models are more available at reduced costs
 - Access to resources including fair financing terms can be a barrier
- Charging access and cost.
 - Homeownership can be low among some disadvantaged communities. Less access to dedicated parking (garages or driveway) and reduced access to charging at home are barriers
 - Multi-unit dwellings need to have enough charging infrastructure to enable to disadvantaged communities to adopt EV. It is expensive to install charging infrastructure and may not happen quickly. Public charging does not result in the fuel cost savings

3.2.10 Developers, Property Managers, Multi-unit Dwelling Owners

Some property manager participants noted that they are EV advocates and the EV charging features they provide to tenants should not be considered typical.

Question: Do you provide parking for residents?

- Many participants have parking for residents.
- Participant with multiple apartment complexes has a parking spot of varying types for each unit.
 - If a tenant buys an EV, they will get charging; generally, 110v with 240v at some locations
 - Charging is currently free but may transition to a monthly charge or paid meter usage
 - To meet code, developers must install infrastructure that could handle the maximum demand, which is "overkill sizing;" utilities may give credits to offset cost
- Participant with condo development has deeded spaces.
 - Has conduit and electrical service to charge at 240v

- No conduit for guest parking
- Line-extension fee to charger is expensive. Utility does not have the ability to split the costs between the developer and homeowners' association/owners
- Submetering is not economical
- Participant with apartment complex has all parking spaces wired with 110v and conduit for at least 240v.
 - Parking is additional cost; EV spaces are discounted according to daily mileage
 - OpConnect chargers verify and differentiate between billings
 - 110v chargers cannot be monitored but are turned off when not in use
 - Working with electric utility to figure out meter and submeter layout (separate meter for parking/charging for each tenant).
- Condominium complex participant has deeded parking.
 - 240v conduit is very expensive (\$3,000 per space). A large investment for low energy use. Need to find option to share capital costs among multiple users
 - Cyberswitch (similar to OpConnect) unit shares a dedicated 240v circuit to serve four cars

Question: If residents request EV charging, what is your concern?

- Utility requirements and high costs of installing infrastructure.
- Difficulty sharing infrastructure capital costs among multiple users.
- Retrofitting complexity and costs.
 - Existing apartments may not have the utility capacity or physical infrastructure needed to install chargers
 - Installing completely new parking areas with new conduits, wiring, and panels costs less than current retrofit options

- Retrofitting challenges need to be solved because multi-unit dwelling (MUD) tenants' ability to charge at home is critical to accelerating electric vehicles (EV) adoption
- Metering/charging tenants.
 - When discussing perceived concerns among other apartment owners, many participants mentioned the ability to meter charging use and bill tenants:
 - Meters are expensive, as is the cost of using a third-party billing company. The cost of billing can be as much as the electricity usage, so developers often pay the electricity costs
- General planning concerns
 - The gas station of the future is people's garages. Tenants in multi-unit dwellings should be provided a unique charging spot rather than a shared charging option
 - Need to create a demand for chargers at MUD owners need to be collaborative partners, or it will be difficult for tenants to own EV
 - The demand for charging is growing among condominium buyers and current owners
 - Size electrical panels to accommodate chargers and run the conduit and wire later
- Provide state-implemented tiered incentives, such as one incentive for sites that are EV charger capable and another for sites that have already installed chargers
- Once EV charger readiness is required in building codes, incentives will not be available. Incentives exist to exceed requirements, not to meet them
- EV-ready building codes.
 - Currently there is an amendment for new residential construction to support Level 2 charging (scheduled for adoption October 2022), with a commercial amendment to follow
 - Making new development EV-ready requires a much smaller investment than retrofitting existing development
 - These requirements will add costs to new development and may result in less parking
 - EV-ready building codes should differentiate between MUD and single-family dwellings
 - Access to knowledgeable electrical contractors.
 - Level 1 and 2 charging meet most needs, are cost-effective, and have less impact on the grid; Direct Current Fast Charge (DCFC) is not economical.
 - Provide Level 1 charging at tenant parking spots with a DCFC hub in the urban center.
 - Strategically incentivize condominiums and apartments to make EV charging more accessible.
 - Start a group of MUD owners and managers to exchange EV charging best practices, information, and ideas.
 - Get MUD to harvest clean fuel credits.
 - Landlords and managers need to recover costs and generate revenue.

Question: How do tenants charge their eBikes or eScooters?

- Bike rooms have outlets. Bill at a flat rate to those who park there.
- Energy cost is quite low, so a monthly charge is the preferred method.
- Looking to evaluate charging patterns.

Question: How could you speed EV adoption, focusing on MUD?

- EV-ready incentives and support.
 - For most landlords, installing chargers and needed infrastructure is a financial decision; incentives can make it feasible
 - Qualify MUD for Oregon Clean Fuels program credits
 - Provide line-extension credits; costs absorbed by the utility instead of developers

3.2.11 Farming/Ranching Representatives

Question: What gaps need to be filled to support electric adoption? Has anyone adopted electric equipment or vehicles yet?

- Many participants do not have any electric farming/ranching vehicles or

equipment but are researching options. Some had personal electric vehicles (EV).

- Once EV trucks and ample infrastructure are available, the industry will make the switch.
- Equipment reliability and charging time is crucial.
- Many farmers have a home operation and lease farming property elsewhere. They transport fuel tanks to their sites for equipment refueling; something they could not do with chargers
- Overnight charging is not a worry but stopping to charge vehicles or equipment during the day is a concern
- Not being able to fix equipment yourself is a concern, and servicing may be difficult
- Cost-effectiveness issues.
- Due to the cyclical demand of farming equipment, the high costs do not pencil out for farmers who may only use it a few weeks each year
- High speed chargers are expensive
- The agriculture community is excited about the shift to electric, but the numbers must make sense

Question: Are there advantages to going electric that you see for farming/ranching if costs pencil out?

- Self-sufficiency.
- Potentially better efficiency.
- Lower carbon emissions than other fuel sources. However, transportation from the farm also needs to be considered. Most emissions produced from agriculture-related activity are from the transportation of goods, not the farming itself.

Question: What type of farming do you see as a good fit for electrification?

- Agricultural equipment varies drastically between what is used on eastern Oregon farms and Willamette Valley farms.
- Nurseries and farms with high density, high value crops like vineyards, blueberries, and hazelnuts are probably the best fit for electric equipment in the near-

term. Wheat is down the list because it requires much larger equipment.

3.2.12 OEMs/EV Dealers

Participants representing dealers noted that they are fully committed to EV and may not represent typical dealers.

Question: What kind of charging would do the most to enable faster and easier sales of electric vehicles?

- All charging types are needed. People will go on a road trip one week and have a short commute the next week. Direct Current Fast Charge (DCFC) chargers are important on corridors and in urban areas; Level 2 at workplaces, etc.
- Plan for the future: Level 1 chargers meet a lot of today's needs, but as vehicles get bigger and heavier that will no longer be the case.

Question: What complaints or questions about charging do you hear most from customers?

- The majority of EV customers have done their homework and are very knowledgeable about charging.
- Most customers have some level of range anxiety.
- Most charging questions are from customers who become curious about EV once they are at the dealership.
- Questions cover charging locations; the different charging levels; how far they can drive on a charge; and how long it takes to fully charge
- Most EV have access to manufacturer apps that provide onboard concierge services. Dealers also provide area charging maps and suggest other established apps
- Most common post-sale comments are about charging stations that are not working.
- Concerns include the cost of EV relative to internal combustion engine vehicles and charging accessibility for apartment dwellers or people who park on the street.

Question: What has been the level of investment needed to pivot to electric?

- Original equipment manufacturer participant said there is a strong commitment to converting the fleet to electric.
- It is not ideal to train a specialist for one product line because it is expensive.
- Infrastructure. Rural dealer purchased a Direct Current Fast Charge (DCFC) to stay informed on how they work and lets customers experience it. Investment in the future.

Question: What is the industry doing or what can others do to create awareness and accelerate adoption?

- Approaches range from Super Bowl advertisements to local Ride and Drive events.
- Ride and Drive events are a lot of work with low rate of return.
- Dealers use electric vehicles (EV) for courtesy cars to let maintenance customers try them.
- Incentives are currently the biggest drivers in increasing EV adoption. There should not be an MSRP cap so that all vehicles are eligible.
- State fleet purchases can make a big difference and shows support of EV adoption.
- Early adopters are wonderful marketers to their friends, family, and co-workers.
- Social media and other lifestyle marketing.
- Rebates are a big reason people purchase EV. After factoring in the existing incentives, leases on EV are often cheaper than their internal combustion engine counterparts.

Question: What equity issues do you see and how can barriers be overcome?

- Charging access for multi-unit dwellings, which can include low-income residents, is the biggest challenge and barrier to EV adoption.
- Create incentives for low-income communities. The incentive should include the cost of the vehicle and the at-home charger.
- California may allocate a portion of their subsidies to the purchase of used EV for qualified low-income applicants. Unused funds would be applied to infrastructure investments.



Appendix D: Infrastructure Needs Assessment Modeling Results

Introduction

The basis of the modeling work performed for the Transportation Electrification Infrastructure Needs Analysis (TEINA) project is a set of three scenarios, described in this document, which outline possible economic trajectories for the state. These scenarios are deliberately constructed as narratives to create separation between the notional futures they depict and the modeling work that converts them into empirical projections for the needed electric vehicle charging infrastructure in Oregon between 2020 and 2035. This separation allows the trajectory of future events to be considered independently of actual electric vehicle (EV) adoption and charging infrastructure deployment trends, which might otherwise become too much of a central focus for the scenarios and anchor them to the world as it is, rather than opening them to the world as it might be.

The scenarios revolve around the impact of the COVID-19 pandemic (hereafter referred to as “the pandemic”) on the economy because the vigor of the economy will largely dictate how confident consumers feel about buying a new vehicle, and, as a result, how willing utilities, electric vehicle service providers (EVSP), and the public sector will be to invest in charging infrastructure to support those vehicles.

The purpose of the study is to bracket the likely future transportation electrification charging infrastructure needs of all modes of electric transportation (including light-duty vehicles (LDVs), transit, delivery, freight, and micromobility vehicles)

measured at three points in time (2025, 2030, and 2035) in order to meet the goals articulated under 2019 Oregon Senate Bill 1044. Those goals include:

- 50,000 registered zero emission vehicles (ZEVs) by 2020
- 250,000 registered ZEVs by 2025
- 25% of registered ZEVs and 50% of new vehicle sales by 2030
- 90% of new vehicle sales by 2035
- 25% of new LDVs purchased or leased by state agencies are targeted to be ZEVs by 2025, with exceptions
- All new LDV purchases or leases by state agencies are targeted to be ZEVs by 2029

Logically working back from those goals:

- We must understand what the economic conditions would need to be in order for the requisite numbers of EVs to be adopted.
- In order to understand the economic conditions, we must understand how the state might recover from the impact of the pandemic.
- In order to understand the pace of recovery, we must imagine how the state and its citizens respond to the trajectories of infection, the availability and efficacy of vaccines, and the various forms of support and stimulus offered by the states and the federal government.

Scenario Overview

Each of the three scenarios imagines a different trajectory for the Oregon economy between 2020 and 2035.

As a separate exercise, these scenarios will be used as a basis for a data model that depicts how electric vehicle (EV) adoption and charging infrastructure deployment might proceed under each scenario.

The scenarios contemplate a number of factors, such as:

- Overall economic vigor and activity
- Evolving technologies
- Consumer preferences
- Future policies
- The changing cost of charging
- Potentially changing demographics
- The economic effects of the COVID-19 pandemic
- How utility tariffs and infrastructure investment programs might evolve to accommodate the growing demand for transportation electrification
- How utility tariffs and investments may feed back onto the transportation sector, potentially changing demand levels, costs, and charging behaviors.

A brief summary of each scenario follows.

Scenario 1: Business as Usual

Before the pandemic, EV adoption and charging infrastructure deployment in Oregon were proceeding nicely. In 2018, Oregon was the number three state in the union in EV market share, behind only California and Washington.¹⁸ Therefore, it makes sense to consider what the trajectories of electrification might look like had the pandemic never happened. In this study, we use this scenario as a baseline for comparison to the other two scenarios and as a proxy for what a “business as usual” outlook might have been.

Scenario 2: Rapid Recovery

This “rapid recovery” scenario assumes that one or more vaccines are widely deployed so that the overall United States economy quickly returns to its previous vigor by the end of 2021. Considering the current understanding that at least two vaccines offer high (~95%) levels of efficacy; that more vaccines are on the way; and that the current expectation assumes that enough vaccines can be manufactured, delivered, and administered to enough of the United States population to achieve “herd immunity” at some point in 2021, this scenario will serve as a proxy for an “optimistic” outlook.

Scenario 3: Slow Recovery

This “slow recovery” scenario imagines a future in which economic activity remains depressed through the end of 2024 before quickly recovering to full vigor toward the end of the forecast period. This late, quick recovery is necessary in order to meet the objectives set out in Senate Bill 1044 by 2035, as all three of the scenarios must do.

This scenario contemplates possible logistical issues in distributing the vaccine (which have already occurred during the initial rollout); uncertain vaccine efficacy (which will probably not be known until the second quarter of 2021 or later); rapid mutations in dominant coronavirus strains (which we are already seeing) that render the vaccines less effective; severe and debilitating long-term effects of the virus (which we are already seeing in some “long-haulers” who have been infected and ‘recovered’) that make it difficult for people to return to their work and their normal lives; and poor vaccine uptake among “anti-vaxxers” so that it is harder to achieve “herd immunity” and restore the economy to full operation. As such, this scenario serves as a “pessimistic” outlook.

Scenarios in Detail

Here we describe the scenarios in detail and consider how each might affect the factors we will consider in the modeling exercise.

Scenario 1: Business as Usual—Life as if the pandemic never happened

This scenario uses the electric vehicle (EV) adoption and charging infrastructure trends that existed before 2020 as a basis and then applies a classic technology adoption S-curve to depict how those trends might have continued through 2035, had the pandemic never happened. This scenario will function as a baseline for comparison to the other two scenarios and as a proxy for what a “business as usual” outlook might have been. For example, if the economy reverts to the historical mean within two or three years, then the “rapid recovery” scenario would depict an unrealistically rapid economic recovery, while the “slow recovery” scenario would depict an unrealistically slow economic recovery. This Business as Usual Scenario would offer a more accurate view of the future.

Narrative

A fundamental economic vitality drives Oregon forward through 2035 at the same rates it had from 2009–2019, with a Compound Annual Growth Rate (CAGR) for real Gross Domestic Product (GDP) of 3.2% and a per-capita personal income growth rate of 4.1%.¹⁴

The largest industries in Oregon continue to grow at 2019 rates: finance, insurance, real estate, rental, and leasing at 2.3%, and government and government enterprises at 1.7% real growth.

Population distribution is expected to remain roughly the same as it was in 2019, with no major changes in the balance between urban and rural. However, urban areas continue to attract young urban professionals moving from other states.

With roughly half the GDP provided by professional services, disposable income is strong enough to ensure steady and growing demand for personal vehicles from a significant population that largely supports taking personal action to combat climate change.

EV sales continue to be strong. In 2018, Oregon ranked third in the country for

EV market share, at 3.41%⁶ and 2019 sales should have grown beyond 2018 sales.⁵³

The strong EV adoption trends give electric vehicle service providers (EVSPs) confidence in continuing to expand their charging networks throughout the state, especially in the urban areas where EV adoption is highest and the numbers of EV are the most concentrated. Growth of the charging networks is among the highest in the country, commensurate with EV adoption rates.

The strong support of the Oregon government and legislature for transportation electrification and reducing Vehicle Miles Traveled (VMT) of petroleum-fueled vehicles leads to increasing investment in bike- and pedestrian-friendly infrastructure in the urban areas, including protected lanes, exclusive rights of way, and urban redesign. These features enhance the reputation of Oregon cities as being bicycle and pedestrian friendly and attract a growing population that is interested in those features for their quality of life attributes. This lends momentum to a virtuous cycle of expansion for modes of transportation that do not rely on petroleum fuels or personal cars.

It also sends a signal of confidence to all parties on the supply side of the market (EVSPs, utilities, auto dealers, and auto service providers) and on the demand side (fleets, government agencies, and individuals). These industries and actors all contribute to a strong and vital transportation electrification sector.

A large, growing, and dense population of young, active, and environmentally conscious citizens in the three largest major urban areas (Portland, Salem, and Eugene) leads to one of the highest adoption rates for micromobility in the country. People increasingly choose to stop owning cars in favor of electric bicycles and scooters for routine travel along with ridesharing and carsharing services for occasional longer-distance trips.

The leading utilities in Oregon, which have already demonstrated leadership in offering co-investment in charging infrastructure and progressive tariffs that are supportive of transportation electrification, significantly ramp up their offerings. Investments in charging infrastructure at all levels of power demand and favorable tariffs become regular features of integrated resource plans.

As government, private sector providers, and utilities continue to make larger investments in

transportation electrification and mode switching away from personal internal combustion engine (ICE) vehicles, personal transportation based on light-duty electric vehicles (EVs) and electrified micromobility takes ever-growing market share year after year. This steadily drives down the per-mile cost of electrified personal mobility and drives up the cost of ICE-based personal mobility over the forecast period.

By 2025

EV in key segments have reached sticker-price parity with ICE vehicles, driving a spike in consumer interest. The market share for EVs is 8%, commensurate with the 2025 goal of Senate Bill 1044. Charging networks have expanded significantly. Public Direct Current Fast Charge (DCFC) are now available within a 50 mile radius of anywhere in the state, and Level 2 charging ports are increasingly getting installed in public, workplace and multi-unit dwelling parking lots. “Range anxiety” about the availability of charging stations isn’t really something anyone experiences anymore.

In keeping with the Senate Bill 1044 targets, 250,000 zero emission vehicles (ZEVs) are registered in the state, and 25% of new light-duty vehicles purchased or leased by state agencies are ZEVs. 95% of these vehicles are EVs, with the remainder being hydrogen fuel cell vehicles.

By 2030

The market share of EVs is over 30% and it’s obvious to all that EVs are the future. Driven by the electrification trends in the urban areas and the significant price advantage that EV now have over ICE vehicles, EV adoption spreads from the urban cores to the rural areas of the state, led by electrified pickups and electrified farm equipment.

In keeping with the Senate Bill 1044 targets, 25% of registered vehicles and at least 50% of new vehicle sales are ZEVs. All new light-duty vehicle purchases or leases by state agencies are ZEVs. EVs make up 95% of these vehicles.

By 2035

Gasoline stations that do not offer EV charging ports have started disappearing from the state, making it less convenient and more expensive to own a personal ICE vehicle. Gasoline station coverage has largely shrunk toward the major highway corridors. Rising state taxes on carbon-

emitting fuels as part of the state’s overall climate policies, and a shrinking global oil industry, also put upward pressure on gasoline and diesel prices. EV have become dominant in all vehicle classes.

It is becoming clear to all that using ICE vehicles will become increasingly inconvenient and much more expensive than EVs. EVs account for 90% of new vehicle sales.

Scenario 2: Rapid Recovery

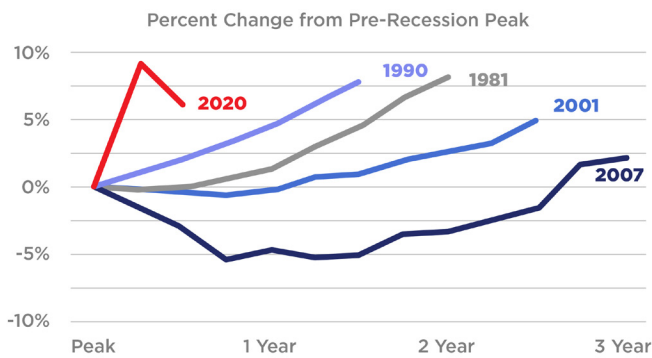
This scenario will use the EV adoption and charging infrastructure trends that existed through the end of 2019, then hold EV sales and charging port deployment flat throughout 2020 (unless 2020 data can be obtained in a timely fashion) and into the third quarter of 2021. This scenario assumes that no significant recovery in EV sales or charging port deployment will begin until Q4 2021, because not enough of the population can be vaccinated to restore normal, unfettered economic activity until late in the summer of 2021, even under a best-case scenario for vaccination.

Beginning with Q4 2021 this scenario applies the same technology adoption S-curve used in Scenario 1. The difference in Scenario 2 is that the S curve will start at a lower absolute level, after approximately two years of flat EV sales and charging port deployment, and the early part of the curve will have a steeper inflection than in Scenario 1, assuming a surge of pent-up demand is unleashed as the economy rebounds.

Narrative

In 2019, wages and salaries in Oregon grew by an average of 1.35% from quarter to quarter. With the onset of the pandemic, wages and salaries fell by 6.3% in Q2 2020, then rebounded by 5.9% in Q3. The loss of wages in Q2 was offset by personal transfer payments (such as stimulus or other relief payments), which allowed personal income to grow for each quarter of 2020 on a year-over-year basis. Personal income per capita in Q3 2020 was 8.1% higher than Q3 2019, and if that level of income were to persist through Q4 2020, 2020 would be an above average year in terms of personal income per capita. Leaving aside transfer payments, wages in Q3 2020 were about even with wages in Q4 of 2019. On the whole, the economic data reflect an economy that is already rebounding to 2019 levels or higher.

Figure D1. Total Oregon Personal Income



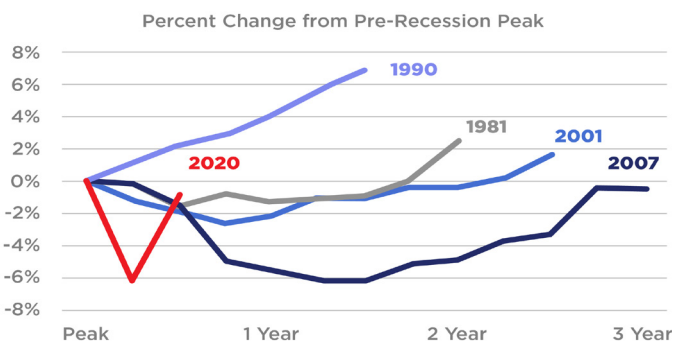
Source: Oregon Office of Economic Analysis²⁸

It is reasonable to expect 2019 levels of economic growth or higher to resume in 2021. Since we have entered 2021 with most Oregon counties, including the most populous counties, in a state of “Extreme” COVID-19 risk according to state data,²³ this scenario assumes personal income per capita levels will hold at Q4 2020 levels through Q1 and Q2 of 2021, with the likelihood of additional transfer payments offsetting any additional declines in wages and salaries.

To account for the effect of pent-up demand being unleashed once normality returns, Scenario 2 assumes above normal Compound Annual Growth Rates for Q4 2020 on the order of 5% for real Gross Domestic Product and 7% for per-capita personal income growth. (These numbers are not intended to be used in calculations for the modeling of this scenario. Rather, they are provided merely as a notional backdrop for the modeling, which concerns electric vehicle (EV) adoption and charging port infrastructure deployment. The modeled results for those outcomes are not directly calculated from the background economic data since there are no established relationships between economic indicators and EV purchasing or charging port deployment.)

Non-farm wages and salaries declined sharply in Q2 and rebounded sharply in Q3 2020.

Figure D2. Oregon Wages and Salaries



Source: Oregon Office of Economic Analysis²⁸

The two largest industries in Oregon—real estate, rental, and leasing and government and government enterprises—reflected this trend. Inter alia, the real estate sector saw record levels of business transacted in 2020 nationally, driven by the ultra-low interest rates the Federal Reserve implemented as part of its response to the economic damage of the pandemic. The other largest non-farm industry in Oregon, finance and insurance, posted strong growth in Q2 and modest growth in Q3, which may reflect the effect of transfer payments. By contrast, farm wages and salaries posted modest 0.4 to 2.5% growth in every quarter of 2020, reflecting the fact that it is an essential sector of the economy.⁵⁵

Scenario 2 assumes that EV sales trends in rural farming counties will be largely unaffected by the pandemic, whereas they will rebound more vigorously in urban professional counties. This scenario might expect the recovery to produce a more pronounced surge in EV adoption and charging port deployment in urban areas than in rural areas.

Although the rebounding economy should stimulate sales of EVs and internal combustion engine (ICE) vehicles alike, the sticker prices of EVs will continue to fall, driven by the long-running decline in battery costs. By 2024, most electric light-duty vehicles will reach sticker price parity with ICE equivalents. With the economy growing at above historical rates by 2022, this might lead to ICE vehicle sales taking as much or more market share as they had before the pandemic, but only for a year or two. Then, they will lose market share to EVs relatively quickly beginning in 2024.

As in Scenario 1, the increasing adoption of EVs steadily drives down the per-mile cost of electrified personal mobility and drives up the cost of ICE-based personal mobility over the forecast period.

Population distribution is expected to shift modestly from urban to rural areas, reflecting national trends seen during the pandemic. Many workers in professional industries who worked from home in 2020 and will be able to continue doing so have opted to move to less-congested, more rural locations. Although this scenario features an economic rebound, this scenario does not expect it to reverse these trends because many people who chose to move did so for quality of life reasons, not because of changes in income. The influx of young urban professionals to major population centers in Oregon that has been seen in recent years may temper somewhat, as those workers are drawn to more rural areas instead. Accordingly, this demographic

shift may increase interest in electric vehicle (EV) adoption in rural counties over the levels seen before the pandemic, and there will be more robust deployment of charging ports in rural than in urban areas. However, the charging ports deployed in rural areas are more likely to be privately owned than part of electric vehicle service provider (EVSP) networks.

With roughly half the state's Gross Domestic Product provided by professional services and a strong rebound in the sector, disposable income is strong enough to support growing demand for personal vehicles. Oregon may be expected to maintain its position in the top five states in terms of EV adoption.

The strong EV adoption trends give EVSPs confidence in continuing to expand their charging networks throughout the state, especially in the urban areas where light-duty vehicle (LDV) EV adoption is highest and the numbers of EVs are the most concentrated. Growth of the charging networks is among the highest in the country, commensurate with EV adoption rates. All parties on the supply side of the market (EVSPs, utilities, auto dealers, and auto service providers) and on the demand side (fleets, government agencies, and individuals) may be expected to seize the opportunity to accelerate electrification efforts, starting with light-duty EVs and charging ports. However, owing to the increased interest in rural parts of the state, and increased shipping activity in and out of the state driven by the sharp rebound, investment in charging ports for vehicles of all classes will be strong. Expected investments in corridor charging ports for transport trucks, charging ports for farm equipment in rural counties, and other investments that were thought to be years in the future might be pulled more into the present.

To support the increased demand for EVs of all weight classes, leading utilities in Oregon accelerate investments in charging infrastructure at all levels of power demand and offer tariffs that are favorable to EVSPs.

Investments in infrastructure and rights of way for bike- and pedestrian-friendly infrastructure, including micromobility options, could be less robust in urban areas under this scenario than in Scenarios 1 and 3, driven by a perception that everything is quickly going "back to normal" and the in-migration of young urban professionals falls off from the pace of the pre-pandemic era. Major cities may find that the counterbalancing effect of out-migration to other states or to more rural areas has reduced their tax revenues and are no longer able

to fund investments into modes of transportation that do not rely on petroleum fuels or personal cars as they had planned prior to the pandemic. In this scenario, the trends away from personal vehicle ownership that had existed before the pandemic could lose momentum or actually reverse, as more people now living in more rural areas now have to drive instead of taking public transit or other non-driving options. Transportation network companies (TNCs), like Uber and Lyft, could flounder in this scenario as the growth in ridership they experienced before the pandemic fails to return.

By 2025

EV have reached sticker-price parity with ICE vehicles, driving a spike in consumer interest. The market share for EVs is 15%—stronger than in Scenario 1 and well over the 1.15% share in 2020. Charging networks for light-duty EVs have expanded significantly. As in Scenario 1, public Direct Current Fast Charge (DCFC) are available within a 50-mile radius of anywhere in the state, and Level 2 charging ports are increasingly getting installed in public, workplace, and multi-unit dwelling parking lots. "Range anxiety" about the availability of charging stations isn't really something anyone experiences anymore. Proposed upgrades to underpowered charging ports and expansion of charging stations along the West Coast Electric Highway have been made, and the 2025 targets in the West Coast Clean Transit Corridor Initiative have been fully met, including eight sites along I-5 in Oregon. Preparations are being made to align with California's Advanced Clean Trucks (ACT) rule, which will require new Class 7-8 semi-truck sales to be 30% zero emission by 2030 and 40% by 2035.

EV adoption is running slightly ahead of the Senate Bill 1044 targets, with 300,000 zero emission vehicles (ZEVs) registered in the state. Adoption by state agencies is also ahead of the targets, with 30% of new light-duty vehicles purchased or leased by state agencies being ZEVs. 95% of these vehicles are EVs, with the remainder being hydrogen fuel cell vehicles.

By 2030

Driven by their superior economics, the market share of light-duty EVs is nearing 60% and EVs are quickly gaining share in all other market segments. There is broad support for adopting EVs wherever vehicles are suitable for the use case in both urban and rural environments. For specialized applications where EVs have far lower costs of ownership, like refuse

trucks and forklifts, electric models enjoy very high (90% or higher) market shares. Electrified pickups and electrified farm equipment are commonplace and no longer regarded as novel in rural communities, but are not yet dominant in the overall rolling stock.

Adoption of electric vehicles (EVs) is above the Senate Bill 1044 targets for 2030, with 35% of registered vehicles being zero emission vehicles (ZEVs). All new light-duty vehicle (LDV) purchases or leases by state agencies are ZEVs. EVs make up 95% of these vehicles.

By 2035

As in Scenario 1, gasoline stations have started disappearing from the state, making it less convenient and more expensive to own a personal internal combustion engine (ICE) vehicle. Gasoline station coverage has largely shrunk toward the major highway corridors. Rising state taxes on carbon-emitting fuels as part of the state's overall climate policies, and a shrinking global oil industry, also put upward pressure on gasoline and diesel prices. EVs have become dominant in all vehicle classes.

All of these factors accelerate transportation electrification as ICE vehicles become increasingly inconvenient and much more expensive than EVs. EVs account for over 90% of new vehicle sales.

Scenario 3: Slow Recovery

In this scenario, rapid mutations of the coronavirus require ongoing innovation in vaccines; issues with distributing and administering the vaccines make it difficult to vaccinate enough of the population to reach "herd immunity" levels and restore normal unfettered economic activity; immunity effects prove to be short-lived, requiring annual vaccinations of at least 70% of the population to maintain protection; and a significant share of those who "recovered" from COVID-19 experience chronic health issues that prevent them from returning to normal full employment. Humanity does not finally get the virus under control so that normal life can resume until 2025. From 2021-2024, a severe recession is firmly in place.

To model this scenario, the levels of EV adoption and charging infrastructure deployment that existed at the end of 2020 will be held flat throughout 2024. No significant increase in EV sales or charging port deployment will occur until 2025.

After four years of economic stasis marked by recurring lockdowns imposed in response to

waves of new infection, by the end of 2024 the economy is weak, unemployment rates are high, and the ability of federal and state coffers to cover the shortfalls and support the unemployed is wearing thin. Everyone is looking to the federal government to pull the economy out of its slump, using printed money if necessary.

However, because all three scenarios must achieve the targets set forth in Senate Bill 1044, an extremely rapid transition to EVs commences in 2025, with steep adoption curves for EVs and aggressive investments in charging infrastructure in both the public and private sectors. These investments in electrification are not only driven by the motivations that existed before the pandemic; they are now considered to be vital economic stimulus programs as well, with surging federal and state investment to reinvigorate a moribund economy that has sustained significant damage.

Beginning with 2025, this scenario applies steeper S curves than in Scenario 1 to model a rapid transition to EVs and the requisite charging infrastructure to support them.

Narrative

For the period between 2021 and 2024 in Scenario 3, all economic indicators in Oregon show no significant growth. Wages are stagnant, and personal income per capita slowly declines throughout the period as more workers lose their jobs. This scenario assumes that the federal aid received in 2020 as transfer payments will not be repeated, apart from occasional efforts to stanch the bleeding in various sectors of the economy. By the end of 2024, 20% of the eligible workforce is unemployed, the Federal Reserve can no longer stimulate economic growth with further monetary stimulus, Oregon has run its reserves dry, and any attempts to provide further federal aid to individuals has to overcome the opposition of those who are concerned about the rising mountain of national debt. Many businesses have failed, especially in the sectors of the economy that suffered most in 2020, and both the public and private sectors find it difficult to raise investment capital for transportation electrification.

New vehicle sales of all weight classes and all kinds (both EVs and ICE vehicles) will be depressed until 2025. Fleet managers and individual personal vehicle owners alike try to keep their existing vehicles on the road a bit longer to avoid the cost of buying a new vehicle. In the absence of vigorous and growing EV market, electric vehicle service providers scale back their deployment plans for

new charging ports and wait for the economy to recover and new vehicle sales to rebound.

Although new vehicle sales are anemic in Scenario 3, auto manufacturers remain committed to the EV strategies they had adopted before the pandemic. Their continued efforts to squeeze out the costs of EVs, especially in battery components, will yield results, and EVs still achieve sticker price parity with internal combustion engine (ICE) equivalents by 2025. Accordingly, EVs slowly increase their market share, albeit in a lackluster market.

When the virus is finally brought under control by the end of 2024, and normal economic activity can resume, only a major federal stimulus program will have the power to reinvigorate the economy. In 2025, the United States Congress takes aggressive action and embarks on an infrastructure investment program that dwarfs the New Deal, putting tens of millions of people to work. Part of the program is a “cash for clunkers” program designed to replace every light-duty ICE vehicle older than five years with an EV. It also offers substantial rebates and tax credits aimed at electrifying medium- and heavy-duty vehicles and creates funding channels that provide federal dollars directly to utilities that support the expansion of charging infrastructure across the country.

Non-farm sector jobs in Oregon have contracted to pre-2019 levels as the pandemic has raged on, and while they do rebound in response to the new stimulus investments, the majority of the federal aid flows to sectors, like construction and engineering, that are directly involved in infrastructure projects. Farming and ranching jobs have not sustained as much contraction or damage as the professional sector because they are critical jobs sustaining the flow of food and other essentials.

With more disposable income available to them, workers in rural farming and ranching counties may be more able to buy new vehicles than workers in largely urban professional counties, and EV sales and charging port deployment may rebound more strongly in rural than in urban counties for the first few years. However, once the professional classes get back on their feet circa 2027, they are likely to lead in EV adoption, and urban areas will see more pronounced activity in charging port deployment.

As in the other two scenarios, the increasing adoption of EVs steadily drives down the per-mile cost of electrified personal mobility and drives up the cost of ICE-based personal mobility over the forecast

period, only these effects start later due to the economic damage of the pandemic through 2024.

Population distribution shifts asymmetrically. During the 2021-2024 recession, wealthier citizens who can afford it seek refuge from the pandemic in more remote and rural areas where they can continue working from home and enjoy a slower-paced, higher quality of life. Whereas low- and middle-income citizens and early-career professionals may find it easier to live in cities where they can rely on walking, micromobility, and public transportation instead of owning their own cars. Car-dependent suburbs may experience net outflows of residents as a result, accompanied by declining property values, at least until the stimulus-driven rebound kicks in.

Because micromobility options are so much cheaper than owning a car or using ridehailing services, they experience a surge of popularity in the 2021-2024 period within cities. Cities begin planning to accommodate this shift in mobility. Effectively, the longer it takes to restore normality, the less likely it is that we'll rebound to the way things were, and the more opportunity there will be for new or changed modes of living and mobility to gain traction.

To support the increased demand for EVs of all weight classes that are supported by the infusion of federal infrastructure spending, leading utilities in Oregon make larger investments into charging infrastructure than in the other two scenarios at all levels of charging port power demand. They also offer tariffs that are favorable to EVSPs and launch co-investment programs with site hosts to reduce the capital cost of building charging ports.

By 2025

Driven by the increasing popularity of transportation modes that do not rely on cars, cities devote a significant share of their federal infrastructure dollars to investments in infrastructure and rights of way for bicycles, pedestrians, and other micromobility modes instead of rebuilding all the automobile-based infrastructure. Lanes or entire streets are permanently repurposed for these modes. Urban parks, public squares, and shopping areas catering to pedestrian traffic spring up around them. Personal vehicle ownership as a whole starts to decline, albeit at a very gradual pace.

To meet the remaining need for car-based mobility, transportation network companies gain significant market share. When the economic rebound begins in 2025, many people who switched to

micromobility options don't switch back to car ownership, so new vehicle sales to those citizens remain low. Instead, when they need a car, they turn to transportation network companies (TNCs) and car-sharing and car-rental services, which experience sharp growth starting in 2025. Enabled by federal stimulus and infrastructure spending, autonomous vehicle technology is deployed in Oregon cities by 2026, and over the subsequent five years, scales to full commercial levels.

Electric vehicles (EVs) have reached sticker-price parity with internal combustion engine (ICE) vehicles, attracting strong consumer interest from those who still wish to own a personal vehicle. The market share for EVs is 25%—stronger than in the other two scenarios—albeit at lower absolute sales levels.

To meet the increased demand for ridehailing services, there is more demand for high-speed public charging stations. Level 2 charging ports, especially at residential and workplace locations, grows less quickly than public Direct Circuit Fast Charge (DCFC). Public DCFC are being deployed in much greater numbers and are available within a 25-mile radius of anywhere in the state. The market for Level 2 charging ports is still mostly residential, as public DCFC run away with the public charging market, and workplace charging stations start to look like infrastructure at risk of being stranded as TNC use and autonomous vehicles become more common.

EV adoption overall is still below the Senate Bill 1044 target for 2025 but has started growing strongly. With the support of federal stimulus money, adoption by state agencies is ahead of the targets, with 50% of new light-duty vehicles (LDVs) purchased or leased by state agencies being zero emission vehicles (ZEVs). All these vehicles are EVs because, in the 2021-2024 recession, the hydrogen sector has been unable to mobilize the capital needed to create a viable hydrogen production and distribution network for vehicles.

By 2030

The long-expected conversion of drivers to riders in autonomous vehicles arrives by 2030, but the mix of TNC riders and new EV owners leads to a different topology of charging infrastructure than in the other two scenarios. EV owners largely depend on Level 2 charging at home and use public DCFC for longer trips. Those who have elected not to own a personal vehicle anymore are now served by autonomous vehicles provided through TNC services. Because those vehicles are autonomous, and the cost of

recharging them is trivial, they increasingly use charging depots that are not located on expensive real estate in city centers, as they were when they were driven by professional drivers. Instead, their charging depots are located where provisioning high levels of utility power is cheapest, such as former brownfield industrial sites equipped with high-capacity grid power or in proximity to utility substations or even power plants. These industrial charging depots may even become fully automated, using wireless charging or some other technology to eliminate the need for charging attendants to connect and disconnect charging cables.

Driven by the federal stimulus spending in infrastructure, all highway corridors are being outfitted with DCFC every 10 miles or so. Medium-duty and heavy-duty vehicles are replaced with electric models at a rapid clip under the federal "cash for clunkers" program. Like the West Coast Electric Highway and the West Coast Clean Transit Corridor Initiative programs on steroids, large charging depots catering to fleets of transport trucks are being constructed at key junctions across the state, with the intent of eliminating all ICE vehicles of all classes by 2035.

Driven by their superior economics and efficiencies of scale arising from the electrification of all vehicle classes and use cases at once (instead of being largely led by LDVs), the cost of EVs plummets. EVs quickly start to eclipse the market for ICE vehicles, with the market share of light-duty EVs at 70% and EVs quickly gaining market share in all other vehicle classes. There is broad support for adopting EVs wherever vehicles are suitable for the use case in both urban and rural environments. As in Scenario 2, electrified pickups and electrified farm equipment are commonplace and no longer regarded as novel in rural communities.

Adoption of EVs is still slightly below the Senate Bill 1044 targets for 2030, with 30% of registered vehicles being ZEVs. However, they are quickly on their way to exceeding the 2030 target thanks to their outsized market share. All new LDV purchases or leases by state agencies are ZEVs. The cost of EVs has fallen so sharply, and the performance of batteries across the LDV sector has been more than sufficient, that there is no longer an opportunity for hydrogen fuel cell vehicles to catch up, and all of the vehicles purchased by state agencies are EVs.

By 2035

By 2035, gasoline stations have become virtually non-existent. Charging infrastructure is so ubiquitous

that only hobbyists and enthusiasts still own petroleum burners. Personal vehicle ownership has plummeted to levels not seen in a century. Electric Vehicles (EVs) have become utterly dominant, with 95% market share in all vehicle classes. In part owing to the reduced cost of transportation across the board, the economy is roaring. State and federal stimulus spending is no longer needed. Instead of focusing on how to reinvigorate the economy, state agencies are thinking about ways to optimize the new arrangements of vehicles and charging infrastructure, such as novel mobility services dispatched on demand. These new services may begin displacing transit buses and light-duty inner city trains. There are few actual drivers anymore, as autonomous technology has become a feature of all new vehicles.

Modeling and Findings

Objectives

The purpose of the study is to bracket the likely future charging infrastructure needs of all modes of electric transportation, including light-duty vehicles (LDVs), transit, delivery, freight, and micromobility vehicles, during the modeling period of 2020–2035, as measured at three milestone years (2025, 2030, and 2035), in order to meet the goals articulated under 2019 Oregon Senate Bill 1044. Those goals include:

- 50,000 registered zero emission vehicles (ZEVs) by 2020
- 250,000 registered ZEVs by 2025
- 25% of registered ZEVs and 50% of new vehicle sales by 2030
- 90% of new vehicle sales by 2035
- 25% of new LDVs purchased or leased by state agencies are targeted to be ZEVs by 2025, with exceptions
- All new LDV purchases or leases by state agencies are targeted to be ZEVs by 2029

We translated those goals into the following incremental goals that were used in the modeling.

2020	50,000 ZEVs
2025	250,000 ZEVs
2030	25% registered LDVs and 50% annual new ZEV sales
2035	90% annual new ZEV sales

Milestone Years

The modeling aimed to estimate the needed charging infrastructure at three “milestone years” spaced at five-year intervals include 2025, 2030, and 2035.

Charging Needs Assessment by Use Case

The TEINA charging needs assessment was done by modeling the charging requirements for the following nine use cases at each of the three milestone years under each of the three scenarios detailed in [“Scenario Overview” on page 14](#).

- Urban LDVs
- Rural LDVs
- Corridor LDVs
- Local Commercial and Industrial Vehicles
- Transit and School Buses
- Transportation Network Companies (TNCs)
- Long-Haul Trucking
- Micromobility
- Disadvantaged Communities

Our assumptions and methodology for modeling the use cases is as follows:

Urban and Rural LDV

We modeled the need for urban and rural LDV charging ports using a three-step process:

Step 1: We developed a forecast for the total number of LDVs—including both EVs and internal combustion engine (ICE) vehicles—throughout the modeling period.

Step 2: Using a combination of EV/ICE ratios and independent growth rates for EV and ICE, we forecast the number of LDVs that will exist statewide in each of the milestone years.

Step 3: We determined how many charging ports would be needed to support that number of EVs using a combination of workplace Level 2, public Level 2, and public Direct Current Fast Charge (DCFC) charging ports. (Residential charging was considered exogenous to the model.) This determination was based on six regression models that we derived from hundreds of runs of the EVI-Pro Lite modeling tool from the National Renewable Energy Laboratory (NREL).

Our assumptions for the ratio of Plug-in Hybrid Electric Vehicles (PHEVs) to Battery Electric Vehicles (BEVs) in the urban and rural cases, based on the current ratio in Oregon, and expected trends, were as follows:

Year	PHEV20	PHEV50	BEV100	BEV250
2020	9%	24%	25%	42%
2025	7%	18%	27%	49%
2030	4%	11%	28%	57%
2035	1%	5%	29%	65%

Our assumptions for each scenario were as follows:

Base Scenario

For Step 1, the total light-duty vehicle (LDV) growth trend was set at a 2.5% compound annual growth rate (CAGR), consistent with the growth trend of LDVs in Oregon from 2014-2019, from 2020 to 2035.

For Step 2, the number of urban and rural EVs required in all milestone years to achieve the incremental goals as included in Senate Bill 1044 are calculated. The ratio of EVs in urban-to-rural areas is based on the existing ratio of passenger vehicles in urban-to-rural areas. Census tracts were defined as urban or rural based on population density and employment density, as explained in Appendix A. The existing passenger vehicles in each census tract are calculated by assigning the number of passenger vehicles in the county (taken from the 2019 Oregon Motor vehicle Registrations by County) to census tracts proportionally to the number of vehicles available to households in the census tract (taken from the 2019 American Community Survey). The ratio of existing passenger vehicles and expected EVs is 1.75 urban-to-rural.

For Step 3, we used the number of EVs determined in Step 2 as inputs to our regression models. Residential charging is another key input into the regression models. We assumed that 90% of all LDV charging is at home in 2020, decreasing linearly to 60% in 2035. This implied that more workplace and public charging ports are needed to fulfill the residential charging gap. The output of this step gave us the number of charging ports of each type (workplace Level 2, public Level 2, and public Direct Current Fast Charge (DCFC)) statewide and in urban areas. Subtracting the urban totals from the statewide totals gave us the number of charging ports needed in rural areas.

Rapid Recovery Scenario

For Step 1, we assumed that the growth in LDV fell by 0.84% in 2020 and by 1.72% in 2021. We derived these factors by studying the last major economic disruption in the US: the 2008 global financial crisis. Then, starting in 2022, we forecast a 1.9% CAGR, consistent with the trend that obtained in Oregon from 2018–2019.

For Step 2, we assumed that the EV adoption rate in 2019 continued through 2021. Then, starting in 2022, we assumed that the EV adoption rate accelerated to achieve the goal set in Senate Bill 1044 for 2035, without requiring the model to achieve the incremental goals for the intervening milestones. The ratio of EVs in urban-to-rural areas remains 1.75, the same ratio as used under the Base Scenario.

For Step 3, we used the number of EVs determined in Step 2 as inputs to our regression models. Residential charging is another key input into the regression models. We assumed that 90% of all LDV charging is at home in 2020, decreasing linearly to 60% in 2035. This implied that more workplace and public charging ports are needed to fulfill the residential charging gap. The output of this step gave us the number of charging ports of each type (workplace Level 2, public Level 2, and DCFC) statewide and in urban areas. Subtracting the latter from the former gave us the number of rural charging port. Then we made the following adjustments to the share of each type of charging ports to reflect the effects articulated in the narrative scenario while maintaining roughly the same total number of charging ports.

	2025	2030	2035
Workplace Level 2	-10%	-18%	-10%
Public Level 2	7%	16%	15%
DCFC	22%	32%	14%

Slow Recovery Scenario

For Step 1, we assumed that the growth in LDVs fell by 0.84% in 2020 and by 1.72% for each year from 2021–2024. We derived these factors by studying the last major economic disruption in the US: the 2008 global financial crisis. Then, starting in 2025, we forecast a 2.4% CAGR which is consistent with the trend obtained in Oregon from 2015–2019.

For Step 2, we assumed that the EV adoption rate in 2019 (roughly 6,000 EVs per year) continued through 2024. Then, starting in 2025, we assumed that the EV adoption rate accelerated to achieve the goal

set in Senate Bill 1044 for 2035, without requiring the model to achieve the incremental goals for the intervening milestones. To reflect this scenario’s expectation of increased migration from urban to rural locations, the urban/rural ratio shifted 20% over the model years, from 1.75 in 2020 to 1.42 in 2035.

For Step 3, we used the number of EVs determined in Step 2 as inputs to our regression models. Residential charging is another key input into the regression models. We assumed that 90% of all LDV charging is at home in 2020, decreasing linearly to 60% in 2035. This implied that more workplace and public charging ports are needed to fulfill the residential charging gap. The output of this step gave us the number of charging ports of each type (workplace Level 2, public Level 2, and Direct Current Fast Charge (DCFC)) statewide and in urban areas. Subtracting the latter from the former gave us the number of rural charging

ports. Then, we made the adjustments shown in the charts to the right to the share of each type of charging port to reflect the effects articulated in the narrative scenario while maintaining roughly the same total number of charging ports.

Urban

	2025	2030	2035
Workplace Level 2	-31%	-38%	-29%
Public Level 2	37%	21%	-9%
DCFC	64%	145%	+72%

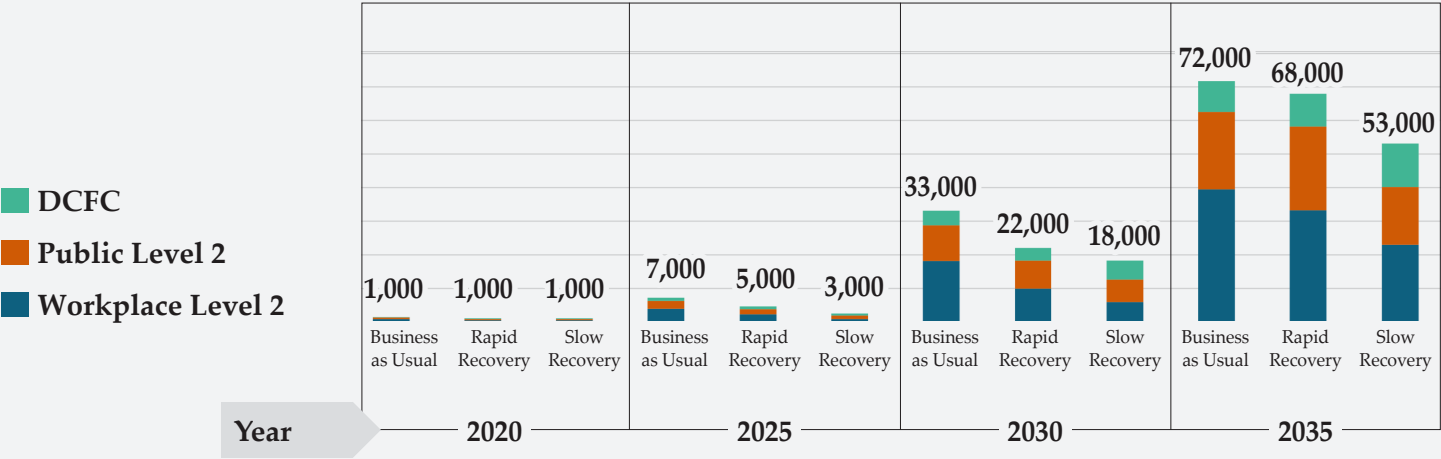
Rural

	2025	2030	2035
Workplace Level 2	0%	-14%	-27%
Public Level 2	0%	6%	7%
DCFC	0%	11%	32%

Results

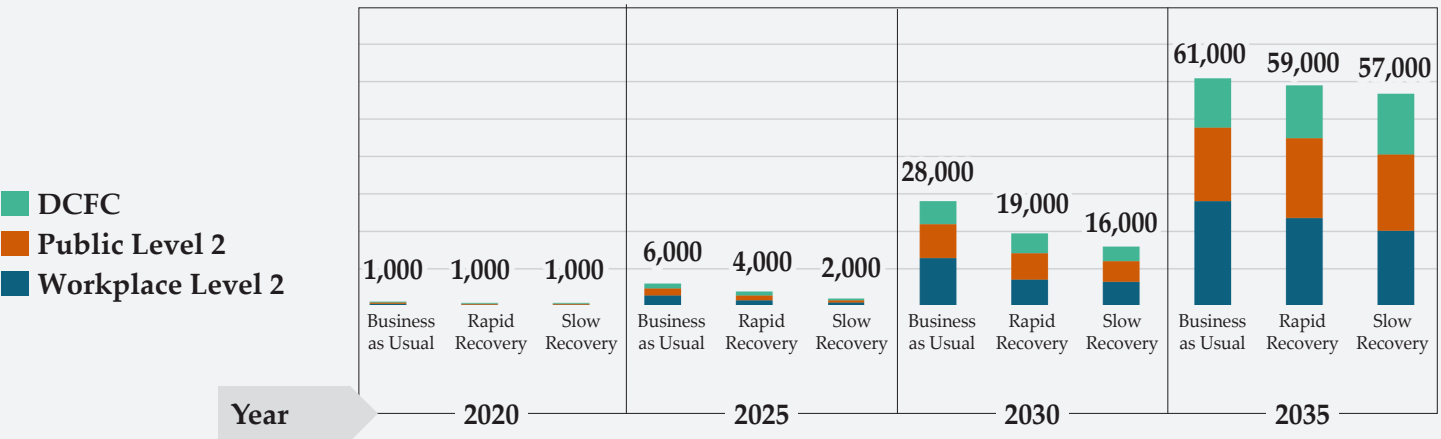
The results of this modeling are shown in **Figure D3** and **Figure D4**.

Figure D3. Charging Ports Needed for Urban eLDVs



Note: Modeling assumes 50,000 electric vehicles in 2020.

Figure D4. Charging Ports Needed for Rural eLDVs



Note: Modeling assumes 50,000 electric vehicles in 2020.

To produce the heatmaps in **Figures D5, D6, and D7**, the number of charging ports calculated at the statewide level were distributed to census tracts as follows:

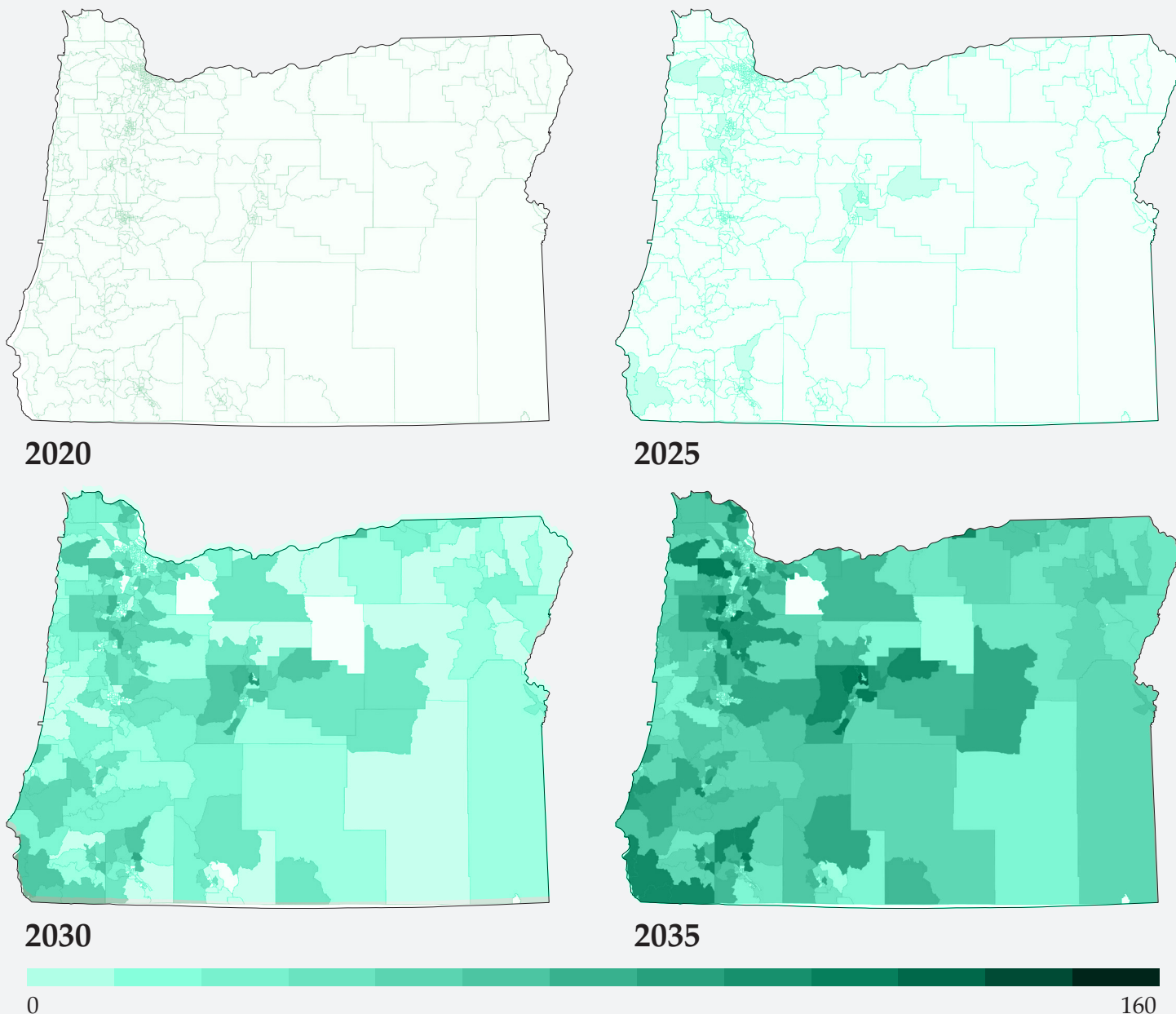
Urban Census Tracts:

- Allocate public Level 2 and public Direct Current Fast Charge (DCFC) charging ports proportionally to the number of existing passenger vehicles in the census tract compared to all urban census tracts in Oregon.
- Allocate workplace Level 2 chargers to census tracts proportionally to the number of jobs in the census tract compared to all urban census tracts in Oregon.

Rural Census Tracts:

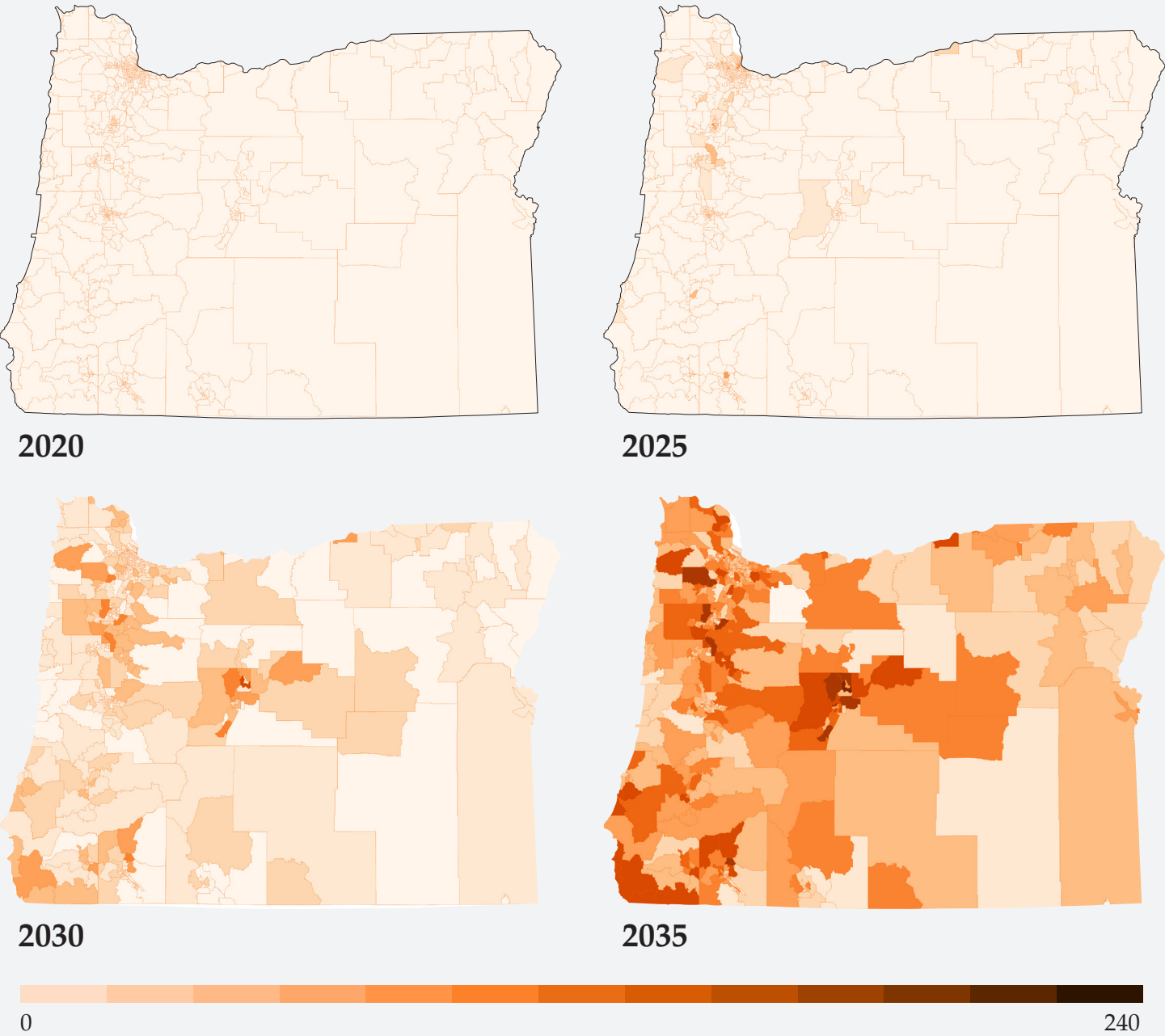
- Allocate public Level 2 and public Direct Current Fast Charge (DCFC) charging ports proportionally to the number of existing passenger vehicles in the census tract compared to all rural census tracts in Oregon.
 - Allocate workplace Level 2 chargers to census tracts proportionally to the number of jobs in the census tract compared to all rural census tracts in Oregon.
- DCFC Charging Ports Needed in Urban & Rural LDV Use Cases

Figure D5. Public DCFC Charging Ports Needed in Urban & Rural LDV Use Cases



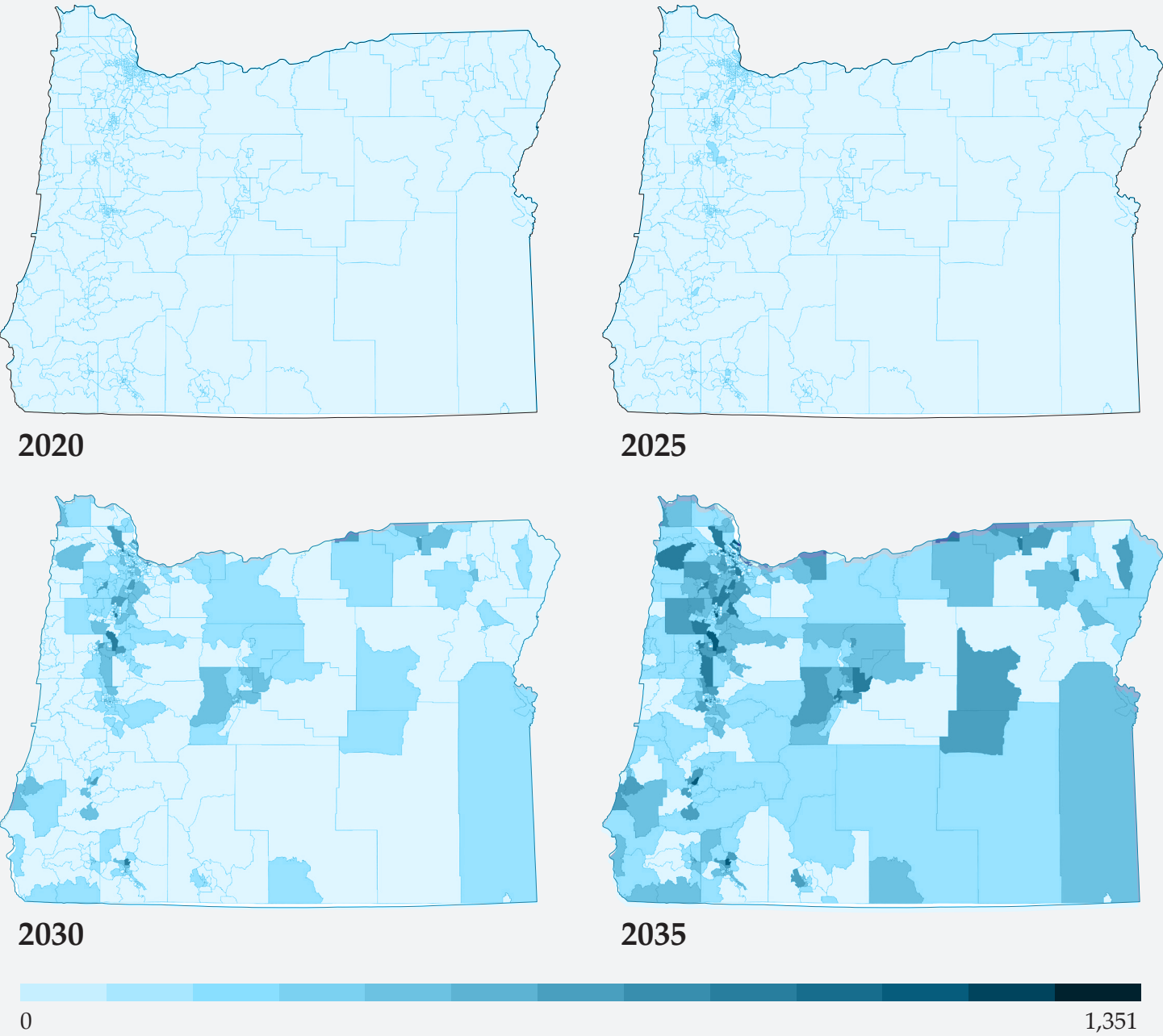
Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Figure D6. Public Level 2 Charging Ports Needed in Urban & Rural LDV Use Cases



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Figure D7. Workplace Level 2 Charging Ports Needed in Urban & Rural LDV Use Cases



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Corridor LDV

We modeled the need for light-duty vehicle (LDV) charging ports along major state corridors (I-5, I-84, I-82, US 101, US 97, US 20, and US 26) using a three-step process:

Step 1: We developed a forecast for the total number of LDVs traveling these corridors for the milestone years by interpolating between ODOT's Annual Average Daily Traffic (AADT) data for 2018 and 2038. After analyzing the historical traffic recorder data, we calculated that LDVs had an average 68% share of traffic on all major corridors in the state. This formed the basis for the subsequent corridor LDV electric vehicle (EV) calculations.

Step 2: We assumed that every LDV traveling these corridors in Oregon, even if their trips originate and end in other adjacent states, will need to gain 30% more energy using corridor charging ports in Oregon than is needed to finish their trips. This 30% can be interpreted in two ways: a) 30% of EVs will add more energy than is needed to reach the next available charging station, or b) on average, each EV will finish its trip with 30% more state of charge than it had when it started the trip.

We calculated the energy required for these stops by multiplying the vehicle's energy efficiency by the distance between each adjacent traffic recorder. For all scenarios, we assumed the following average vehicle efficiencies, recognizing that there will be a wide range of efficiencies between the LDVs that will use these corridors:

Year	kWh/mile
2020	0.3
2025	0.27
2030	0.23
2035	0.2

Step 3: We forecast the number of charging ports needed in each 30-mile segment of each corridor, assuming charging is done using 150kW public Direct Current Fast Charge (DCFC), to provide the amount of energy calculated in Step 2. For all scenarios, we assumed the following charging port utilization rates (the share of hours in a day the charging port is in use):

Year	Utilization Rate
2020	20%
2025	25%
2030	30%
2035	35%

Our assumptions for each scenario were as follows:

Base Scenario

For Step 1, we analyzed the historical traffic recorder data and calculated that LDVs had an average 68% share of traffic on all major corridors in the state. We then modeled the EV share of this LDV corridor traffic, starting with 2% in 2020, then increasing to 15% in 2025, 30% in 2030 and 55% in 2035. (These assumptions are slightly higher than would be needed to meet the Senate Bill 1044 goals because we allow for the effect of California's more ambitious EV goals spilling over into more EV traffic on Oregon's highway corridors.)

For Step 2, we calculated the energy required, as explained above.

For Step 3, we used the utilization rates given above to calculate how many 150kW DCFC will be needed in each 30-mile segment to provide the energy requirement calculated in Step 2. We did this by calculating the share of total demand represented by each 30-mile segment, then allocating the charging ports to each segment proportionate to that share of demand. For example, if the total demand on segment A is 10 times larger than segment B, then segment A will get 10 times the number of charging ports as segment B.

Rapid Recovery Scenario

For Step 1, we determined the baseline AADT, as described above, then adjusted it downward by 10% for the 2025 milestone and by 2% for the 2030 milestone to account for the lower demand as described in the narrative scenario. Then, we applied the 68% factor, as described above, to obtain the LDV miles of travel on the corridors. We then modeled the EV share of this LDV corridor traffic, starting with 2% in 2020, then increasing to 12% in 2025, 28% in 2030, and 55% in 2035. (These assumptions are slightly higher than would be needed to meet the Senate Bill 1044 goals because we allow for the effect of California's more ambitious EV goals spilling over into more EV traffic on Oregon's highway corridors.)

For Step 2, we calculated the energy required to finish the corridor trips, as explained above.

For Step 3, we used the utilization rates given above to calculate how many 150kW DCFC will be needed in each 30-mile segment to provide the energy requirement calculated in Step 2. We did this by calculating the share of total demand

represented by each 30-mile segment, then allocating the charging ports to each segment proportionate to that share of demand. For example, if the total demand on segment A is 10 times larger than segment B, then segment A will get 10 times the number of charging ports as segment B.

Slow Recovery Scenario

For Step 1, we determined the baseline Average Annual Daily Traffic, as described above, then adjusted it downward by 20% for the 2025 milestone, and by 10% for 2030, to account for the lower demand as described in the narrative scenario. Then, we applied the 68% factor as described above to obtain the light-duty vehicle (LDV) miles of travel on the corridors. We then modeled the electric vehicle (EV) share of this LDV corridor traffic, starting

with 2% in 2020, then increasing to 8% in 2025, 22% in 2030, and 50% in 2035. These assumptions result in reaching the Senate Bill 1044 goal.

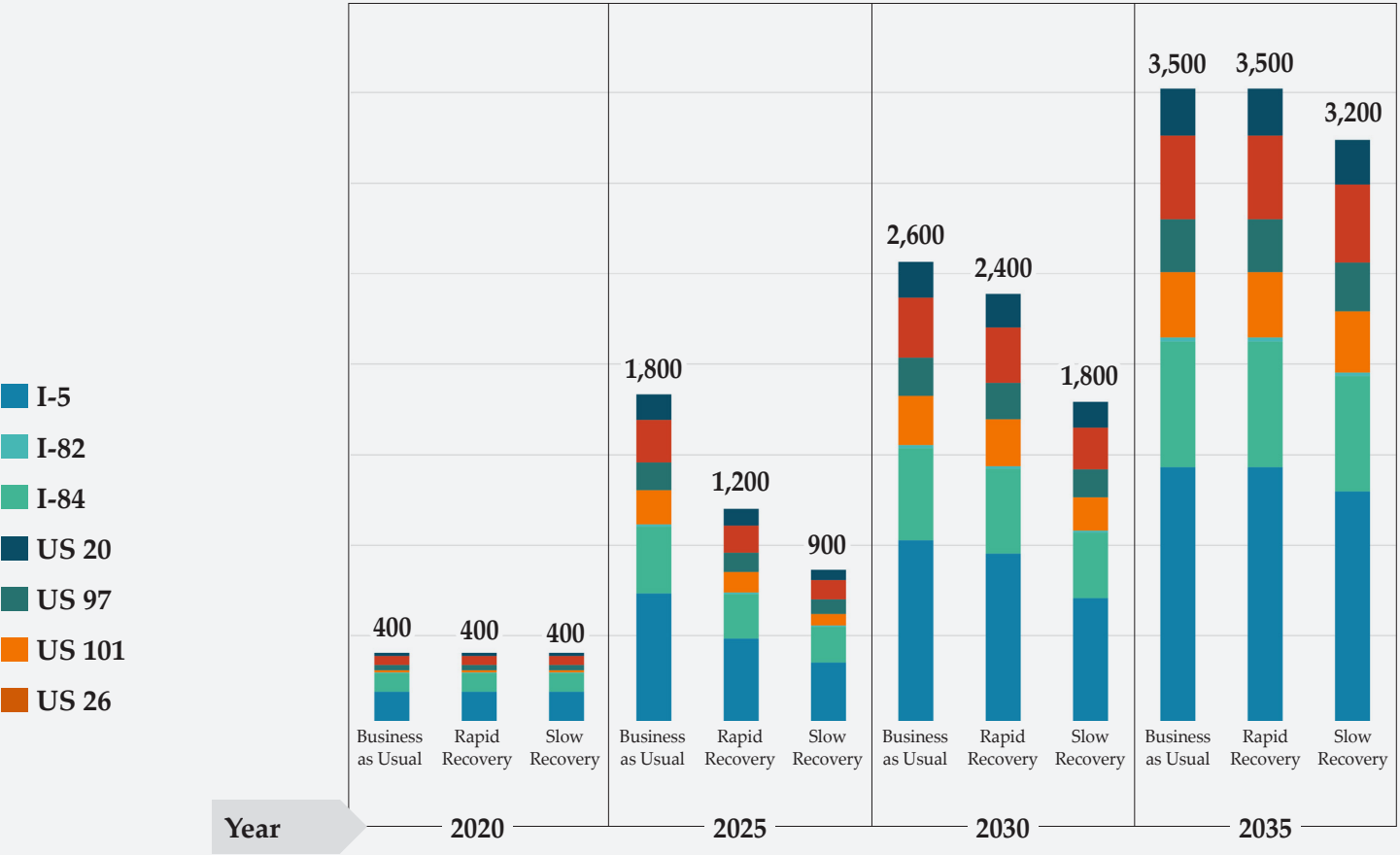
For Step 2, we calculated the energy required to finish the corridor trips, as explained above.

For Step 3, we used the utilization rates given above to calculate how many 150kW Direct Current Fast Charge (DCFC) will be needed in each 30-mile segment to provide the energy requirement calculated in Step 2. We did this by calculating the share of total demand represented by each 30-mile segment, then allocating the charging ports to each segment proportionate to that share of demand. For example, if the total demand on segment A is 10 times larger than segment B, then segment A will get 10 times the number of charging ports as segment B.

Results

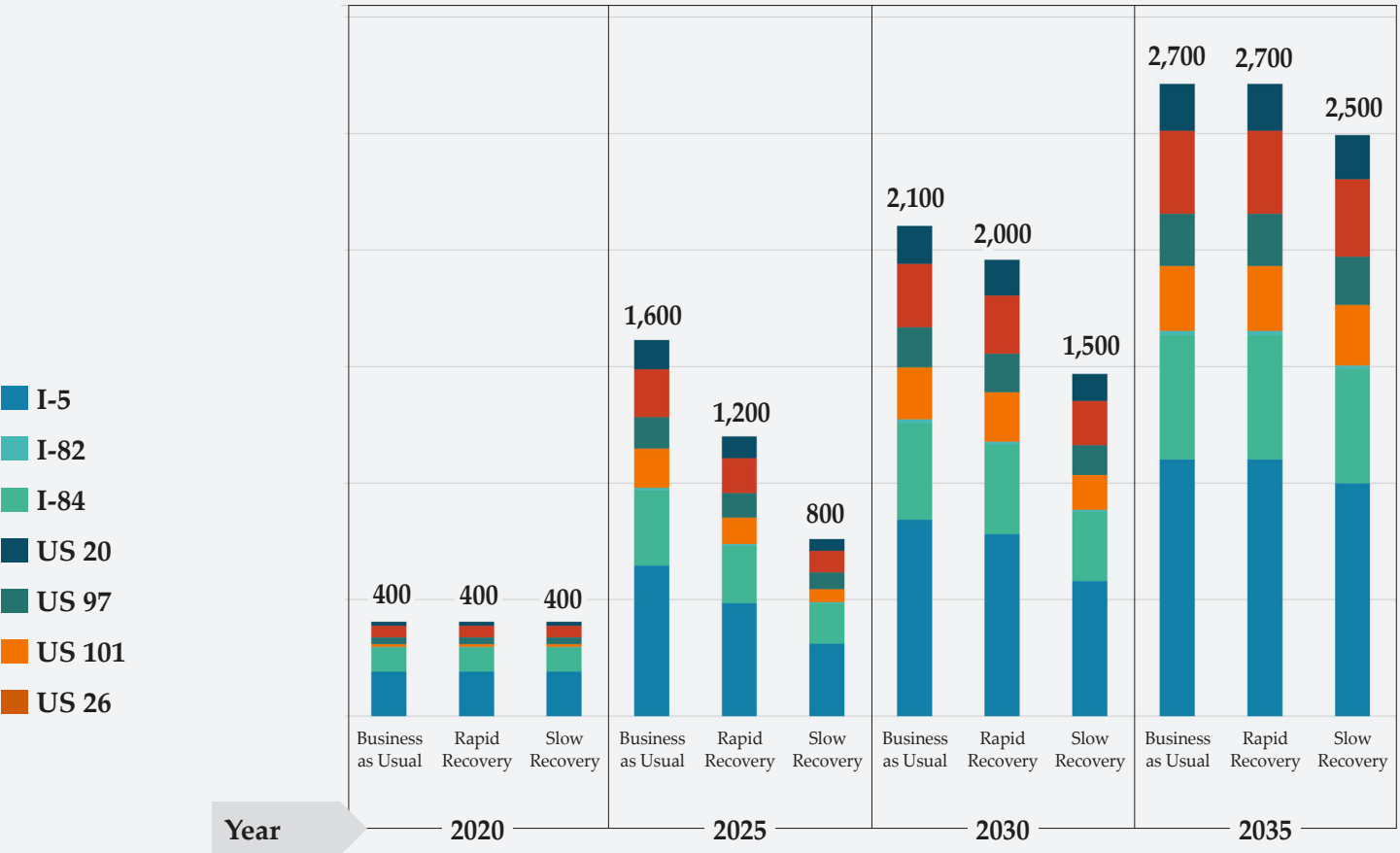
The results of this modeling are shown in **Figure D8** and **Figure D9**. **Figure D8** indicates charging ports needed for corridor LDVs before optimization, and **Figure D9** indicates charging ports needed for corridor LDVs after optimization.

Figure D8. Charging Ports Needed for Corridor eLDVs Before Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

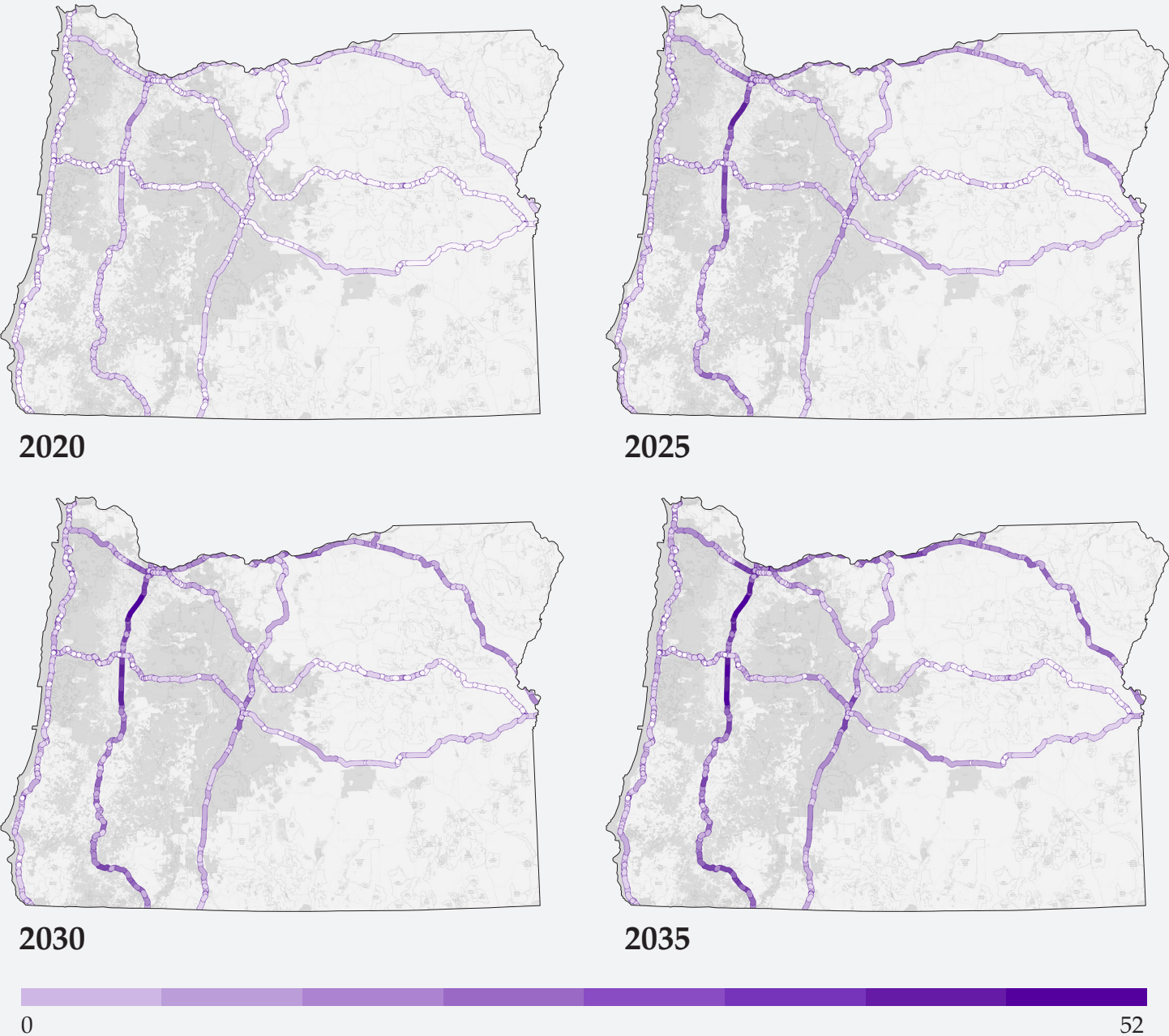
Figure D9. Charging Ports Needed for Corridor eLDVs After Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

To produce the heatmaps in **Figure D10**, we showed the expected number of 150kW charging ports needed along each segment (between traffic recorders) of the modeled corridors.

Figure D10. Charging Ports Needed (150k DCFC) in Highway LDV Corridor Use Case



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Local Commercial and Industrial Vehicles

This use case encompasses a range (Class 3–6) of electric medium-duty vehicles (MDVs) with commercial and industrial uses that will need charging infrastructure. This use case is mostly concerned with local traffic serving the port and industrial zones.

Unlike the corridor use cases for LDVs and long-haul trucks, there is no readily available data set for the movement of these vehicles on surface streets, which lack the kind of traffic data recorders that exist for the major corridors. Accordingly, we needed to develop a methodology to determine where these vehicles travel, and what their Vehicle Miles Traveled (VMT) is on an annual basis, using a variety of sources.

One source we used is the Oregon Statewide Integrated Model, which represents the behavior of the economy, land use, and transport system in the State of Oregon and the interactions between them.

Another is the West Coast Clean Transit Corridor Initiative (WCCTCI) study, which modeled the charging ports needed for long-haul trucking (Class 7 trucks and above, or “big rigs”) along major West Coast corridors. This study forecast the annual average daily traffic for MDVs through 2035.

We modeled the charging ports needed by local commercial and industrial vehicles using a three-step process:

Step 1: We forecast the electric VMT for MDV in each of the milestone years based on the projections used in the WCCTCI study.

Step 2: We calculated the energy required for the MDV VMT. To begin this calculation, we multiplied the vehicle’s energy efficiency by the VMT. For all scenarios, we assumed that vehicle energy efficiency will improve over time and applied the following average vehicle efficiencies, recognizing that there will be a wide range of efficiencies between the MDVs that will use these corridors:

Year	kWh/mile
2020	2
2025	1.8
2030	1.6
2035	1.4

We then forecast the share of energy that would need to be supplied en route. We assume that any

additional energy needed is supplied at the vehicle’s depot. For all scenarios, we assumed the following shares of energy would be supplied en route:

Year	Energy Share Supplied En Route
2020	10%
2025	20%
2030	30%
2035	50%

We then applied these factors to the VMT to determine the energy that would need to be provided en route by census tract.

Step 3: We forecast the charging ports needed in each census tract to provide the energy calculated in Step 2.

Our assumptions for each scenario were as follows:

Base Scenario

For Step 1, using the WCCTCI traffic projections as a basis, we extrapolated the MDV VMT for each of the milestone years. We assume that VMT grows by 1.2% annually, as implied in the WCCTCI projections.

We assumed that MDV would have a life span of 12 years.

To calculate the share of MDV VMT that would be electric, we started with the WCCTCI study’s assumption that electric MDV was 7% of all MDV sales in 2020. Then, we forecast that the share of electric MDV sales would rise to 25% by 2035. We then used those ratios to calculate the share of total MDV VMT that would be traveled by electric MDV. These calculations showed that electric MDV VMT would increase from 1% of all MDV VMT in 2020 to 5% in 2025, 12% in 2030, and 21% in 2035.

For Step 2, we calculated the energy that would need to be supplied by charging ports in each census tract, as explained above.

For Step 3, we assumed the following charging ports utilization rates (the share of hours in a day the charging port is in use), reflecting our expectation that more electric MDV will be deployed over time.

Year	Utilization Rate
2020	15%
2025	20%
2030	25%
2035	30%

We assumed that each charging session would be supplied by 350kW Direct Current Fast Charges (DCFCs). If the needed amount of energy for a given charging session would require less than 35kWh (10% of the charging port’s nameplate capacity), we ignored it and assumed that the charging session didn’t happen.

Finally, we calculated how many charging ports would be needed in each census tract to provide the energy calculated in Step 2 at the given utilization rates.

Rapid Recovery Scenario

For Step 1, using the West Coast Clean Transit Corridor Initiative (WCCTCI) traffic projections as a basis, we extrapolated the medium-duty vehicle (MDV) vehicle miles traveled (VMT) for each of the milestone years. We assume that VMT grows by 1.2% annually, as implied in the WCCTCI projections, as we did for the Base scenario.

Then, we adjusted those figures upward using the adjustment factors in the table below. We made this adjustment to reflect the greater demand for delivery services served by MDV, as described in the narrative scenario.

Year	Adjustment Factor
2020	2
2025	1.3
2030	1.2
2035	1.1

We assumed that MDV would have a life span of 10 years.

To calculate the share of MDV VMT that would be electric, we started with the WCCTCI study’s assumption that electric MDV was 7% of all MDV sales in 2020. Then, we forecast that the share of electric MDV sales would rise to 35% by 2035. We then used those ratios to calculate the share of total MDV VMT that would be traveled by electric MDV. These calculations showed that electric MDV VMT would increase from 1% of all MDV VMT in 2020 to 7% in 2025, 19% in 2030, and 35% in 2035.

For Step 2, we calculated the energy that would need to be supplied by charging ports in each census tract, as explained above.

For Step 3, we assumed the following charging port utilization rates (the share of hours in a day the

charging port is in use), reflecting our expectation that more electric MDV will be deployed over time.

Year	Utilization Rate
2020	15%
2025	25%
2030	30%
2035	35%

We assumed that each charging session would be supplied by 350kW DCFCs. If the needed amount of energy for a given charging session would require less than 35kW (10% of the charging port’s nameplate capacity), we ignored it and assumed that the charging session didn’t happen.

Finally, we calculated how many charging ports would be needed in each census tract to provide the energy calculated in Step 2 at the given utilization rates.

Slow Recovery Scenario

For Step 1, using the WCCTCI traffic projections as a basis, we extrapolated the MDV VMT for each of the milestone years. We assume that VMT grows by 1.2% annually, as implied in the WCCTCI projections, as we did for the Base scenario.

Then, we adjusted those figures upward using the following adjustment factors. We made this adjustment to reflect the greater demand for delivery services served by MDV, as described in the narrative scenario.

Year	Adjustment Factor
2020	2
2025	2
2030	1.5
2035	1.3

We assumed that MDV would have a life span of 10 years.

To calculate the share of MDV VMT that would be electric, we started with the WCCTCI study’s assumption that electric MDV was 7% of all MDV sales in 2020. Then, we forecast that the share of electric MDV sales would rise to 45% by 2035. We then used those ratios to calculate the share of total MDV VMT that would be traveled by electric MDV. These calculations showed that electric MDV VMT would increase from 1% of all MDV VMT in 2020 to 9% in 2025, 24% in 2030, and 44% in 2035.

For Step 2, we calculated the energy that would need to be supplied by charging ports in each census tract, as explained above.

For Step 3, we assumed the following charging port utilization rates (the share of hours in a day the charging port is in use), reflecting our expectation that more electric medium-duty vehicles (MDVs) will be deployed over time.

Year	Utilization Rate
2020	15%
2025	25%
2030	30%
2035	35%

We assumed that each charging session would be supplied by 350kW Direct Current Fast Charges (DCFCs). If the needed amount of energy for a given charging session would require less than 35kW

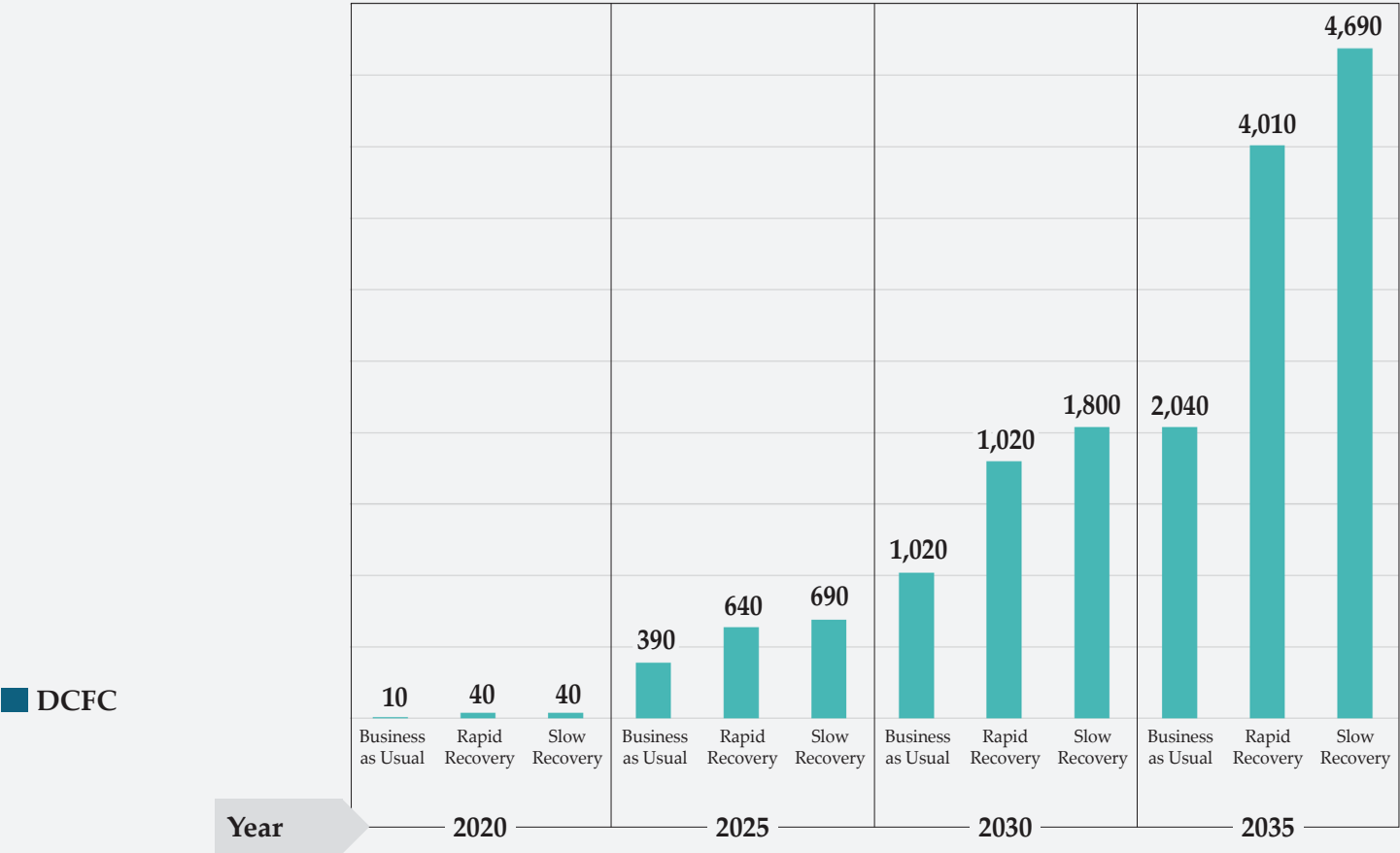
(10% of the charging port’s nameplate capacity), we ignored it and assumed that the charging session didn’t happen.

Finally, we calculated how many charging ports would be needed in each census tract to provide the energy calculated in Step 2 at the given utilization rates.

Results

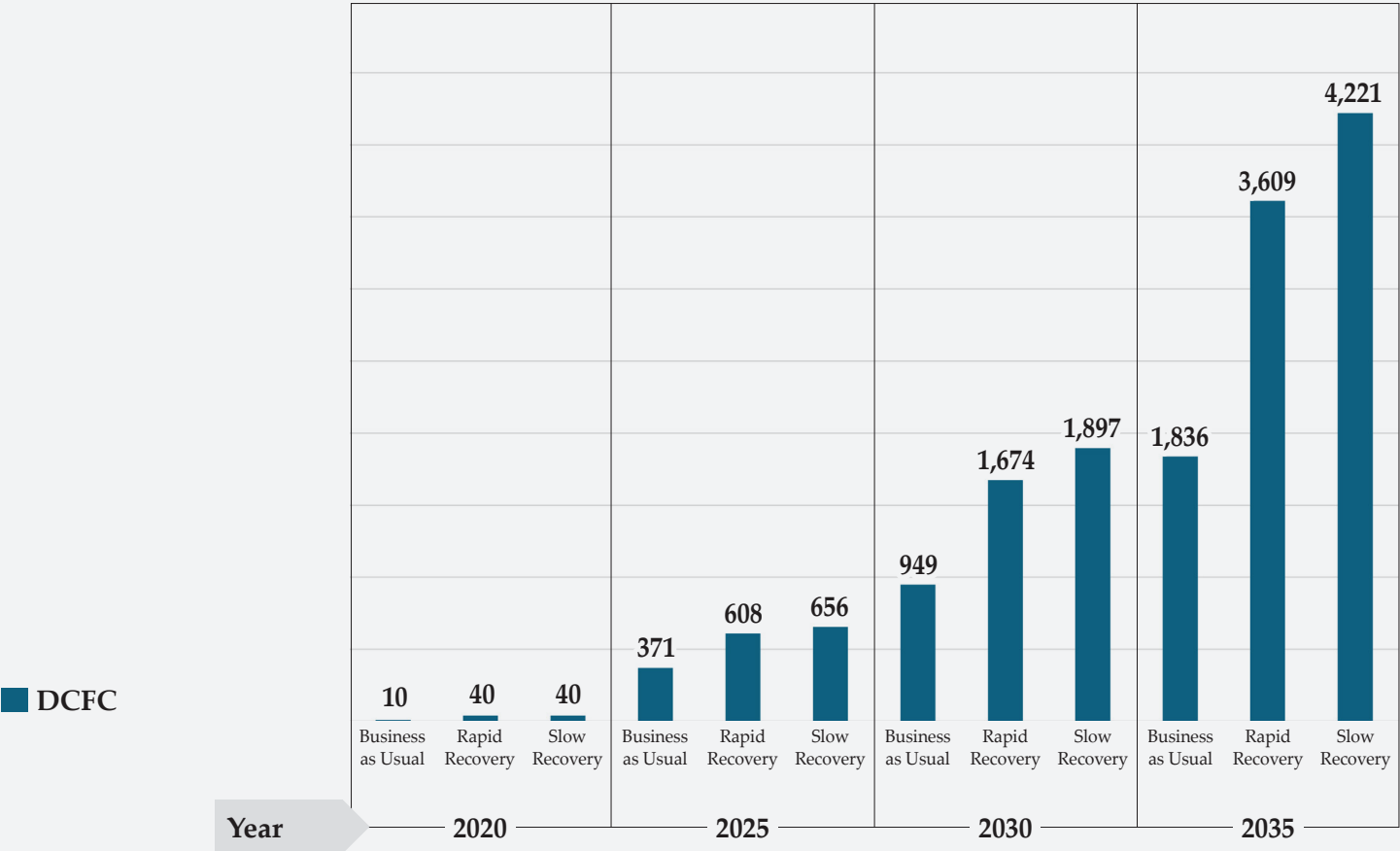
The results of this modeling are shown in **Figure D11** and **Figure D12**.

Figure D11. Charging Ports Needed for Local Commercial and Industrial eMDVs Before Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

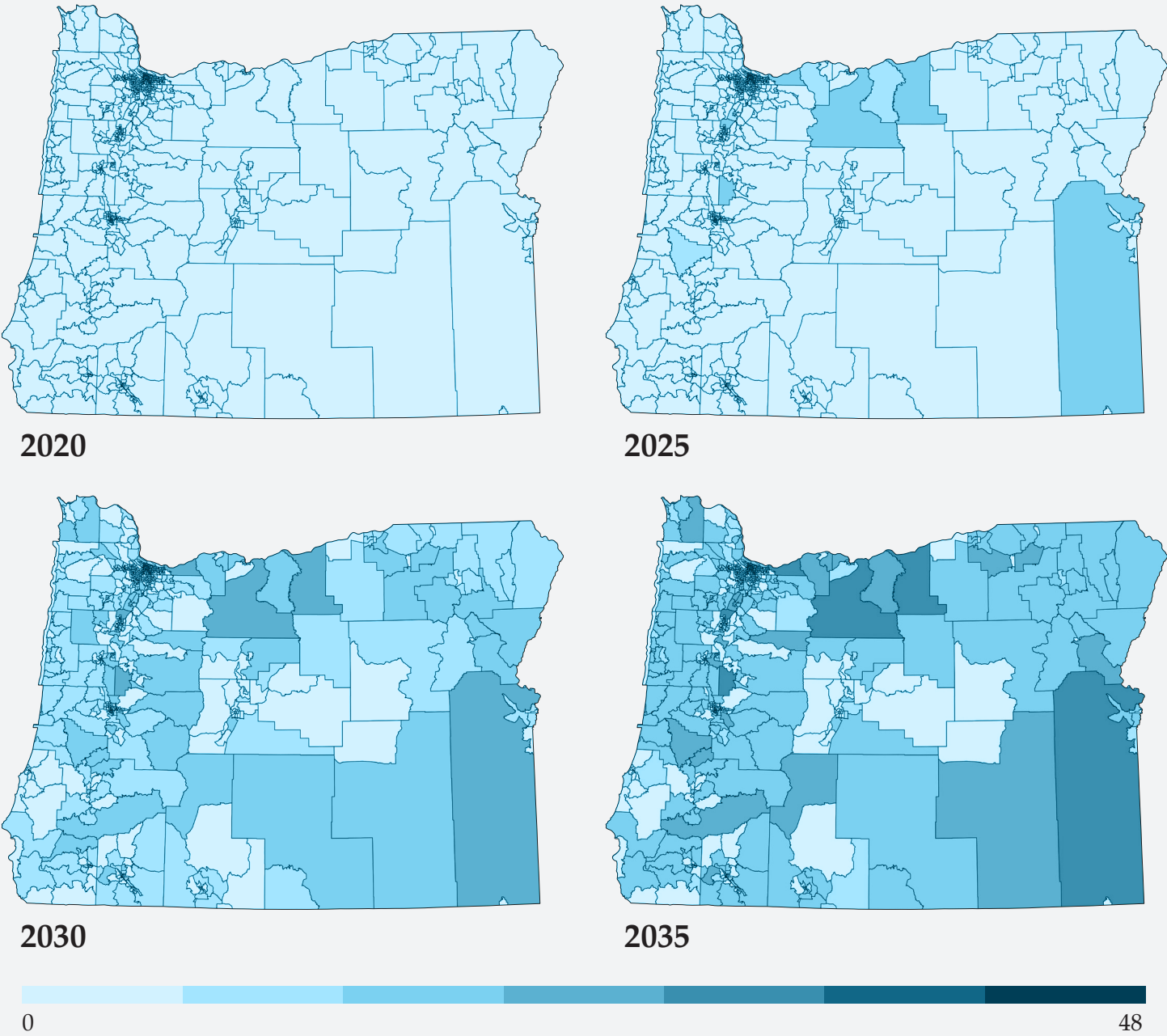
Figure D12. Charging Ports Needed for Local Commercial and Industrial eMDVs After Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

To produce the heatmaps in **Figure D13**, we showed the expected number of 350kW charging ports needed in each census tract to provide en route charging.

Figure D13. Charging Ports Needed (350kW DCFC) in Local Commercial and Industrial MDV Use Case



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Transit Buses

We modeled the need for bus charging ports using a three-step process.

Step 1: We developed a forecast for the total number of transit buses in Oregon (both electric vehicle and internal combustion engine) throughout the modeling period and allocated them to their home counties. We allocated 70% of the transit buses to the top three transit agencies. These three agencies (Tri-County Metropolitan Transportation District of Oregon, serving Portland; Salem Area Mass Transit District, serving Salem; and Lane Transit District, serving Eugene) account for approximately three-quarters of all transit buses in the state and the vast majority of transit rides. We allocated the remaining 30% of transit buses to the remaining counties based on each county's share of the state population and applied an adjustment factor.

Step 2: We forecast the number of eBuses that will be needed through 2035 for each county based on growth rate factors.

Step 3: We applied bus-to-charging port ratios to determine the number of 60kW charging ports that will be needed for the projected number of buses in each county.

Our assumptions for each scenario were as follows:

Base Scenario

For Step 1, the total number of transit buses in each county were assumed to grow by a 1.5% Compound Annual Growth Rate (CAGR), reflecting the general population growth rate. We assumed that each bus would remain in service for nine years and have an average residual lifetime of nine years. Using these assumptions, we calculated the number of newly purchased buses each year.

For Step 2, we assumed that eBus sales would grow roughly linearly from near-zero in 2020 to 90% in 2035. By 2035, 75% of all transit buses in the state will be electric in this scenario.

For Step 3, we applied bus-to-charging port ratios to determine the number of 60kW charging ports that will be needed for the projected number of buses. The ratios start at 1:1 in 2020 (reflecting conditions nationally in 2020), then increase to 1.5:1 starting in 2027 and to 2:1 starting in 2031, reflecting our assumption that transit bus fleets will learn to optimize their charging infrastructure over time to require the fewest charging ports to meet their operational requirements.

Rapid Recovery Scenario

For Step 1, we projected that the number of transit buses in each bus fleet would decline from the 2020 level by -0.8% starting in 2021 and by -1.7% in 2022, then start growing by a CAGR of 0.5% from 2023–2035. We assumed a slightly longer average residual lifetime of 10 years for this scenario.

For Step 2, we assumed that eBus sales would grow roughly linearly from near-zero in 2020 to 90% in 2035. By 2035, 70% of all transit buses in the state will be electric in this scenario.

For Step 3, we applied bus-to-charging port ratios to determine the number of 60kW charging ports that will be needed for the projected number of buses. The ratios start at 1:1 in 2020 (reflecting conditions nationally in 2020), then increase to 1.5:1 starting in 2027 and 2:1 starting in 2031, reflecting our assumption that transit bus fleets will learn to optimize their charging infrastructure over time to require the fewest charging ports to meet their operational requirements.

Slow Recovery Scenario

For Step 1, we projected that the number of transit buses in each bus fleet would decline from the 2020 level by -0.8% starting in 2021 and by -1.7% per year between 2022 and 2025. Under this narrative scenario, bus ridership remains low as people continue to be averse to riding the bus due to ongoing COVID infection risk, so we model that the number of transit buses continues to decline by a CAGR of -0.5% from 2026–2035. We assumed a longer average residual lifetime of 12 years for this scenario, reflecting lower bus utilization. We also allocate slightly more buses to rural counties to reflect this scenario's outlook for greater migration from urban to rural communities.

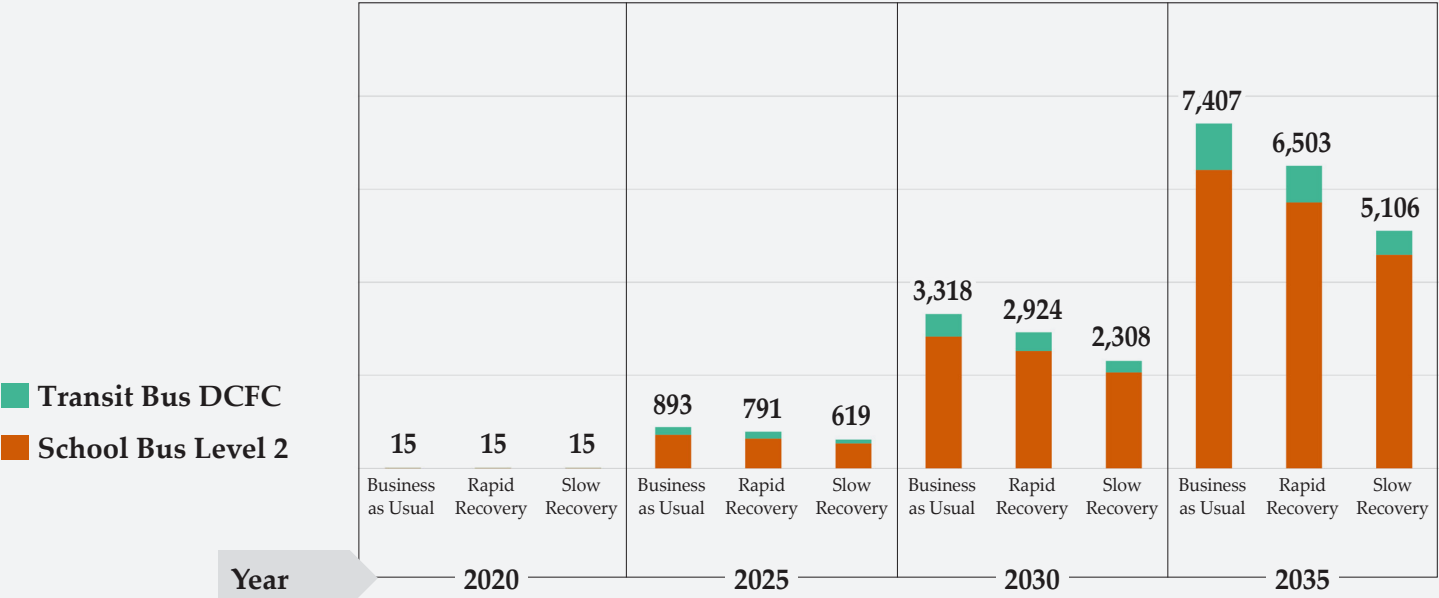
For Step 2, we assumed that eBus sales would grow roughly linearly from near-zero in 2020 to 90% in 2035. By 2035, 60% of all transit buses in the state will be electric in this scenario.

For Step 3, we applied bus-to-charging port ratios to determine the number of 60kW charging ports that will be needed for the projected number of buses. The ratios start at 1:1 in 2020 (reflecting conditions nationally in 2020), then increase to 1.5:1 starting in 2027 and 2:1 starting in 2031, reflecting our assumption that transit bus fleets will learn to optimize their charging infrastructure over time to require the fewest charging ports to meet their operational requirements.

Results

The results of this modeling are shown in **Figure D14**.

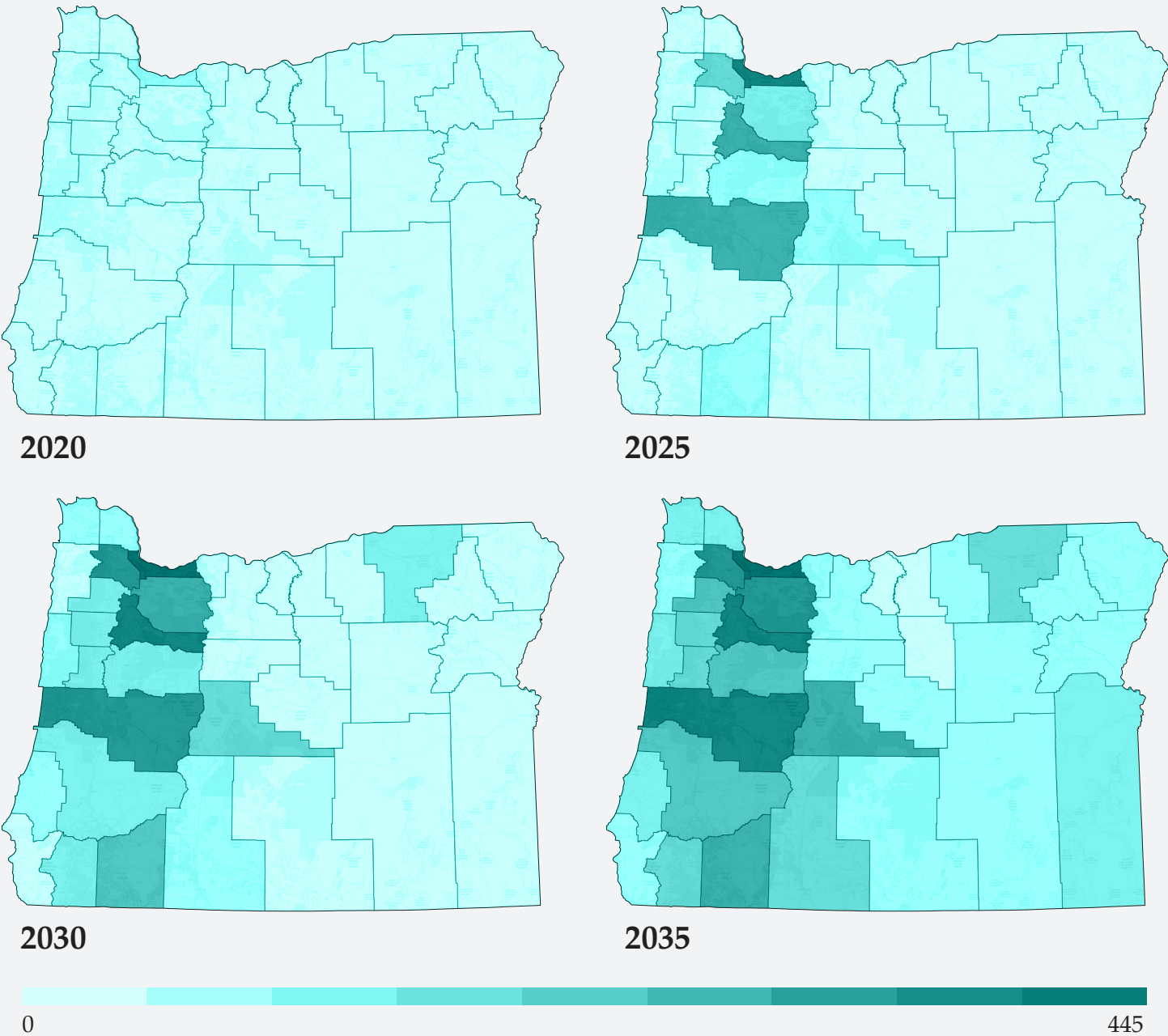
Figure D14. Charging Ports Needed for Transit and School Buses



Note: Modeling assumes 50,000 electric vehicles in 2020.

To produce the heatmaps in **Figure D15**, we distributed the statewide number of charging ports to the county level in proportion to the number of bus stops in the transit system and the population of each county.

Figure D15. Charging Ports Needed in Transit Bus (DCFC) Use Case



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Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

School Buses

We modeled the need for bus charging ports using a three-step process.

Step 1: Starting with the number of school buses in the state according to the 2018 Oregon Pupil Transportation Manual, we developed a forecast for the number of school buses (both electric vehicle and internal combustion engine) in each county based on its share of the state's school-aged pupils (ages 5–9).

Step 2: We forecast the number of eBuses that will be needed through 2035 statewide based on growth rate factors.

Step 3: We applied bus-to-charging port ratios to determine the number of Level 2 charging ports that will be needed for the projected number of school buses.

Our assumptions for each scenario were as follows:

Base Scenario

For Step 1, the total number of school buses in each agency were assumed to grow by a 0.5% Compound Annual Growth Rate (CAGR), reflecting the recent population growth trend. School buses are assumed to remain in service for nine years, with an average residual lifetime of nine years. Using these assumptions, we calculated the number of newly purchased buses each year.

For Step 2, we assumed that eBus sales would grow roughly linearly from near-zero in 2020 to 90% in 2035. By 2035, 75% of all school buses in the state will be electric in this scenario.

For Step 3, we applied a 1:1 bus-to-charging port ratio to determine the number of Level 2 charging ports that will be needed for the projected number of school buses. This ratio is held constant through 2035.

Rapid Recovery Scenario

For Step 1, we projected that the number of school buses would remain flat through 2022, then start growing by a CAGR of 0.5% from 2023–2035 as overall growth quickly returns to the Base Scenario rate. We assumed a slightly longer average residual lifetime of 10 years for this scenario.

For Step 2, we assumed that eBus sales would grow roughly linearly from near-zero in 2020 to 90% in 2035. By 2035, 70% of all school buses in the state will be electric in this scenario.

For Step 3, we applied a 1:1 bus-to-charging port ratio to determine the number of Level 2 charging ports that will be needed for the projected number of school buses. This ratio is held constant through 2035.

Slow Recovery Scenario

For Step 1, the total number of school buses were assumed to remain flat throughout the forecast period (2020–2035). However, some buses migrate from urban to rural areas in accordance with the shifting demographics of this scenario.

For Step 2, we assumed that eBus sales would grow roughly linearly from near-zero in 2020 to 90% in 2035. By 2035, around 60% of all school buses in the state will be electric in this scenario.

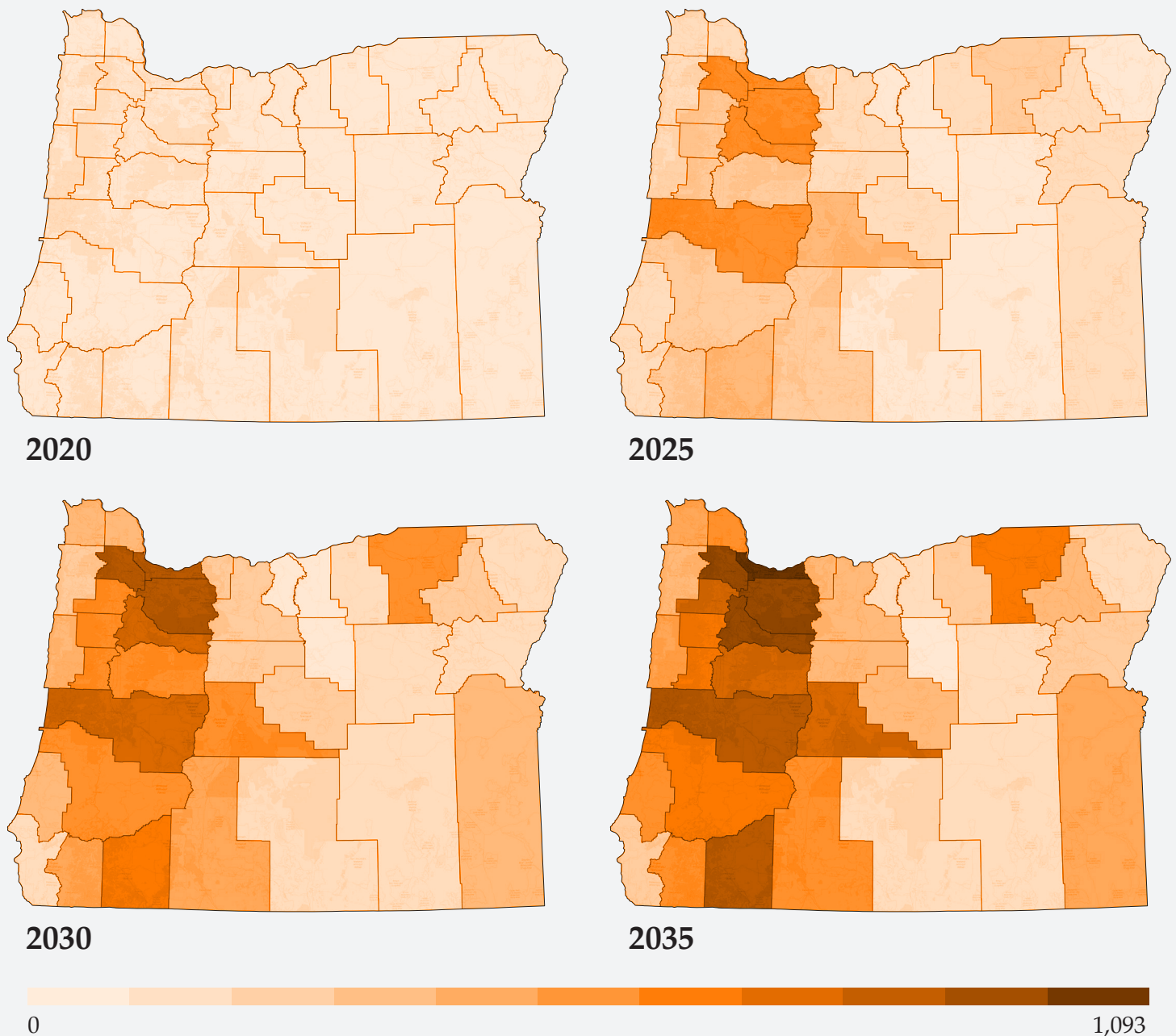
For Step 3, we applied a 1:1 bus-to-charging port ratio to determine the number of Level 2 charging ports that will be needed for the projected number of school buses. This ratio is held constant through 2035.

Results

The results of this modeling are shown in **Figure D14**, shown previously.

To produce the heatmaps in **Figure D16**, we distributed the statewide number of charging ports to the county level in proportion to the school-age (5–19) population of each county.

Figure D16. Charging Ports Needed in School Bus (Level 2) Use Case



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Transportation Network Companies (TNCs)

We modeled the need for charging ports for TNCs using a three-step process.

Step 1: We forecast the TNC vehicle miles traveled (VMT) in each county through 2035. We began by distributing the total statewide VMT per year across the counties based on each county's share of the state population. Then, to establish a 2019 baseline for the TNC VMT, we performed a regression of TNC shares of VMT based on population density.

Step 2: We converted the TNC VMT into a number of TNC vehicles based on the weighted average TNC VMT in California.

Step 3: We applied vehicle-to-charging port ratios to the number of electric vehicles (EVs) from Step 2 to determine the number of charging ports that will be needed for TNC EVs. First, we used housing stock estimates from the 2010 United States Census, as well as various assumptions about which types of residences could install charging ports, to estimate how many TNC drivers will be able to charge at home using a Level 2 charging ports. For drivers who could install Level 2 charging port at home, we assume they will be able to use them for all their charging needs by 2025. For those TNC drivers without access to home Level 2 charging ports, we used a vehicle-to-plug ratio of 33 vehicles per plug to calculate the total number of public Direct current fast charge (DCFC) that TNC drivers will need in each county. As a share of all TNC drivers, we assume that 22% will charge at home by 2025, 33% by 2030, and 44% by 2035, reflecting increasing deployment of home charging ports over the forecast period.

Our assumptions for each scenario were as follows:

Base Scenario

For Step 1, we project that demand for TNC services will grow from the 2019 baseline through 2035 at a Compound Annual Growth Rate (CAGR) of 8%, based on the growth rate of private for-hire vehicles in Portland from 2016–2019.

For Step 2, we converted the TNC VMT to a number of TNC vehicles, as explained above.

For Step 3, we estimated the TNC demand for charging ports, as explained above.

Rapid Recovery Scenario

For Step 1, we project that demand for TNC services fell by 50% in 2020 and remains constant throughout 2021. Then, it grows at a 6% CAGR in urban areas and at a 7% CAGR in rural areas, consistent with the narrative scenario.

For Step 2, we converted the TNC VMT to a number of TNC vehicles, as explained above.

For Step 3, we estimated the TNC demand for charging ports, as explained above.

Slow Recovery Scenario

For Step 1, we project that demand for TNC services fell by 50% in 2020 and remains constant throughout 2021. Then, we assume that it starts growing as follows:

- In urban areas, we assume that TNC VMT grows at a 16% CAGR from 2021–2025, at 24% from 2025–2030, and at 40% from 2030–2035 as autonomous EVs become dominant, consistent with this narrative scenario.
- In rural areas, we assume that TNC VMT grows at a 20% CAGR from 2021–2025, at 28% from 2025–2030, and at 44% from 2030–2035 as autonomous EVs become dominant, consistent with this narrative scenario.

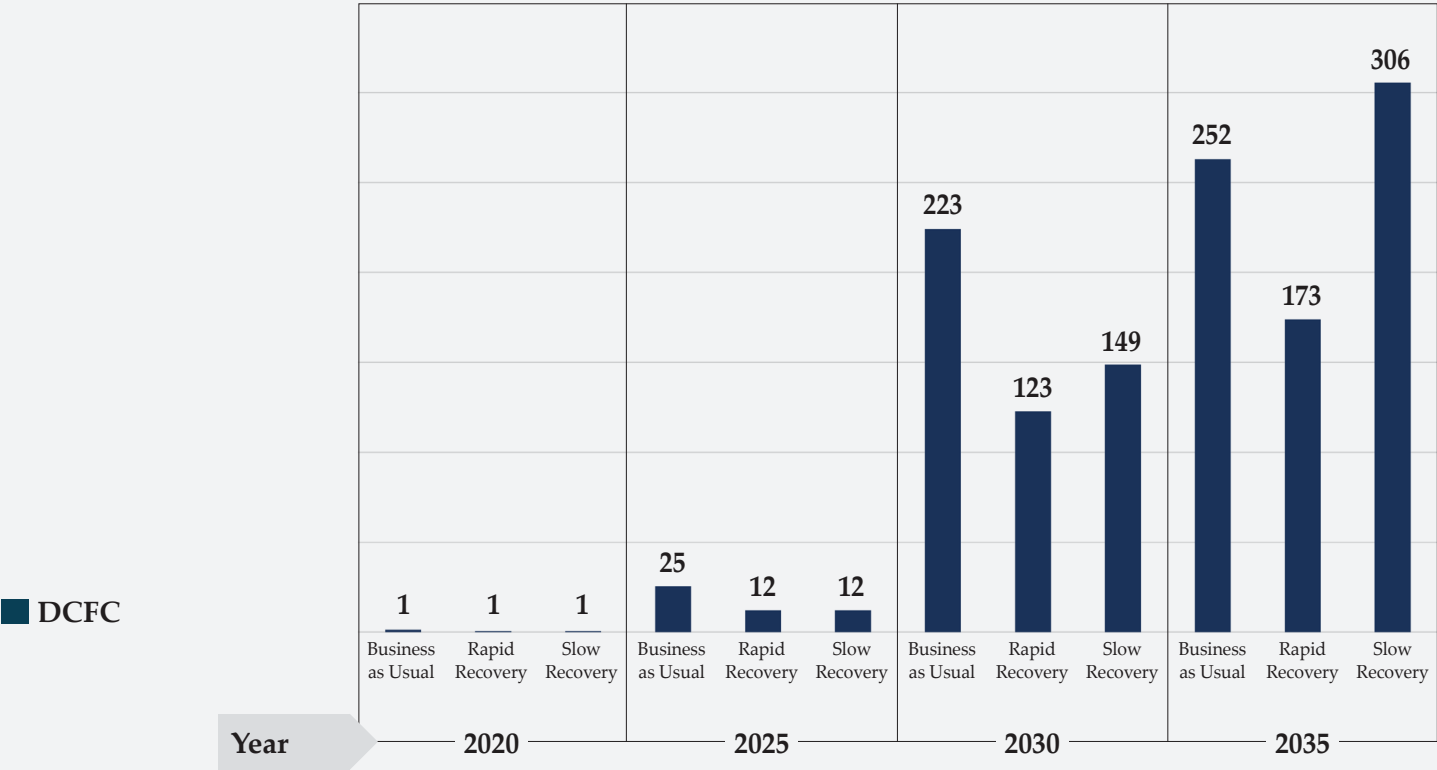
For Step 2, we converted the TNC VMT to a number of TNC vehicles, as explained above.

For Step 3, we estimated the TNC demand for charging ports as explained above, with a slight modification: Because TNCs switch to autonomous EVs from 2030–2035 in this narrative scenario, we increase the vehicle-to-plug ratio by 25% to reflect that autonomous EVs will increasingly use public DCFC. The share of charging that TNC drivers do at home does not change in the model and still approaches 44% by 2035; however, we assume that TNC drivers start disappearing after 2030 as EVs go autonomous. There is an implied assumption in this scenario that after 2035, autonomous EVs used for TNC services will increasingly use some combination of public DCFC (as the remaining drivers use them less) and dedicated charging depot charging ports (which are outside the scope of this modeling).

Results

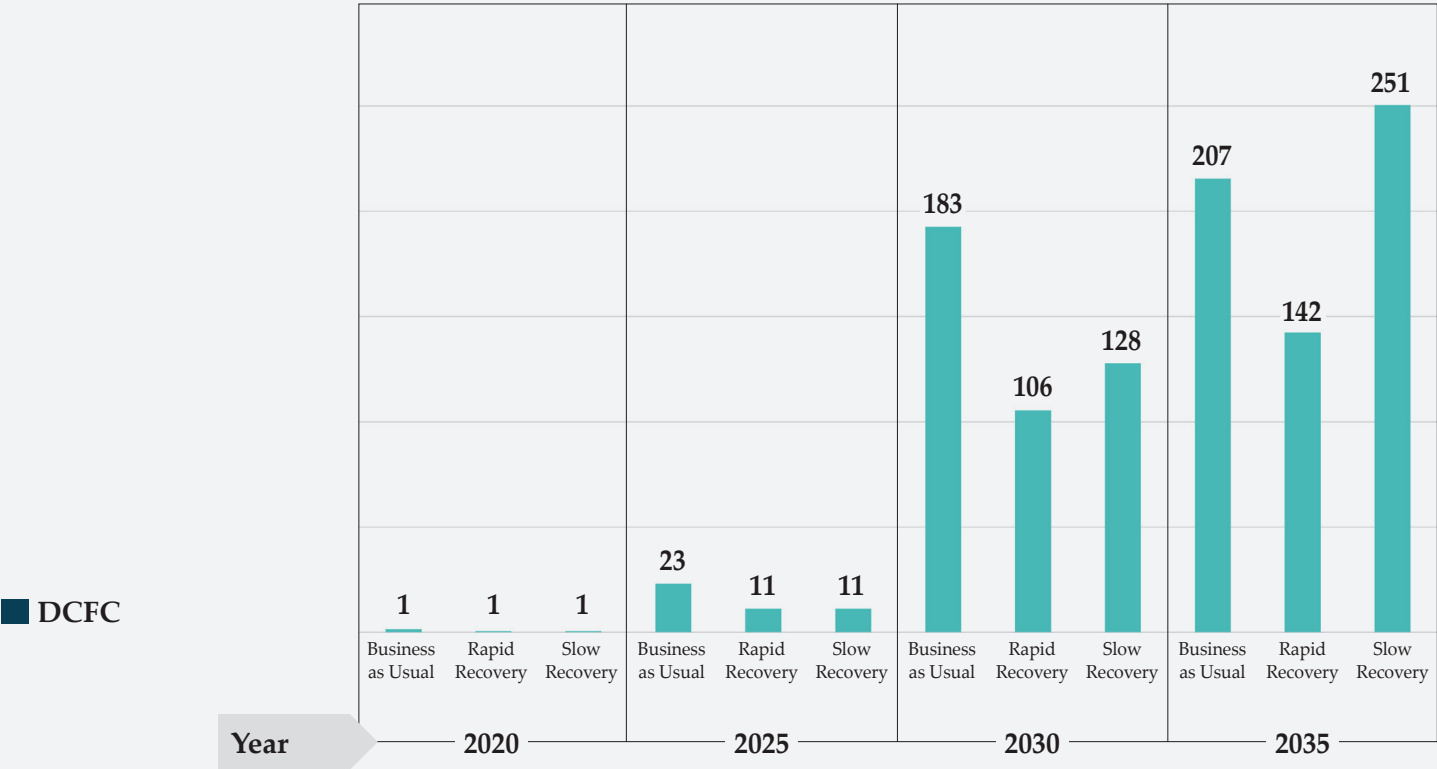
The results of this modeling are shown in **Figure D17** and **Figure D18**.

Figure D17. Charging Ports Needed for eTNCs Before Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

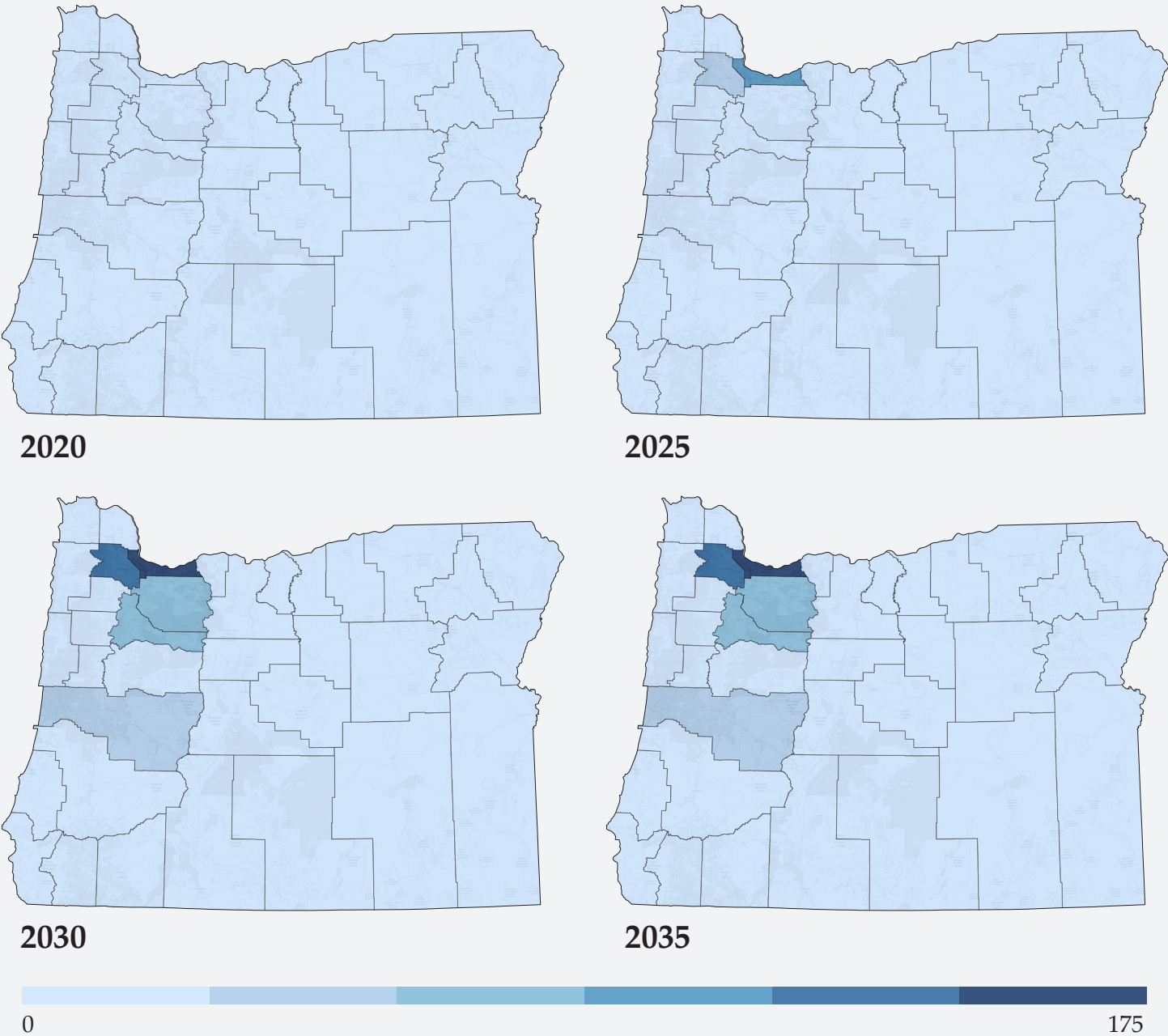
Figure D18. Charging Ports Needed for eTNCs After Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

To produce the heatmaps shown in **Figure D19**, we plotted the number of 150kW DCFC by county. (We do not independently model residential charging in this analysis.)

Figure D19. Charging Ports Needed in the TNC (DCFC) Use Case



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Long-Haul Trucking

We modeled the need for charging ports for long-haul trucking using heavy-duty (Class 7 and above) vehicles (HDV or “big rigs”) statewide, not just on highway corridors. Because there is no readily available data for the movement of these vehicles on surface streets, we developed a methodology to determine where these vehicles travel, and what their vehicle miles traveled (VMT) is on an annual basis, using a variety of sources.

One source we used is the Oregon Statewide Integrated Model (SWIM), which represents the behavior of the economy, land use, and transport system in the State of Oregon and the interactions between them. This data was used to determine the current level of traffic of these vehicles.

Another is the West Coast Clean Transit Corridor Initiative (WCCTCI) study, which modeled the charging ports needed for long-haul trucking along major West Coast corridors. This study forecast the annual average daily traffic for HDVs through 2035. We used that data to model the future traffic levels in long-haul trucking.

We assume that all charging will be done using 500kW Direct current fast charge (DCFC), which is the maximum charging speed for the majority of existing and proposed eTruck models in the market.

Our modeling for this use case followed a three-step process.

Step 1: We forecast the electric VMT for HDV in each of the milestone years based on the projections used in the WCCTCI study. To calculate the share of HDV VMT that would be electric, we used the assumptions in the WCCTCI study (where electric HDV varied from 0% of all HDV sales in 2020 to 15% in 2035) to forecast the share of HDV sales that would be electric, then used that ratio to calculate the share of total HDV VMT that would be traveled by electric HDV.

For all scenarios, we assumed that HDV would have a life span of 12 years.

Step 2: We calculated the energy required for the HDV VMT. To begin this calculation, we multiplied the vehicle’s energy efficiency by the VMT. For all scenarios, we assumed the following average energy efficiencies, recognizing that there will be a wide range of efficiencies between the big rigs traveling in Oregon. These assumptions reflect our expectation that these vehicles will become more energy efficient over time.

Year	kWh/mile
2020	3.2
2025	3.0
2030	2.8
2035	2.5

We then forecast the share of energy that would need to be supplied en route (Private charging at dedicated depots is not modeled in this project). (Private charging at dedicated depots is not modeled in this project.) For all scenarios, we assumed the following shares of energy would be supplied en route. These assumptions increase over time to reflect our expectation that more big rigs will use these charging stations over time.

Year	Percentage Energy
2020	10%
2025	20%
2030	30%
2035	50%

Step 3: We applied these factors to the VMT to determine the energy that would need to be provided en route by census tract.

The WCCTCI study assumed that 2 MW (2000kW) charging ports will be used to charge long-haul trucks. We have instead assumed that all big rig charging will use 500kW charging ports because 500kW is the maximum charging speed for the majority of existing and proposed eTruck models now on the market, and we preferred to estimate the need in terms of today’s charging technology. Should 2000kW charging become a market reality in the future, the number of those charging ports can be approximated by dividing our projected number of 500kW units by four.

For all scenarios, we assumed the following charging port utilization rates (the share of hours in a day the charging port is in use), reflecting our expectation that more electric big rigs will be deployed over time. If the needed amount of energy for a given charging session would require less than 50kW (10% of the charging port’s nameplate capacity), we ignore it and assume that the charging session didn’t happen.

Year	Utilization Rate
2020	15%
2025	20%
2030	25%
2035	30%

Our assumptions for each scenario were as follows:

Base Scenario

For Step 1, using the WCCTCI traffic projections as a basis, we extrapolated the heavy-duty vehicle (HDV) vehicle miles traveled (VMT) for each of the milestone years.

Because long-haul trucks may traverse parts of states adjacent to Oregon in the course of a trip, we assume that charging infrastructure in Oregon will need to support a portion of the trucks registered in those states. Since California has an ambitious goal for electric trucks, we assume that by 2035, one-third of VMT will come from out-of-state trucks.

Ultimately, we calculate that electric HDV VMT in this scenario will increase from 0% of all HDV VMT in 2020 to 1% in 2025, 6% in 2030, and 15% in 2035.

For Step 2, we calculated the energy that would need to be supplied by charging ports in each census tract, as explained above.

For Step 3, we calculated how many 500kW Direct Current Fast Charge (DCFC) would be needed in each census tract to provide the energy calculated in Step 2 at the given utilization rates.

Rapid Recovery Scenario

For Step 1, using the WCCTCI traffic projections as a basis, we calculated the HDV VMT for each of the milestone years as we did for the Base Scenario. Then, we adjusted those figures downward using the following adjustment factors to accommodate the economic impact depicted in the narrative scenario:

Year	Adjustment Factor
2020	1
2025	0.9
2030	0.95
2035	1

Because long-haul trucks may traverse parts of states adjacent to Oregon in the course of a trip, we assume that charging infrastructure in Oregon will need to support a portion of the trucks registered in those states. Since California has an ambitious goal for electric trucks, we assume that by 2035, 25% of VMT will come from out-of-state trucks—less than the Base Scenario, reflecting the impact of a few years of economic downturn in this narrative scenario.

Ultimately, we calculate that electric HDV VMT will increase in this scenario from 0% of all HDV VMT in 2020 to 1% in 2025, 4% in 2030, and 12% in 2035.

For Step 2, we calculated the energy that would need to be supplied by charging ports in each census tract, as explained above.

For Step 3, we calculated how many 500kW DCFC would be needed in each census tract to provide the energy calculated in Step 2 at the given utilization rates.

Slow Recovery Scenario

For Step 1, using the WCCTCI traffic projections as a basis, we calculated the HDV VMT for each of the milestone years as we did for the Base Scenario. Then, we adjusted those figures downward using the following adjustment factors to accommodate the economic impact depicted in the narrative scenario:

Year	Adjustment Factor
2020	1
2025	0.8
2030	0.9
2035	1

Because long-haul trucks may traverse parts of states adjacent to Oregon in the course of a trip, we assume that charging infrastructure in Oregon will need to support a portion of the trucks registered in those states. Since California has an ambitious goal for electric trucks, we assume that by 2035, 15% of VMT comes from out-of-state trucks—less than the Base Scenario, reflecting the impact of the economic downturn in this narrative scenario.

Ultimately, we calculate that electric HDV VMT will increase in this scenario from 0% of all HDV VMT in 2020 to 1% in 2025, 3% in 2030, and 8% in 2035.

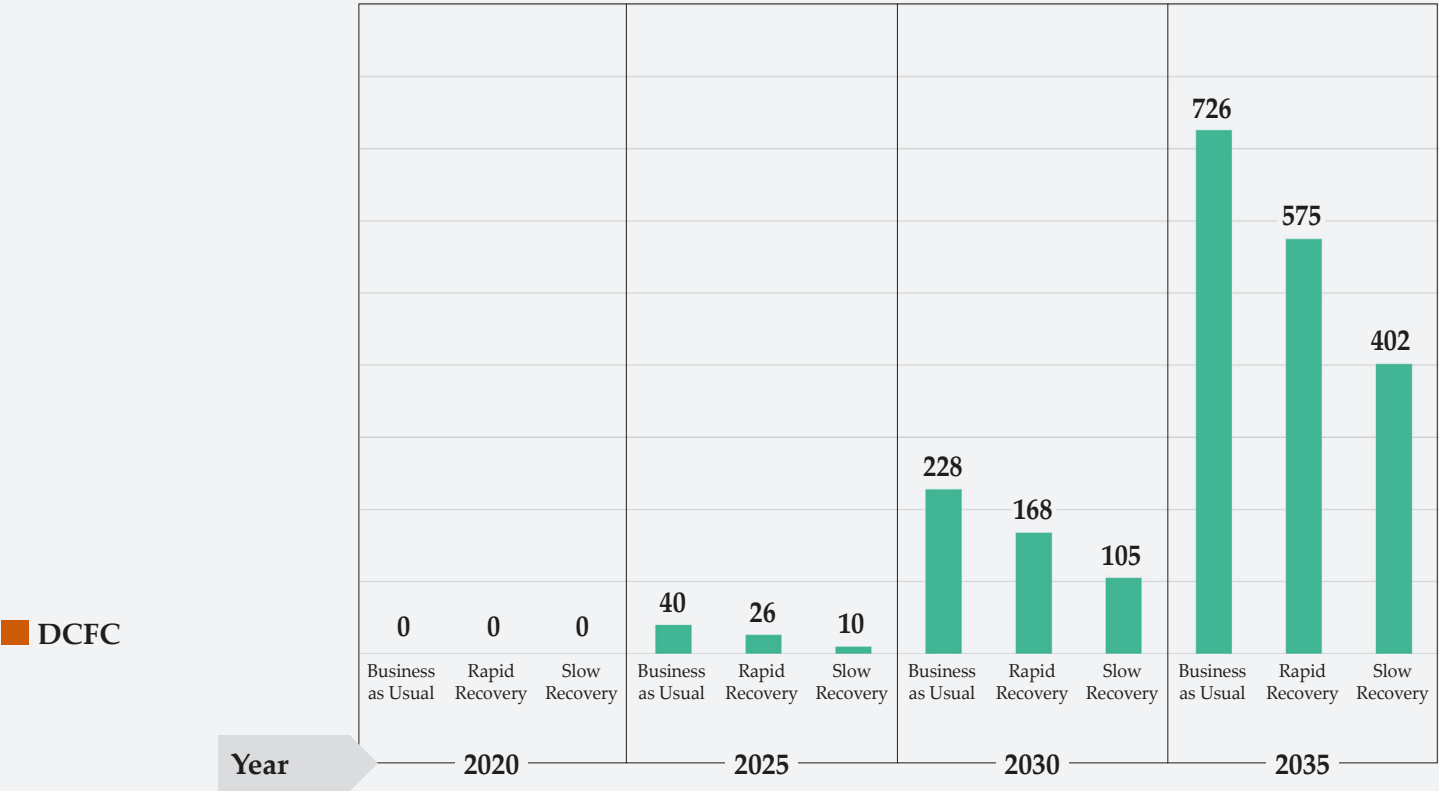
For Step 2, we calculated the energy that would need to be supplied by charging ports in each census tract, as explained above.

For Step 3, we calculated how many 500kW DCFC would be needed in each census tract to provide the energy calculated in Step 2 at the given utilization rates.

Results

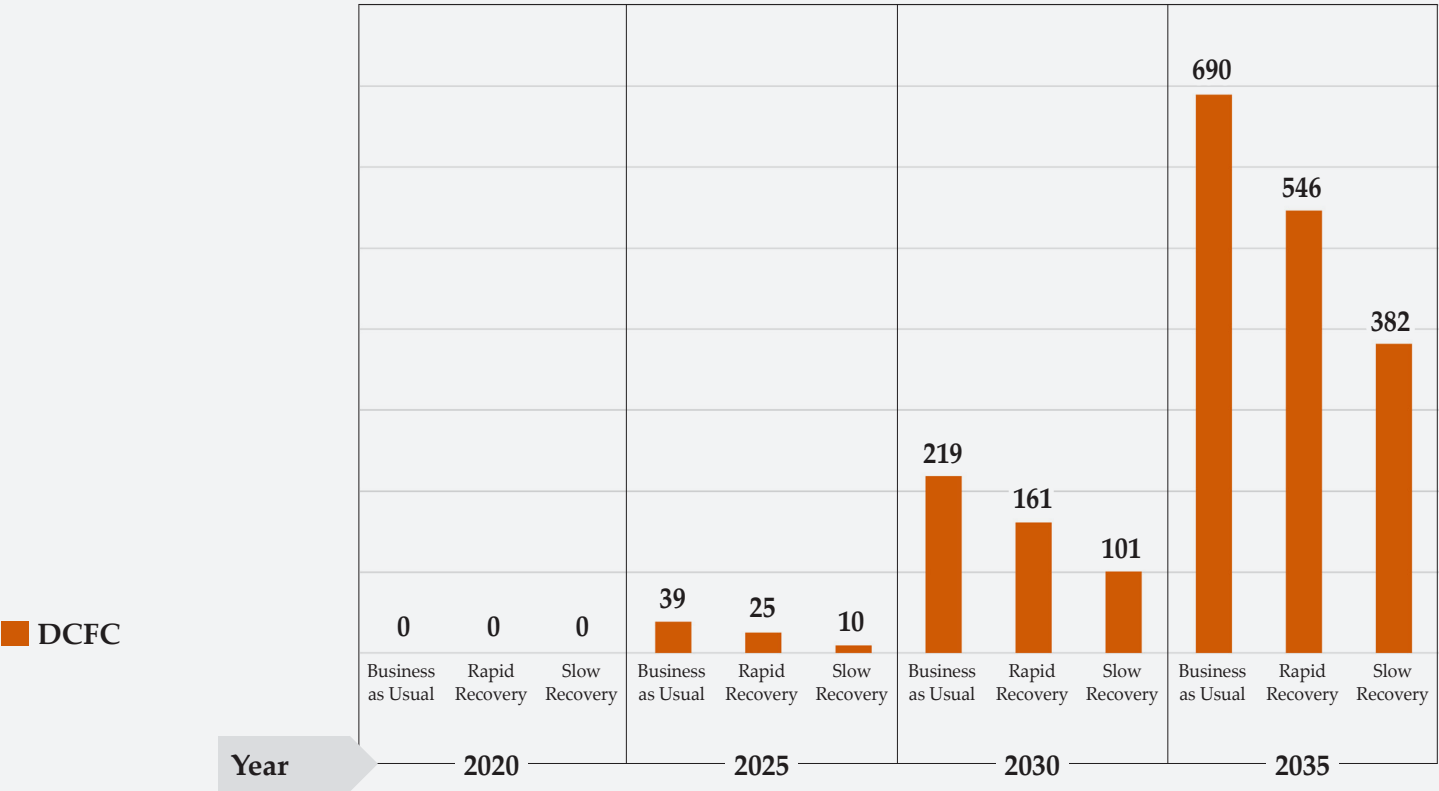
The results of this modeling are shown in **Figure D20** and **Figure D21**.

Figure D20. Charging Ports Needed for Long-Haul Trucks Before Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

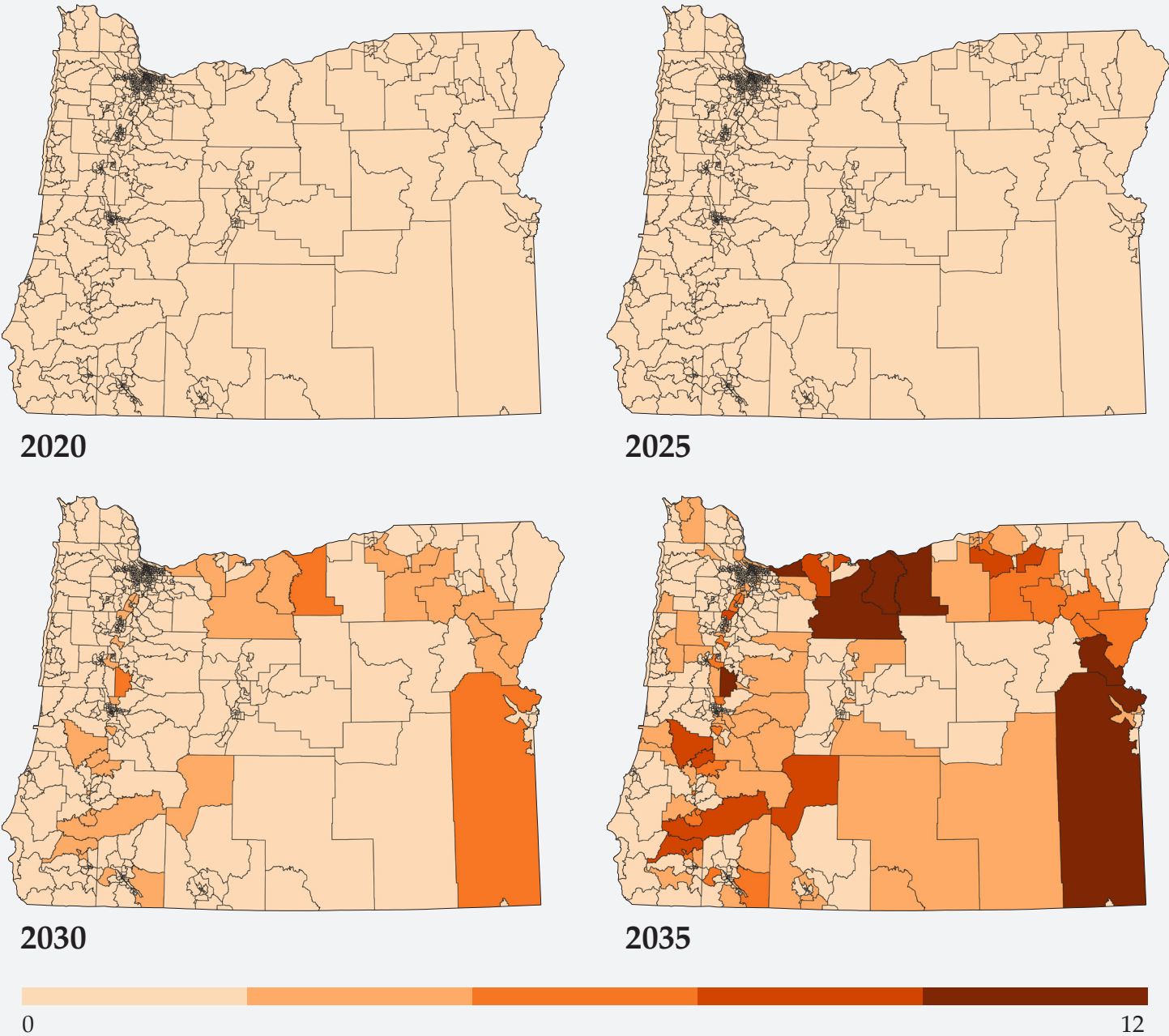
Figure D21. Charging Ports Needed for Long-Haul Trucks After Optimization



Note: Modeling assumes 50,000 electric vehicles in 2020.

To produce the heatmaps in **Figure D22**, we plotted the number of 500kW DCFC by census tract.

Figure D22. Charging Ports Needed in the Long-Haul Trucking (DCFC) Use Case



Note: Modeling assumes 50,000 electric vehicles in 2020. Heatmaps also available at <https://www.oregon.gov/odot/Programs/Pages/TEINA.aspx>.

Micromobility

Micromobility comprises a suite of electrified personal mobility devices, including bicycles, scooters, mopeds, skateboards, one-wheels, unicycles, and more. These devices are charged using regular 110V outlets, not special charging ports with higher power requirements, so there is no “charging infrastructure” to model for them. We do anticipate that as micromobility demand increases, there will be a need for more 110V outlets where people will want to park and recharge their personal mobility devices, but that need is outside the scope of this modeling work.

Instead, we model this use case by projecting how increased adoption of micromobility modes will reduce the projected adoption and use of light-duty vehicles (LDVs), both electric and internal combustion engine (ICE), resulting in reduced need for public charging ports of all types.

We also considered the potential impact on transportation network companies (TNCs) and transit buses. On the one hand, increased micromobility use is likely to reduce some demand for short-distance rides on TNCs and transit buses. On the other hand, if micromobility proves to be suitable for a significant share of demand for rides, especially in urban areas, some people may elect to not own a car at all and instead use TNCs and transit buses for longer-distance rides. Because there is no clear empirical data to inform the magnitude of these countervailing effects, we assume that they cancel each other out and do not make a clear directional impact on the demand for charging infrastructure.

Given the relative nascency of the micromobility sector, there is little empirical data on which to base our modeling. However, we have taken into account two external projections:

- Portland has a long-term goal of meeting 25% of commuting trips with bikes. We assume this goal can be met by 2035, and we further assume that it will include other forms of micromobility, like eScooters.
- According to a September 2020 report from Guidehouse Insights, the global market for micromobility sharing services revenue is expected to grow from \$8.0 billion in 2020 to \$30.8 billion by 2030 at a compound annual growth rate (CAGR) of 14.4%.³² Based on this projection, we use a 15% CAGR for micromobility adoption.

We modeled the Micromobility case as follows:

Step 1: As a baseline, we begin with the output of the modeling from Urban and Rural LDV use case described above for the demand for LDV charging ports. We set the baseline for Micromobility use at its 2020 level of 3% of all trips.

Step 2: We calculate the potential reduction in demand for LDV charging ports in urban and rural areas, defined by county as discussed in Appendix A, separately since micromobility is assumed to be far more prevalent in urban areas. We calculate this potential reduction using the factors shown in the following tables. In accordance with the narrative scenarios, micromobility takes a much larger share of total trips in the Slow Recovery Scenario than in the other two.

Step 3: We estimate the potential reduction in demand for LDV charging ports against the Urban and Rural LDV baseline.

Our assumptions for the micromobility share in each scenario were as follows:

Base Scenario

Year	Urban Micromobility Share	Rural Micromobility Share
2020	3%	0%
2025	10%	2%
2030	18%	4%
2035	25%	5%

Rapid Recovery Scenario

Year	Urban Micromobility Share	Rural Micromobility Share
2020	3%	0%
2025	6%	1%
2030	15%	3%
2035	25%	5%

Slow Recovery Scenario

Year	Urban Micromobility Share	Rural Micromobility Share
2020	3%	0%
2025	15%	3%
2030	30%	6%
2035	40%	10%

The complete set of adjustment factors for the Micromobility use case are shown in **Table D1**.

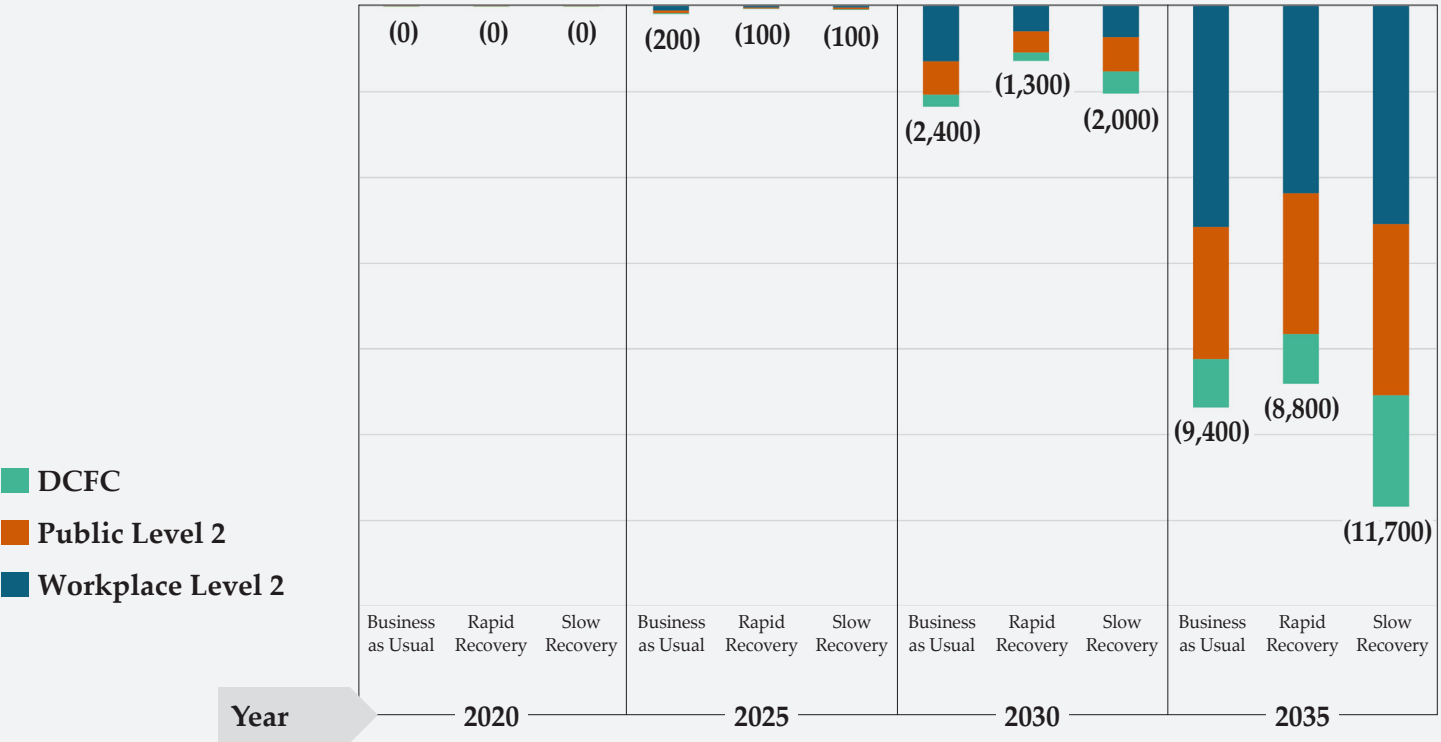
Table D1. Micromobility Adjustment Factors

Scenario	Year	Urban Micromobility Penetration	Rural Micromobility Penetration	Home Charging Access	Urban Charging Demand Reduced Due to Micromobility	Rural Charging Demand Reduced Due to Micromobility	Original Total Chargers	Micromobility Adjusted Total Chargers	Difference	% Difference
Business as Usual Workplace Level 2 by Census Tract	2020	3%	0%	90%	0.30%	0.00%	-	-	-	-
	2025	10%	2%	80%	2.00%	0.40%	6,719	6,616	(103)	2%
	2030	18%	4%	70%	5.40%	1.20%	31,005	29,714	(1,291)	4%
	2035	25%	5%	60%	10.00%	2.00%	67,385	62,234	(5,152)	8%
Business as Usual Public Level 2 by Census Tract	2020	3%	0%	90%	0.30%	0.00%	2,400	2,395	(5)	0%
	2025	10%	2%	80%	2.00%	0.40%	4,279	4,217	(62)	1%
	2030	18%	4%	70%	5.40%	1.20%	19,722	18,946	(776)	4%
	2035	25%	5%	60%	10.00%	2.00%	42,854	39,767	(3,087)	7%
Business as Usual DCFC by Census Tract	2020	3%	0%	90%	0.30%	0.00%	458	457	(1)	0%
	2025	10%	2%	80%	2.00%	0.40%	2,285	2,263	(23)	1%
	2030	18%	4%	70%	5.40%	1.20%	10,322	10,034	(288)	3%
	2035	25%	5%	60%	10.00%	2.00%	22,328	21,208	(1,120)	5%
Rapid Recovery Workplace Level 2 by Census Tract	2020	3%	0%	90%	0.30%	0.00%	-	-	-	-
	2025	6%	1%	80%	1.20%	0.20%	3,930	3,895	(35)	1%
	2030	15%	3%	70%	4.50%	0.90%	18,094	17,499	(595)	3%
	2035	25%	5%	60%	10.00%	2.00%	58,591	54,219	(4,372)	7%
Rapid Recovery Public Level 2 by Census Tract	2020	3%	0%	90%	0.30%	0.00%	2,400	2,395	(5)	0%
	2025	6%	1%	80%	1.20%	0.20%	2,813	2,788	(25)	1%
	2030	15%	3%	70%	4.50%	0.90%	14,593	14,102	(491)	3%
	2035	25%	5%	60%	10.00%	2.00%	44,048	40,767	(3,281)	7%
Rapid Recovery DCFC by Census Tract	2020	3%	0%	90%	0.30%	0.00%	324	324	(0)	0%
	2025	6%	1%	80%	1.20%	0.20%	1,593	1,583	(10)	1%
	2030	15%	3%	70%	4.50%	0.90%	7,813	7,617	(196)	3%
	2035	25%	5%	60%	10.00%	2.00%	22,050	20,889	(1,161)	5%
Slow Recovery Workplace Level 2 by Census Tract	2020	3%	0%	90%	0.30%	0.00%	-	-	-	-
	2025	15%	3%	80%	3.00%	0.60%	1,736	1,702	(34)	2%
	2030	30%	6%	70%	9.00%	1.80%	1,200	11,280	(720)	6%
	2035	40%	10%	60%	16.00%	4.00%	43,000	37,920	(5,080)	12%
Slow Recovery Public Level 2 by Census Tract	2020	3%	0%	90%	0.30%	0.00%	2,400	2,395	(5)	0%
	2025	15%	3%	80%	3.00%	0.60%	1,722	1,683	(39)	2%
	2030	30%	6%	70%	9.00%	1.80%	12,500	11,699	(801)	6%
	2035	40%	10%	60%	16.00%	4.00%	37,000	33,000	(4,000)	11%
Slow Recovery DCFC by Census Tract	2020	3%	0%	90%	0.30%	0.00%	324	324	(0)	0%
	2025	15%	3%	80%	3.00%	0.60%	994	976	(18)	2%
	2030	30%	6%	70%	9.00%	1.80%	9,100	8,576	(524)	6%
	2035	40%	10%	60%	16.00%	4.00%	29,000	26,400	(2,600)	9%

Results

The potential reduction in LDV charging ports calculated for the Micromobility use case is shown in **Figure D23**.

Figure D23. Reduction in Needed Charging Ports Due to Increased Micromobility Use Case



Note: Modeling assumes 50,000 electric vehicles in 2020.

Disadvantaged Communities

In terms of charging infrastructure, the main need that disadvantaged communities have is for more fast charging ports. Residents of multi-unit dwellings (MUDs) who do not have a dedicated parking space where they can reliably charge at Level 1 or Level 2 speeds need to be able to charge quickly while doing errands. In addition, drivers for transportation network companies (TNCs) like, Uber and Lyft, who often live in these communities need to be able to charge quickly in order to maximize their driving time.

In addition to these specific needs for more Direct Current Fast Charge (DCFC) charging ports, disadvantaged communities need more passenger vehicles, which will need public charging ports of all types to support them. Passenger vehicle registrations in Oregon are about 10% lower in disadvantaged communities than non-disadvantaged communities. Because our model allocates charging ports to counties or census tracts based on their share of vehicle registrations, it allocates fewer charging ports to disadvantaged communities.

To compensate for this, we increase the number of charging ports in the disadvantaged communities by various factors for each scenario. This also helps to compensate for the fact that disadvantaged communities have less access to home charging, due to a smaller portion of housing units being one unit (for example a single family home with a dedicated parking spot). In disadvantaged communities 56% of housing units are one unit, compared to 72% of housing units in other communities (taken from the 2019 American Community Survey).

At the time of this analysis, Disadvantaged Communities were not formally defined at the State or Federal level. To best capture the disadvantages a community may face with respect to EV adoption, a low-income threshold was used to classify census tracts in Oregon as disadvantaged for this purpose. HUD defines low-income for a 2-person household in the Bend-Redmond MSA as \$49,050 in annual household income, and the Portland-Vancouver-Hillsboro MSA as \$59,000. For this analysis, \$48,800 was selected as the state average low-income threshold to denote a disadvantaged community.

As a final check on our analysis, we benchmarked Portland General Electric’s forecast for electric vehicle (EV) charging ports needed by 2025 and confirmed that our modeling results aligned with their forecast.

We modeled the disadvantaged community use case as follows:

Step 1: As a baseline, we started with the output of the modeling from Urban and Rural LDV use case described above for the demand for LDV charging ports.

Step 2: We added an increment of all types of charging ports to each of the disadvantaged communities to compensate for the bias in our model due to lower vehicle registrations in those communities. Census tracts with a median household income less than \$48,800 were defined as disadvantaged communities.

Step 3: We further adjusted the number of charging ports by charging port type, in accordance with the narrative scenarios.

Our assumptions for each scenario were as follows:

Base Scenario

For Step 2, we added 25% to the number of all types of charging ports (workplace Level 2, public Level 2, and public DCFC) to the disadvantaged communities for each of the milestone years. No further adjustments were made for this scenario.

Rapid Recovery Scenario

For Step 2, we added 25% to the number of all types of charging ports (workplace Level 2, public Level 2, and public DCFC) to the disadvantaged communities for each of the milestone years.

For Step 3, we made the following additional adjustments. These adjustments reflect the outlook of the Rapid Recovery narrative scenario, particularly.

Year	Workplace Level 2	Public Level 2	Public DCFC
2025	-10%	+30%	+40%
2030	-5%	+25%	+35%
2035	-5%	+15%	+20%

Slow Recovery Scenario

For Step 2, we added 25% to the number of all types of charging ports (workplace Level 2, public Level 2, and public DCFC) to the disadvantaged communities for each of the milestone years.

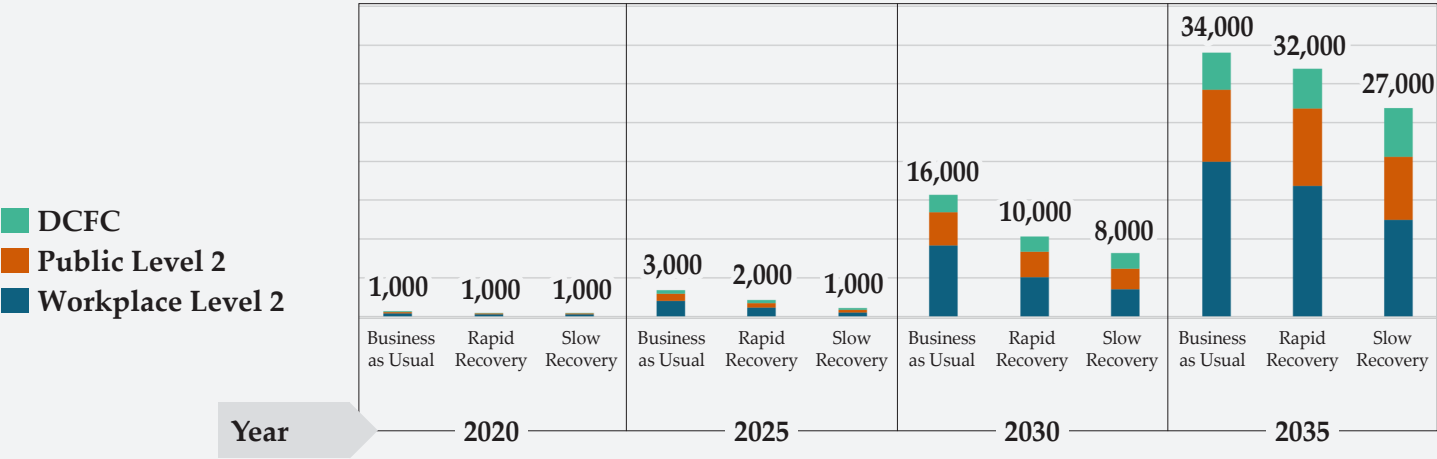
For Step 3, we made the following additional adjustments. These adjustments reflect the outlook of the Slow Recovery narrative scenario, particularly the reduced outlook for light-duty vehicle (LDV) adoption, and the increased outlook for micromobility demand, which also reduces the need for LDV charging ports.

Year	Workplace Level 2	Public Level 2	Public DCFC
2025	-10%	+20%	+40%
2030	-5%	+15%	+40%
2035	-5%	+5%	+25%

Results

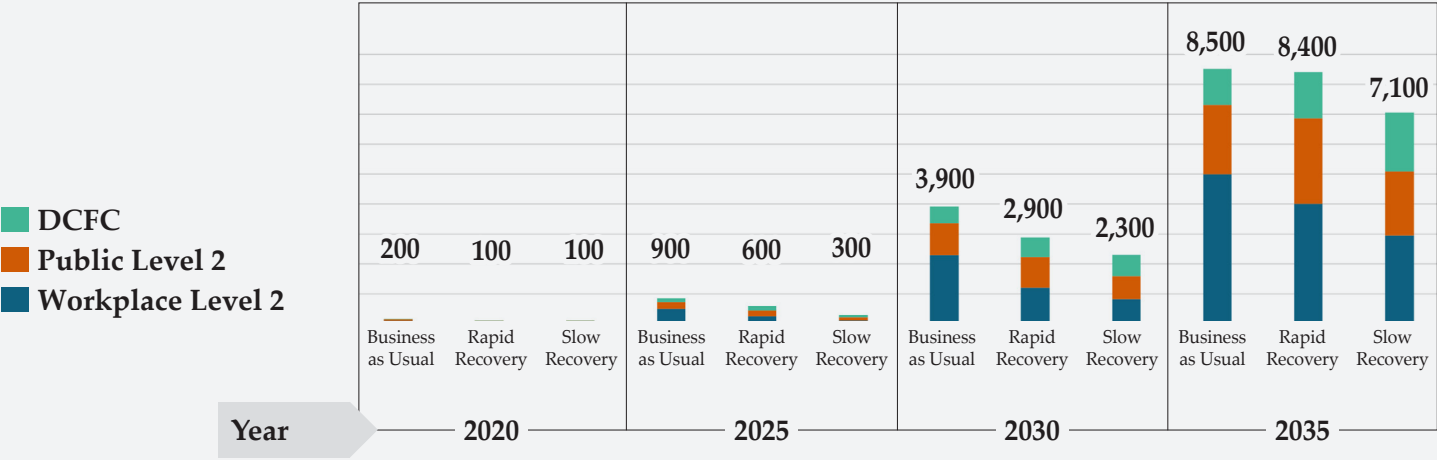
The original number of charging ports calculated for the disadvantaged communities use case (based on the Urban and Rural LDV use case) are shown in **Figure D24**. The additional LDV charging ports needed for disadvantaged communities is shown in **Figure D25**. The resulting adjusted number of charging ports needed for disadvantaged communities is shown in **Figure D26**.

Figure D24. Baseline Number of Charging Ports Needed for Disadvantaged Communities (Urban and Rural LDV Use Cases)



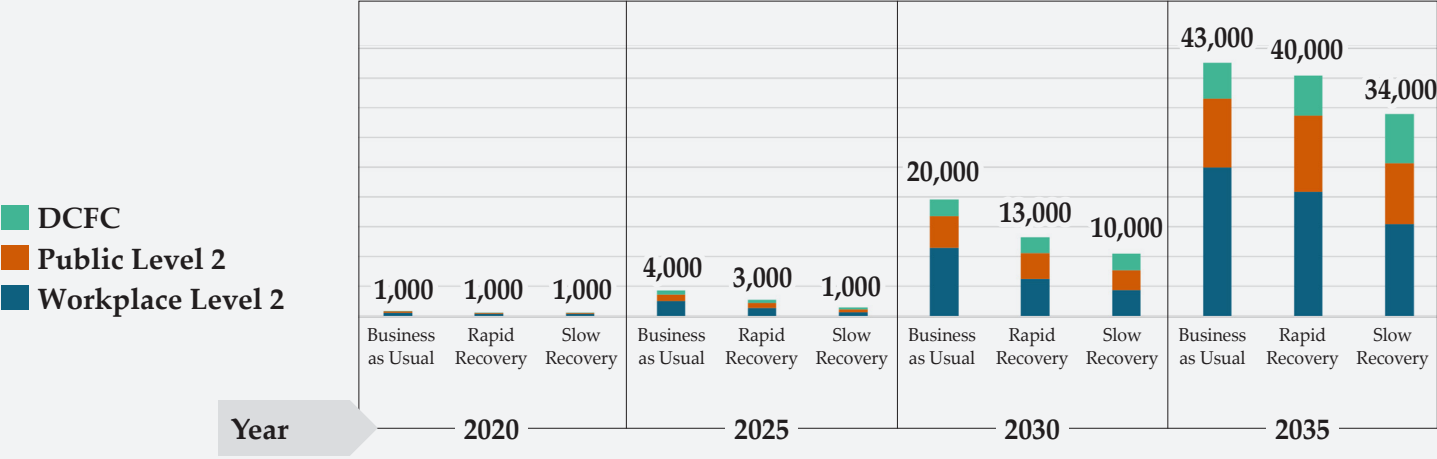
Note: Modeling assumes 50,000 electric vehicles in 2020.

Figure D25. Additional Charging Ports Needed for Disadvantaged Communities



Note: Modeling assumes 50,000 electric vehicles in 2020.

Figure D26. Total Adjusted Charging Ports Needed for Disadvantaged Communities



Note: Modeling assumes 50,000 electric vehicles in 2020.

To produce the heatmaps in **Figure D27** and **Figure D28** we showed the census tracts defined as being a disadvantaged community. Note that the number of chargers is not shown for other communities.

Figure D27. Total Number of DCFC Charging Ports Needed in Disadvantaged Communities

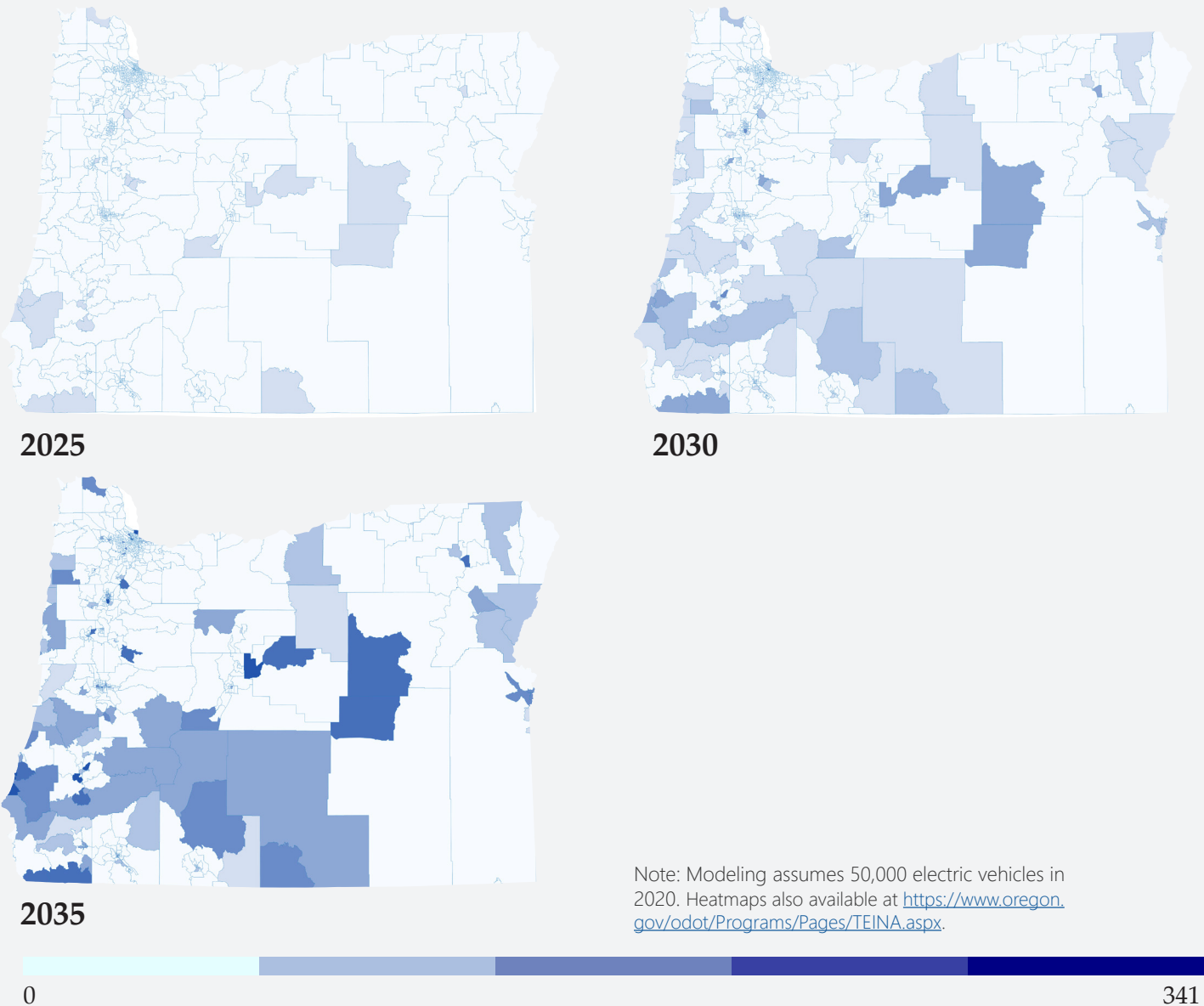
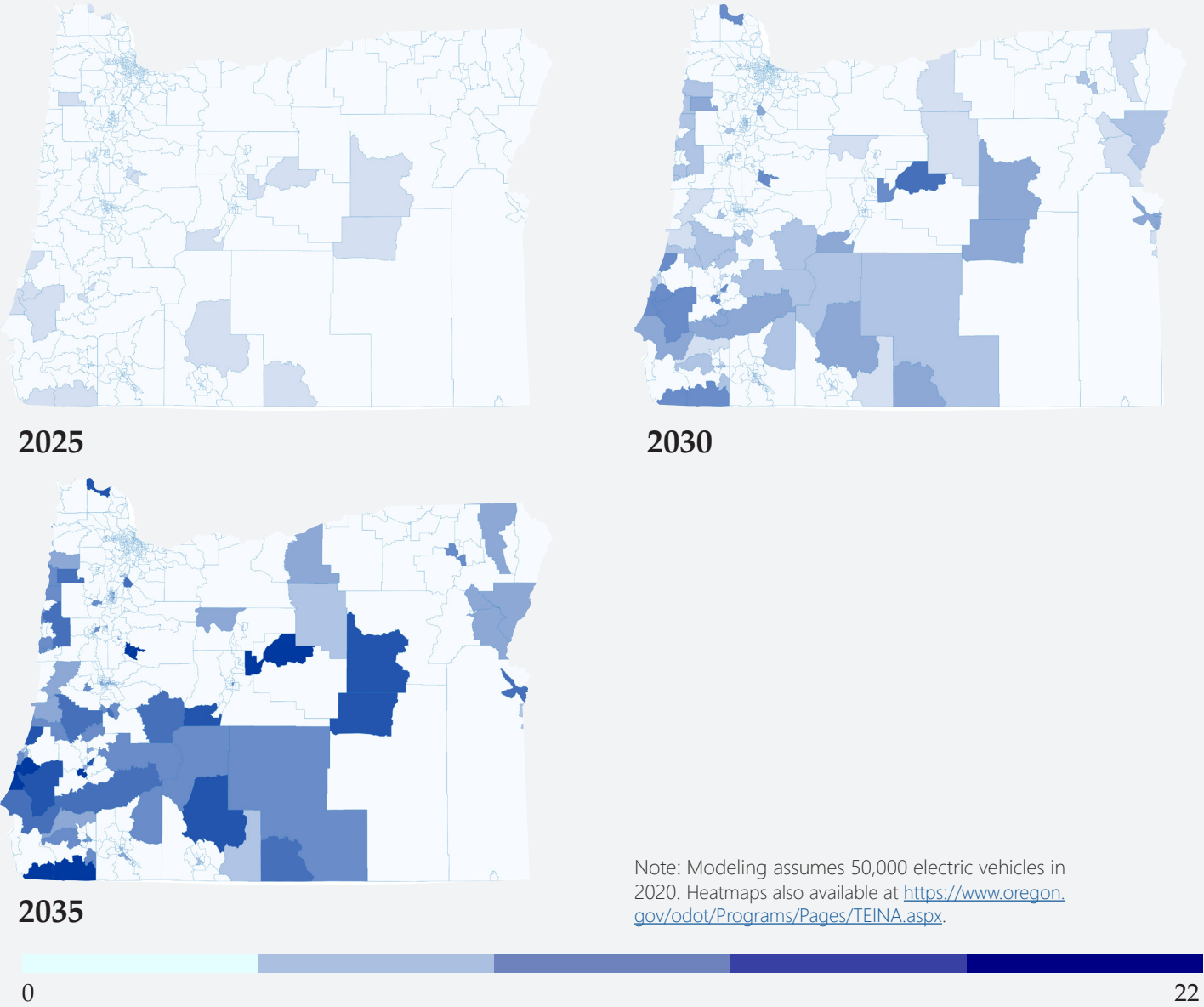


Figure D28. Net Additional DCFC Charging Ports Required in Disadvantaged Communities



Model Optimization

The modeling discussed treats each use case individually, as if a dedicated set of charging ports existed for each one. In reality, some charging ports will be used by multiple use cases, so we performed an optimization pass on the model results to estimate how such sharing might reduce the total number of charging ports needed in Oregon.

Given the nascent state of the electric vehicle (EV) market and its charging infrastructure, there is insufficient literature or data on which to base any empirical modeling of how multiple use cases might be able to share charging ports. However, we have used our informed opinions to attempt to model it.

Our optimization modeling makes two assumptions:

1. The overall impact of sharing in each use case will be quite modest because our modeling assumes at that some point, as the EV fleet grows, the utilization of charging ports will be maximized, and the hours of the day that charging ports will not be in use will be fairly minimal.

2. As the EV fleet grows, the use of charging ports by EVs in multiple use cases will increase.

Not all use cases will have potential overlap with other use cases, as shown in the Venn diagram in **Figure D29**. We do not expect overlap in the following cases:

- We expect transit buses and school buses to use dedicated charging ports, so we do not anticipate that any other uses cases will use their charging ports.
- Ultra-high speed (1+ MW) Direct Current Fast Charge (DCFC) for long-haul trucks probably won't be usable by anything else.
- Workplace Level 2 charging ports will probably be restricted (via a fence, or software authentication, or another method) to employee use, so we do not expect them to be usable by anyone other than employees.

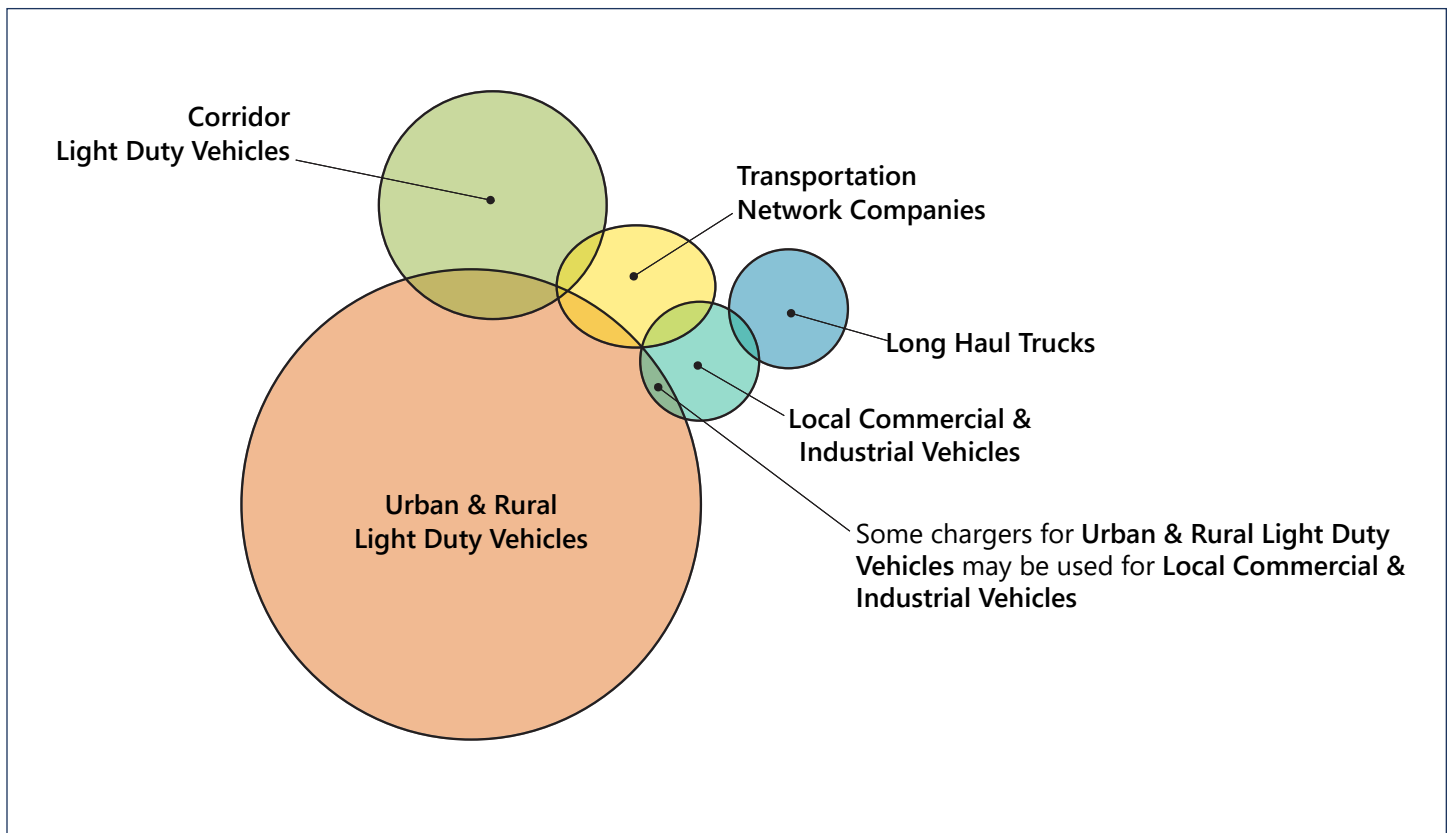


Figure D29. TEINA Model Optimization

To quantify the reduction in charging ports in each of the milestone years, we applied reduction factors as shown in the Tables D2, D3, and D4. These tables only show use cases where some optimization is possible.

For example: In 2025, we assume that 5% of the projected need that transportation network company (TNC) drivers have for charging ports could be met by Urban and Rural light-duty vehicle (LDV) charging ports, that 3% could be met by corridor LDV charging ports, and that the need could be further reduced by 1% as TNC drivers use charging ports installed for local commercial

and industrial vehicles. In total, we estimate that 9% of proposed charging ports for TNC drivers could be eliminated by 2025, and up to 18% of proposed TNC charging ports could be eliminated by 2035, while providing the same level of service.

For another example: Since all corridors pass through both rural and urban areas, some of the need for purely charging Corridor LDVs can be met by the Urban and Rural LDV charging ports. By 2035, up to 25% of the projected need for corridor LDV charging ports could be eliminated.

The potential adjustments to the needed charging ports for each use case as a result of optimization are denoted in each of the charts where adjustments are possible.

Table D2. Optimization Results for 2025

Use Case	Corridor LDVs	Local Commercial and Industrial Vehicles	TNCs	Long-Haul Trucking
Urban LDV and Rural LDV	-12%	-5%	-5%	-
Corridor LDV	-	-	-3%	-
Local commercial and industrial vehicles	-	-	-1%	-3%
<i>Total Changes</i>	-12%	-5%	-9%	-3%

Table D3. Optimization Results for 2030

Use Case	Corridor LDVs	Local Commercial and Industrial Vehicles	TNCs	Long-Haul Trucking
Urban LDV and Rural LDV	-18%	-7%	-8%	-
Corridor LDV	-	-	-4%	-
Local commercial and industrial vehicles	-	-	-2%	-4%
<i>Total Changes</i>	-18%	-7%	-14%	-4%

Table D4. Optimization Results for 2035

Use Case	Corridor LDVs	Local Commercial and Industrial Vehicles	TNCs	Long-Haul Trucking
Urban LDV and Rural LDV	-25%	-10%	-10%	-
Corridor LDV	-	-	-5%	-
Local commercial and industrial vehicles	-	-	-3%	-5%
<i>Total Changes</i>	-25%	-10%	-18%	-5%

The reduced number of needed charging ports after optimization are shown by use case, where applicable, throughout this Appendix and in the main body of the report.

Progress to Date in Achieving Senate Bill 1044 Goals

The 2020 goal in Oregon Senate Bill 1044 was to have 50,000 registered zero emission vehicles (ZEVs) in Oregon by the end of 2020. Actual adoption was short of that goal by a third, at 33,547.

New State Initiatives

As of March 2021, two bills in the Oregon legislature aim to stimulate electric vehicle (EV) adoption and EV charging infrastructure deployment.

Senate Bill 314 would expand the ability of regulated electric utilities to recoup from ratepayers investments in charging stations and other EV infrastructure and allow natural gas utilities to rate-base investments that support the adoption of vehicles powered by renewable natural gas or hydrogen.

House Bill 2165, signed into law May 26, 2021, removes a 2027 sunset on the state's EV rebate, keeps \$12 million flowing annually into the program from a 0.5% tax on new-vehicle sales in the state, and increases the value of the add-on Charge Ahead rebate available to low- and middle-income earners from \$2,500 to \$5,000. This means those residents could get rebates worth up to \$7,500. It also requires Portland General Electric (PGE) and PacifiCorp to assess a charge of 0.25% on customer bills to raise funds for transportation electrification investments, with a large portion of this funding dedicated to historically marginalized communities. PGE would raise approximately \$4.5 million through this mechanism.

Corridor Charging Expansion

Portland General Electric and Daimler Trucks North America are working together on a first-of-its-kind public truck charging site at the Swan Island Industrial Park near Portland, which they are calling "Electric Island." It opened on April 21, 2021 and is designed to support up to nine vehicle charging stations for light-, medium-, and heavy-duty vehicles, with charging levels of up to greater than one megawatt.



Appendix E:

Detailed Policy Recommendations

The following discussion provides more detail and description, in support of the six Overall Infrastructure Goals, and the Recommended Policies and Initiatives to Accomplish Infrastructure Goals addressed in the body of the Transportation Electrification Infrastructure Needs Analysis (TEINA) report.

Level 1: Enable (Shorter-term, easier-to- implement actions)

L1.1. Investigate and Develop Standards for Consistent Electric Vehicle Service Equipment (EVSE) User Experience, Reliability, and Redundancy [Use Cases Impacted: Urban LDVs, Rural LDVs, Corridor LDVs, TNCs, Disadvantaged Communities,]

The State and electric utilities should investigate ways to develop standards on EVSE interoperability to allow easy charging and convenient roaming of electric vehicles (EV) drivers across different charging network platforms. Additionally, there should be reliability and redundancy requirements developed to ensure the availability of EVSE for drivers and instill confidence in the infrastructure (for example, having 4-8 Direct Current Fast Charge charging ports per site could ensure there will always be access to a working charging ports). Such standards could be built into grant or incentive requirements for either State or utility funding. An alternative route could be establishing interoperability requirements on public EVSEs and failure to comply will result in punitive action until corrected.

These charging standards should be developed with input from broader regional working groups to ensure regional reliability, redundancy, and

interoperability. Furthermore, the standards will need to be compatible with adjoining states' standards and could be modeled on similar approaches in the West Coast Electric Highway and the REV West's voluntary minimum standards. Ideally, we would work with federal agencies to develop nationwide protocols.

L1.2. State Directs Public Utility Commission (PUC)/Public Utility Governing Bodies to Enable and Encourage Utilities to:

L1.2.1. Pursue EV make-ready* investments [Use Cases Impacted: Urban LDVs, Rural LDVs, Corridor LDVs, TNCs, Disadvantaged Communities]

EV make-ready funding should be made available to retrofit existing buildings and provide for new developments to create adequate electrical infrastructure up to and past the meter that enable EV charging at workplaces, multi-unit-dwellings, fleet depots, and for medium/heavy-duty applications (such as school and transit bus depots). Incentives to housing projects could be based on building type and number of units and zoning in a manner that prioritizes affordable housing. Additional consideration and prioritization should be given to solutions that incorporate load management capabilities.

** Make-ready means the pre-wiring of electrical infrastructure at a specific location to facilitate easy and cost-efficient future installation of Electric Vehicle Service Equipment, including charging ports.*

In the case of investor-owned utilities, the State should direct the Public Utility Commission (PUC) to emphasize these investments using rate-payer and Clean Fuels Program funds. State incentives or legislative mandates may be required for consumer-owned utilities.

L1.2.2. Create appropriate rates for various electric vehicles (EV) charging activities [Use Cases Impacted: Urban Light-Duty Vehicles (LDVs), Rural LDVs, Transportation Network Companies (TNCs), Disadvantaged Communities]

Depending on charging profiles, charging port types, and user groups, utilities both investor-owned utilities (IOUs) and consumer owned utilities (COUs) should be encouraged to create, explore, and share specific rate schedules for various types of EV charging through altering existing rate schedules or creating new ones. These schedules will help address rate inequities so that EV owners living in multi-unit dwellings aren't stuck paying a "public" charging rate due to a shared electric vehicle service equipment (EVSE) setup or having to use public charging ports exclusively (the cost is generally much higher than the standard residential rates paid by drivers who live in single-family homes). Other examples include rate structures that minimize emissions; change pricing based on the time of day, season, and more Time of Use (TOU) rates; mitigate demand charge impacts for locations with many Level 2 charging ports; and change dynamically to prioritize generation resources and grid resiliency (such as, but not limited, to energy storage or residential and commercial vehicle-to-grid rates).

L1.2.3. Enable Direct Current Fast Charge (DCFC) charging ports deployment through innovative rate design that mitigates demand charge impacts [Use Cases Impacted: Rural LDVs, Corridor LDVs, Long-Haul Trucking]

DCFC deployment is being hindered by electric utility demand charges due to the stations' high power draw. The PUC should direct IOU to create a DCFC-specific rate schedule that adequately mitigates the current impact of demand charges through methods such as deferred demand charges, TOU demand charges, tiered rates, and more. For public utilities, the State should incentivize innovative solutions that can either mitigate the impact of demand charges or provide technical support in the creation of a DCFC rate to help deploy a new rate schedule.

A special/pilot rate schedule could be applied to DCFC to enable more private entities to install them by lessening the impact of demand charges. Continued monitoring of the charging profile of these DCFC can help electric utilities re-evaluate the load profile and renew the rate schedule accordingly every 3-5 years.

L1.2.4. Set standards for IOU rebate programs for EV charging ports and charging port installation to specifically incentivize low-to-moderate income EV drivers [Use Cases Impacted: Urban LDVs, Rural LDVs, Disadvantaged Communities]

Direct PUC to set minimum standards for the utility-funded incentive programs for EV charging infrastructure to have a minimum or enhanced incentive for low- or moderate-income drivers to encourage and facilitate EV adoption. In some cases, this might include removing requirements or expectations that these individuals enter into any utility programs that qualify other individuals for the incentive.

Adopt measures—using state-sponsored grants, Clean Fuels Program funding, and utility guidance and incentives—to increase EV charging investments in low-income, black, indigenous, and people of color, rural, and disadvantaged communities.

Investigate ways to coordinate and ensure charging access and affordability for those eligible for the Charge Ahead rebate.

L1.2.5. Encourage and incentivize public utilities to utilize Clean Fuels revenue to fund public DCFC and Level 2 EVSE in areas (in their territory) without adequate EV charging infrastructure [Use Cases Impacted: Urban LDVs, Rural LDVs, Corridor LDVs, TNCs, Disadvantaged Communities,]

Encourage utilities to leverage the Clean Fuels revenue derived from residential EV charging to help fund public charging ports in areas without adequate access to home charging through public infrastructure support or ownership. This will help create a more balanced distribution of available charging infrastructure and avoid expensive construction or retrofits at locations not suitable for EVSE. Such support should not be limited to impacting EV drivers without home charging and thus should include EV-ready or charging rebates for workplace and fleet (LDV and Short-haul delivery/MDV) charging. Another strategy could be to legislatively mandate that

consumer-owned utilities be required to spend Clean Fuels revenue on transportation electrification efforts.

L1.2.6. Encouraging on-bill financing for electric vehicles (EV) charging ports and installation costs to mitigate upfront cost barriers [Use Cases Impacted: Urban Light-Duty Vehicles (LDVs), Rural LDVs, Transportation Network Companies (TNCs), Disadvantaged Communities]

In order to expand access to electric vehicle service equipment (EVSE) programs, utilities could leverage on-bill financing or other financing methods for both residential and commercial customers to ease the initial costs of EVSE purchase and installation (this could be especially helpful for encouraging workplace charging). This can also facilitate a more streamlined and lower-cost process that will grant utilities more control over their customers' EVSE selection for future demand response programs and support additional growth to the Oregon Clean Fuels Program.

L1.3. Encourage or Incentivize Corridor Charging Through Low-Interest State Loans to Utilities and Interested Third-Party Vendors [Use Cases Impacted: Corridor LDVs]

The State could provide funding to create a long-term low- or no-interest rate program to attract private developers and utilities to install Direct Current Fast Charge (DCFC) along corridors identified by the State and ensure adequate charging capacity to enable long-distance road trips throughout all of Oregon.

L1.4. Streamlining EVSE Permitting at Local Jurisdictions [Use Cases Impacted: All use cases except Micromobility]

The State directs local jurisdictions to develop and follow State guidelines to streamline EVSE permitting processes. This could include basic installations at single-family homes and range to larger projects, such as EVSE installations at multi-unit dwellings, commercial buildings, and DCFC installations along highway corridors or public sites. The targeted time frame for EVSE permitting should be same-day for single-family EVSEs, one-week for multi-family or commercial buildings, and two-week for DCFCs.

The State could also adopt EVSE permitting streamlining requirements similar to California's AB 1236 to require Authority Having Jurisdictions

(cities and counties) to develop an expedited and streamlined permitting process for all EVSE. The streamlining guideline should include resources such as checklists, easily accessible website for resources, and an online electronic application for application tracking and approving systems. The streamlining of permitting can accelerate the deployment of EV make-ready programs drastically and improve the overall efficiency of the charging infrastructure deployment.

L1.5. EV Charging Education [Use Cases Impacted: All use cases except Micromobility]

Oregon Department of Transportation should develop EV charging education programs, such as "EV Charging 101," "EV Charging Etiquette," and an introduction to relevant regulations such as illegally occupying EV charging spaces to improve the general public's awareness of this infrastructure and enhance the user experiences at EV charging stations. The outreach of the educational materials should work with community based organizations to conduct multilingual outreach and engage community leaders to distribute key talking points. A targeted education and outreach effort for black, indigenous, and people of color, and disadvantaged communities on EV charging and infrastructure would be vital to ensure equitable access to information and education.

L1.6. Building Developer, Manager, and Homeowner Association Education [Use Cases Impacted: Urban LDVs, TNCs]

The State directs/mandates the state building code division or local jurisdictions to develop and implement general education on EV charging best practices to improve access to charging at new and existing buildings. This education should include, but is not limited to, siting, charging program design and development, permitting processes, and the final construction and commissioning. The education material should also stress the importance of EV infrastructure in buildings and communicate the upcoming building codes or energy efficiency codes that will have EV-readiness requirements.

L1.7. Uniform and Prominent Signage

[Use Cases Impacted: Urban Light-Duty Vehicles (LDVs), Rural LDVs, Corridor LDVs, Long-Haul Trucking]

Oregon Department of Transportation (ODOT) should develop uniform and prominent guidelines on electric vehicle (EV) charging sign design and placement. This helps create consistency in user experience for EV charging across multiple use cases.

L1.8. Micromobility Public-Private Partnership and Needed Research

[Use Cases Impacted: Micromobility]

State and local jurisdictions should coordinate to develop public-private partnerships to advance opportunities for charging for electric bikes and scooters. Future study is also needed for micromobility infrastructure needs, more industry standardization, commercial technology solutions for payment, and connections to mass transit. Because much of this work is beyond the scope of Transportation Electrification Infrastructure Needs Analysis (TEINA), ODOT should consider a later Micromobility Infrastructure Needs Assessment or similar.

L1.9. Plan for Medium and Heavy Duty Electrification Along Major Corridors [Use Cases Impacted: Long-Haul Trucking]

Utilize RMI's modeling to identify locations for medium-duty vehicles (MDVs)/heavy-duty vehicles (HDVs) electrification locations along major corridors (specifically I-5 and I-84, but quickly assess other routes such as US 97, I-82, US 26, US 20, US 101, and more). Begin a holistic electrical capacity planning process between utility, private entities at or nearby identified sites, and local government entities to ensure adequate capacity at these locations by the mid 2020s.

L1.10. Conduct Statewide Analysis of Grid Electrical Capacity Availability for Targeted Incentivizing of Direct Current Fast Charge (DCFC) [Use Cases Impacted: Rural LDVs, Long-Haul Trucking, Disadvantaged Communities]

Electrical grid capacity is highly variable across the state, resulting in the possibility of charging deserts because of inadequate electrical capacity to support fast charging ports. The State should conduct a statewide analysis of the grid capacity constraints and use that information to create a map of potential DCFC hosting. Such an analysis could also inform efforts to increase overall system resiliency, potentially through battery storage or load management, and help mitigate the effects of power outages.

Level 2 Accelerate (medium-term, medium difficulty of implementation)

L2.1. Targeted State Incentives for Public Electric Vehicle Service Equipment (EVSE) (Level 2 & DCFC) [Use Cases Impacted: Urban LDVs, Rural LDVs, Corridor LDVs, Disadvantaged Communities]

The State provides incentives to Charging Network Providers, consumer owned utilities (COUs), and local government entities through grant or low/no-interest financing. These incentives would solely be available to fund publicly available EVSEs at specific areas to eliminate charging gaps throughout the state due to high-cost rate structures, low-expected utilization, lack of utility investment, or other reasons. Any EVSE funded through this mechanism must ensure that its rates and pricing mechanisms are equitable and affordable.

To identify specific areas that require such state funding to help prevent charging gaps, heatmap modeling outputs from this TEINA will be critical. Additionally, periodic charging gap analyses will be needed to ensure charging gaps are being filled. Existing State-led convening, such as Zero Emission Vehicle Interagency Working Group (ZEVIWG) meetings, could be an appropriate platform for the key stakeholders, including utilities, to review such charging gap analyses. The focus of such meetings should also consider other infrastructure needs, such as grid resiliency, MDV/HDV challenges, and non-ground based transportation "fueling" infrastructure.

Key focuses of such funding will likely include:

1. Urban DCFC charging hub projects that will increase access to charging in densely

populated city areas. This will expand charging access in urban areas with limited off-street parking availability and provide a conducive environment for electrified transportation network companies (TNCs) and general adoption of electric vehicles (EVs) by the public as well.

2. Public Level 2 or Direct Current Fast Charge (DCFC) charging hubs nearby disadvantaged communities that can expand charging access.
3. Rural tourism charging through funding for strategic Level 2 charging port deployments that encourage EV drivers to stay and support rural communities. Work with Travel Oregon and local Chambers of Commerce to identify appropriate and needed charging locations.

L2.2. State adoption of EV-readiness Requirements and Reach Codes for Local Municipalities [Use Cases Impacted: Urban LDVs, Rural LDVs, Disadvantaged Communities]

The State adopts EV-readiness requirements on building codes to provide minimum electrical capacity built-in with conduits that will avoid costly upgrades and retrofits in the future for new developments and major renovations. State should encourage a series of Reach Codes to enable local jurisdictions to adopt more progressive requirements beyond the State building code requirements. The EV-readiness requirements should be differentiated by building types, such as residential one- to two-family homes and townhomes, multi-family dwellings, commercial office buildings, and commercial retail developments.

Level 3 Drive (longer-term, more difficult to implement)

L3.1. State funds Deployment of Infrastructure at State-Owned Properties [Use Cases Impacted: Urban LDVs, Rural LDVs, Corridor LDVs, Local Commercial and Industrial Vehicles, Transit and School Buses, Long-Haul Trucking, Disadvantaged Communities]

The State should make direct funding efforts to deploy electric vehicle service equipment (EVSE)

at State-owned properties, such as State parks and workplaces. This will overcome installation barriers at state-owned facilities or lands and address the lack of business interest from the private sector to provide charging at these locations.

L3.2. State to Adopt Requirement on EV-capable or EV-ready Spaces at Parking Locations by 2050 [Use Cases Impacted: Urban LDVs, Rural LDVs, Local Commercial and Industrial Vehicles, Transit and School Buses, Disadvantaged Communities]

The State should adopt requirements through building codes to ensure adequate EV-readiness at multi-unit dwellings (MUDs), workplaces, and retail/commercial spaces by 2050. The suggested roadmap is as follows:

- 2030: All one- to two-family homes and townhomes will have at least one EV-ready space per unit, MUDs and commercial office buildings will have 20% of parking spaces be EV-ready, and commercial retail parking will have 10% or parking spaces be EV-ready or installed with comparable amount of DCFC.
- 2040: All MUDs and commercial office buildings will have 50% of parking spaces be EV-ready, and commercial retail parking will have 20% or parking spaces be EV-ready or installed with comparable amount of DCFC.
- 2050: All MUDs and commercial office buildings will have 100% of parking spaces be EV-ready, and commercial retail parking will have 30% or parking spaces be EV-ready or installed with comparable amount of DCFC.

The aforementioned requirement would apply to all parking facilities, not just new construction or those undergoing major renovation. Understanding that building owners, management, and home owner associations will naturally pass through costs to renters and homeowners, the State should provide incentives so that charging infrastructure is accessible to all. A suggested solution would be to offer low-to-no interest loans to owners of existing properties who need to retrofit to conform with this mandate.

L3.3. State Collaboration with Federal Agencies on Electric Vehicle Service Equipment (EVSE) Deployment [Use Cases Impacted: Urban Light-Duty Vehicles (LDVs) and Rural LDVs]

The State should collaborate with federal agencies administering the federally-owned lands to deploy EVSE, mostly Level 2 with Direct Current Fast Charge (DCFC), at certain locations. Examples include national parks, national forests, and interstate rest areas. Deploying charging at these tourism-focused federal locations will expand charging access to areas traditionally deemed impossible for shorter range electric vehicles (EVs) to travel and will greatly reduce the barrier of range anxiety when purchasing EVs for outdoor activities. Additionally, it will enhance the tourism activities around the EVSE locations to boost economic recovery and growth thanks to longer dwelling time through Level 2 EVSE deployment.

Additional analyses will be needed to address those use cases and to continue to update the overall findings and direction from TEINA. Oregon Department of Transportation and other agencies should coordinate with stakeholders to determine what other use cases need further analysis.

As for updating the TEINA results, it is suggested that when overall EV adoption in Oregon approaches 300,000 EVs or 10% (likely 2026-2029), a TEINA 2.0 will be needed to reevaluate where the State is and where charging gaps remain. While the next TEINA should ideally not be needed until 60-80% adoption (circa 2035-40), TEINA 3.0 will be needed to assess long-term LDV infrastructure and fleets, including MDVs/HDV. TEINA 2.0 should still have some LDV assessment but should focus on much more than just LDVs. Our expectation is that TEINA 3.0 will mainly focus on harder to electrify vehicle use cases. These studies will require funding and greater direction from future administrations and legislatures.

L3.4. Workforce and Transportation Electrification Industry Development [Use Cases Impacted: All Use Cases]

The State should invest in workforce development to familiarize the workforce with the EVSE deployment process and prepare for the mass transition towards transportation electrification. This not only applies to light-duty passenger vehicles but also medium-duty vehicles (MDVs) and heavy-duty vehicles (HDVs) that are already being electrified (e.g., long-haul trucking and short-haul commercial and industrial vehicles). State investment will help ensure a smooth transition to cleaner methods of transportation and power sources.

L3.5 Determine Next Steps for Transportation Electrification Infrastructure Needs and Update Transportation Electrification Infrastructure Needs Analysis (TEINA) Findings Periodically [Use Cases Impacted: All Use Cases]

Given the Senate Bill 1044 focus for TEINA per Oregon Governor Kate Brown's Executive Order 20-04, the scope of the present analysis is necessarily limited. Not all of the identified use cases can receive the same level of detail for analysis, modeling, or recommendations.

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Acronyms

ACT	Advanced Clean Trucks	EC	Electric Cooperative
AADT	Average Annual Dailt Travel	EINA	Transportation Electrification Infrastructure Needs Analysis
ADA	Americans with Disabilities Act	EPA	Environmental Protection Agency
AFICC	Alternative Fuel Infrastructure Corridor Coalition	EV	Electric Vehicle
BEV	Battery Electric Vehicle	EVI-Pro	Electric Vehicle Infrastructure Projection
BIPOC	Black, Indigenous, and People of Color	EVSE	Electric Vehicle Service Equipment
CAGR	Compound Annual Growth Rate	EVSP	Electric Vehicle Service Provider
CARB	California Air Resources Board	EWEB	Eugene Water & Electric Board
CCC	Clean Cities Coalition	FCV	Fuel-cell Vehicle
CCS	Combined Charging System	FHWA	Federal Highway Administration
CDOT	Colorado Department of Transportation	GDP	Gross Domestic Product
CEC	California Energy Commission	GHG	Greenhouse Gas
CEO	Colorado Energy Office	HDT	Heavy-Duty Truck
COU	Consumer Owned Utility	HDV	Heavy-Duty Commercial Vehicle
CPUC	California Public Utilities Commission	HOV	High Occupancy Vehicle
DAC	Disadvantaged Communities	ICE	Internal Combustion Engine
DCFC	Direct Current Fast Charge	IOU	Investor-owned Utility
DCQC	Direct Current Quick Charging	kW	Kilowatt
DEQ	Oregon Department of Environmental Quality	kWh	Kilowatt-hour
DOS	Department of State	LDV	Light-Duty Vehicle
DRI	Downtown Revitalization Initiative	LMI	Low-to-moderate Income
DTNA	Daimler Trucks North America	MDV	Medium-duty Vehicle
		MOU	Memorandum of Understanding
		MUD	Multi-unit dwellings

NATSO	National Association of Truck Stop Operators	PUD	Public Utility District
NESCAUM	Northeast States for Coordinated Air Use Management	RAQC	Regional Air Quality Council
NGO	Non-governmental Organization	REV	Regional Electric Vehicle
NREL	National Renewable Energy Laboratory	RMI	Rocky Mountain Institute
NYDOS	New York State Department of State	SAE	Society of Automotive Engineers
NYPA	New York Power Authority	SCE	Southern California Edison
NYSERDA	New York State Energy Research and Development Authority	SDG&E	San Diego Gas & Electric
ODAS	Oregon Department of Administrative Services	SMART	South Metro Area Regional Transit
ODOE	Oregon Department of Energy	SWIM	Oregon Statewide Integrated Model
ODOT	Oregon Department of Transportation	TEINA	Transportation Electrification Infrastructure Needs Analysis
OEVC	Oregon Electric Vehicle Association	TNC	Transportation Network Companies
PAC	Pacific Power	TOU	Time of Use
PGE	Portland General Electric	VMT	Vehicle Miles Traveled
PG&E	Pacific Gas and Electric Company	WCC	West Coast Collaborative
PHEV	Plug-in Hybrid Electric Vehicle	WCCTCI	West Coast Clean Transit Corridor Initiative
POU	Publicly-owned Utility	WCEH	West Coast Electric Highway
PSC	Public Service Commission	ZEV	Zero Emission Vehicle
PUC	Public Utility Commission	ZEVIWG	Zero Emission Vehicle Interagency Working Group

