2025 BIENNIAL ZERO-EMISSION VEHICLE REPORT

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50 YEARS of SERVICE
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2025 BIENNIAL ZERO-EMISSION VEHICLE REPORT

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Contributing Authors:
Geoff Crook, Rob Del Mar, Jillian DiMedio, Evan Elias, Bilal Jones, Jessica Reichers

Publication, Data, and Graphics:
Katelyn Jackson, Bilal Jones, Bailey Harris, Jim Gores, Jennifer Kalez

Additional Report Support:
Hugh Arceneaux, Janine Benner, Josie Cardwell, Roger Kainu, Jess Miller, Michelle Miller-Harrington, Lauren Rosenstein, Ruchi Sadhir, Alex Sanderson, Christie Sphoon, Christy Splitt, Gail Sullivan, Jennifer Villanueva, Alan Zelenka

Agency Support:
John Baker, Jeremy Barnes, Vincent Bishop, Linda Bures, Andy Cameron, Jeff Carman, Maggie Carrasco, Richelle Corbo, Connor DePina, Erica Euen, Lina Fallert, Diana Garibay, Michael Grady, Danae Hammitt, Stacey Heuberger, Cecilia Jensen, Sam Krygier, Jessica Liedtke, Wendy Lorimor, Jesse McIntosh, Dan Meloy, Saturnina Mendoza, Sarah Moehrke, Leonard Noel, Nick Ray, Emily Salmeri, Jamshid Sediqi, Jenifer Smith, Kate Steele, Heather Tyre, Nick Wadge, Heidi Wheeler, Gunner Winde

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Special Thanks
to the stakeholders who provided input, feedback, and most importantly, a wealth of data and information used in the production of this report.

On the cover: Charging at the SAGE Center in Boardman

EXECUTIVE SUMMARY

About 15 percent – or nearly five out of every 30 – new passenger vehicles sold in Oregon today are zero-emission vehicles, and as of May 2025 there are 119,850 registered passenger ZEVs across the state – representing 3.2 percent of all registered vehicles. Medium- and heavy-duty registrations more than tripled in the last two years to 803 ZEVs, largely from electric delivery van purchases.

While ZEV adoption is strong, challenges remain. Oregon will not achieve the state goal of 250,000 registered ZEVs by 2025. At the federal level, the loss of incentives and regulatory certainties are likely to affect availability and affordability, especially for low-income and rural Oregonians, where upfront costs and charger availability are significant barriers. Low-cost ZEV options are hard to come by, with only one 2024 model priced below $30,000.

Oregon has many policies and programs driving ZEV adoption, and state agencies are continuing to leverage federal and state funds to support them. This includes funds that reduce upfront costs for ZEV passenger vehicles, trucks, vans, and buses, and for charging. Funds also support state planning efforts like the Oregon Energy Strategy, to ensure the state achieves ZEV and climate goals while maintaining reliable and affordable energy.

Charging infrastructure in Oregon continues to expand, but slower than the national pace. Chargers are critical to encourage ZEV adoption because drivers need to feel confident that chargers will be available when and where needed. Despite federal roadblocks, the Oregon Departments of Transportation, Environmental Quality, and Energy are actively leveraging federal dollars to support charging, including funds for public chargers along major travel corridors and communities, private chargers for fleets, multi-family housing, businesses, school districts, and local governments. Also underway are advances in charging technology and standards that will make EV charging easier, faster, and more reliable for drivers.

The upfront cost of ZEVs is a major barrier for low-income Oregonians because new ZEVs are more expensive than comparable gas vehicles. DEQ is using federal funds to supplement its Charge Ahead Rebate that reduces purchase costs up to $7,500 for low- and moderate-income Oregonians and Tribal members. Used ZEVs often cost less than a comparable gas vehicle, with some available for under $10,000. With up to a $5,000 rebate available for used ZEVs from the Charge Ahead rebate, these vehicles are now accessible for more Oregonians.

The barriers are greater for those purchasing medium- and heavy-duty vehicles, because these ZEVs are 2-3 times more expensive than their diesel or gas counterparts and owners often must also pay to install charging to support them. DEQ provides up to $130,000 for MHD vehicle purchases through its Zero Emissions Rebates for Oregon Fleets program, and both DEQ and ODOT have funds to offset charging installation costs. ODOE has also provided funds through the Energy Efficiency Community Block Grants and administers the Public Purpose Charge Schools Program, both of which help offset ZEV and charging costs for school districts and local governments.

While ZEV adoption helps the state achieve its climate goals, improve air quality, and reduce energy costs for consumers, it will have an affect on state revenues that help fund Oregon's roadways. As Oregonians increasingly choose more fuel efficient vehicles, including ZEVs, revenues from fuel taxes will decline. New mechanisms that do not rely on the tax, like Oregon's OReGO road usage charge program – which requires participants to pay taxes based on the number of miles they drive – can help the state maintain transportation system revenues. At the time of this report, lawmakers are considering mandatory enrollment in OReGO for all ZEVs and standard hybrid vehicles.

For this year's report, ODOE collaborated with Oregon State University's Survey Research Center to collect Oregonians' views on ZEVs. Results indicate Oregonians who are low-income or home renters and those living in rural areas or multifamily housing are less likely to own or consider purchasing a ZEV. Driving a ZEV reduces energy costs, improves local air quality, and provides local jobs. Survey results highlight the need for state programs that help address the barriers to ZEV adoption so that all Oregonians can reap these benefits.

As demand for lithium-ion batteries to power ZEVs increases, so do the social and environmental effects of producing them. Most li-ion batteries use foreign components and resources, often from places that have concerning human rights and environmental records. The battery industry and researchers are innovating design improvements and materials substitutions to reduce reliance on foreign resources, including extending battery lifespans, using alternative minerals, and developing mineral recovery processes from used batteries. Repurposing, recycling, and mineral recovery are a priority as ZEVs become more prevalent, because they will serve as the foundation for a more sustainable circular li-ion battery economy.

ZEVs are an increasing load electric utilities will have to support, but they also act as a flexible resource that can be leveraged to help manage the grid. Many utilities already use ZEVs to balance electric grid loads through programs that offer customers a lower rate to charge at times when electricity is in ample supply and costs less to provide. Some utilities are also conducting pilot projects where, with a customer's permission, they temporarily limit ZEV charging when the grid is stressed to reduce overall demand. Some utilities and grid operators are also experimenting with vehicle-to-grid technologies that enable utilities to pull electricity from ZEVs to meet peak load needs. Although more utility planning and state policies are needed to advance these solutions, they can provide cost benefits to ratepayers while also supporting utility efforts to meet state clean electricity targets.

The complete 2025 Biennial Zero Emission Vehicle Report is available online:
https://www.oregon.gov/energy/energy-oregon/Pages/BIZEV.aspx

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LETTER FROM THE ASSISTANT DIRECTOR

The world is different. Since the 2023 report, we have moved from a time when there were large amounts of funding available to support the transition to zero-emission vehicles to a time where new funding opportunities are hard to come by. Changes at the federal level not only revoked federal funding for the transition to a clean transportation future but pointed the U.S. back to a fossil fuel future. This makes our way forward more daunting, but I am hopeful.

Thankfully, the foresight, planning, and hard work of state agencies had already secured a great deal of funding that will enable more zero-emission vehicle adoption in the coming years, including the development of a broader electric vehicle charging network, reducing ZEV purchase costs, and enabling grid improvements. Over $41 million of National Electric Vehicle Infrastructure grant funds have been obligated, and the Oregon Department of Transportation is in process of securing the remaining $11 million. The Oregon Department of Environmental Quality, in partnership with ODOE and other agencies, secured $197 million in funds through the federal Climate Pollution Reduction Grant, which will expand DEQ programs that significantly reduce the cost to buy a ZEV for low- and moderate-income Oregonians, Tribal members, and businesses. Through Energy Efficiency and Conservation Block grants, ODOE has awarded local governments over $660,000 to transition municipal fleets to ZEVs and add charging infrastructure, and through the Public Purpose Charge School Program provided funding for the Beaverton and Bend-La Pine School Districts to add three new electric school buses.

Oregon is also providing funding and resources to not only reduce costs for ZEV purchases and charging installations, but to also support broader changes that need to occur like helping grid operators and utilities prepare for the growing numbers of electric vehicles. And because we want those ZEV miles to be as clean as possible, we are also helping support Oregon's largest utilities as they transition to 100 percent clean electricity generation. Our grid is the keystone of Oregon's clean energy transition, and utilities, ODOE, the Oregon Public Utility Commission, and other partners are working together to ensure our electricity system stays reliable and affordable. We also are leading by example as the Department of Administrative Services transitions our state fleet to ZEVs. To date, DAS has installed nearly 300 chargers across the state for the public and employees with more coming in the next biennium.

Oregonians spent $19.5 billion on energy in 2022. Of that, $11.2 billion (or 57 percent) was for transportation and most of that was spent outside of Oregon. Using electricity to power our vehicles means bringing our transportation economy home, redirecting those dollars back into Oregon's economy, and providing local jobs to build and maintain the growing grid and charging infrastructure. It also means independence from fuel price variability and increases that are primarily driven by global events outside of Oregon's influence.

In short, while there are more challenges in our path to transitioning our transportation system to zero-emission vehicles, I am optimistic that we will succeed. Oregonians are known for their pioneering spirit. We are forging a path into a new frontier where our transportation system will run on electrons. The challenges are great, but so is the reward of cleaner and cheaper ZEVs and more homegrown transportation fuels. We will continue to lead the way.

Alan Zelenka
Assistant Director for Planning and Innovation

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TRIBAL LAND ACKNOWLEDGMENT

Indigenous Tribes and Bands have been with the lands that we inhabit today throughout Oregon and the Northwest since time immemorial and continue to be a vibrant part of Oregon today. We would like to express our respect to the First Peoples of this land, the nine federally recognized Tribes of Oregon: Burns Paiute Tribe, Confederated Tribes of Coos, Lower Umpqua & Siuslaw Indians, Confederated Tribes of Grand Ronde, Confederated Tribes of Siletz Indians, Confederated Tribes of the Umatilla Indian Reservation, Confederated Tribes of the Warm Springs Reservation, Coquille Indian Tribe, Cow Creek Band of the Umpqua Tribe of Indians, and The Klamath Tribes.

It is important that we recognize and honor the ongoing legal and spiritual relationship between the land, plants, animals, and people indigenous to this place we now call Oregon. The interconnectedness of the people, the land, and the natural environment cannot be overstated; the health of one is necessary for the health of all. We recognize the pre-existing and continued sovereignty of the nine federally recognized Tribes who have ties to this place and thank them for continuing to share their traditional ecological knowledge and perspective on how we might care for one another and the land, so it can take care of us.

We commit to engaging in a respectful and successful partnership as stewards of these lands. As we are obliged by state law and policy, we will uphold government-to-government relations to advance strong governance outcomes supportive of Tribal self-determination and sovereignty.

ABOUT THE OREGON DEPARTMENT OF ENERGY

The Oregon Department of Energy's mission is to help Oregonians make informed decisions and maintain a resilient and affordable energy system. We advance solutions to shape an equitable clean energy transition, protect the environment and public health, and responsibly balance energy needs and impacts for current and future generations.

On behalf of Oregonians across the state, the Oregon Department of Energy achieves its mission by providing:

- A Central Repository of Energy Data, Information, and Analysis
- A Venue for Problem-Solving Oregon's Energy Challenges
- Energy Education and Technical Assistance
- Regulation and Oversight
- Energy Programs and Activities

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www.oregon.gov/energy
AskEnergy@oregon.gov | 800-221-8035

ABOUT THE REPORT

The 2025 Biennial Zero-Emission Vehicle Report examines Oregon's progress on transitioning to zero-emission vehicles, identifies industry and consumer trends influencing ownership, and provides an overview of policies that support the state's zero-emission vehicle adoption goals. It also examines the effects on the state's climate and energy goals.

Zero-emission vehicles include battery electric, plug-in hybrid electric, and fuel cell electric (hydrogen) vehicles, but because there are no hydrogen vehicles operating on Oregon's roads, these are not a significant area of report discussion. They're commonly called electric vehicles, or EVs, but you will see zero-emission vehicles, or ZEVs, in most places throughout the report.

In this year's edition, ODOE collaborated with the Oregon State University Survey Research Center to collect input from a random sample of Oregon households about their views on zero-emission vehicles. The insights from Oregonians are captured in the Oregonians' Awareness of Zero-Emission Vehicles and Their Benefits section.

Within the report, readers will find three additional chapters on related zero-emission vehicle topics: charging infrastructure in Oregon and the impact of federal and state policies and programs; the societal and environmental effects of mining, manufacturing lithium-ion batteries, and opportunities for battery recycling and reuse; and how zero-emission vehicles can be leveraged in electric grid management now and in the future.

Throughout this report you will see two symbols to help guide your reading experience:

The shovel: Read this content to dig in deeper.

The lightbulb: This content gives you a quick bonus fun fact.

About the data

Senate Bill 1044 directed the Oregon Department of Energy to produce a report on zero-emission vehicle adoption in the state. The bill included guidance that ODOE should base the report on "existing studies, market reports, polling data, or other publicly available information." To do this, we prioritized data sources based on the following criteria: relevance to Oregon, credibility, and comprehensiveness.

ODOE prioritized using Oregon-specific data whenever available, and selected unbiased data from credible sources, primarily state and federal agencies, academic institutions, and trusted industry partners. The report includes data from the Oregon Department of Transportation, Oregon Department of Environmental Quality, Oregon State University Survey Research Center, Portland State University, the U.S. Census Bureau, U.S. Energy Information Administration, International Energy Administration, Atlas EV Hub, and Oregon electric utilities.

ODOE relies on ODOT's electric vehicle registration data to track Oregon's progress on meeting our ZEV adoption goals. ODOT provides an updated ZEV registration data set monthly, with results for all current registrations that are at least two months old. This is done to ensure that any lagging registrations at the beginning of a new month do not bias the data toward a lower estimate. After two months have elapsed, ODOT and ODOE assume the data is mostly firm, and future updates will account for any additional lagging registrations. For this reason, the report only includes ZEV registrations through May 2025. Monthly updated ZEV registration counts are available on ODOE's EV Dashboard.

For this report, we collaborated with Oregon State University's Survey Research Center to collect the opinions of 736 Oregon households about electric vehicles, electric vehicle charging, and incentives that would encourage electric vehicle adoption. The results of the survey are presented in the Zero-Emission Vehicle by the Numbers chapter of this report including demographic breakouts of survey answers. Complete survey data and frequency tables are provided in Appendix A. The original data file for the survey results is stored internally at ODOE and is available upon request. A report of the survey's research procedures can be found on our website.

In this edition, ODOE made methodological changes to some of the analyses in the report. This included a change in the description and types of geographic areas in the state for the demographic analysis of ZEV adoption, which does not allow us to provide trend data for ZEV adoption by geographic area, although results were similar between both methodologies. We also updated our carbon intensity data calculations, replacing fuel consumption data dating back to 2016, which had been created using multiple data sources, with more standardized DEQ Clean Fuels Program data. ODOE made these changes to provide the most current and comprehensive data and to better align data sets and reporting with peer agencies.

There is limited available data and information for some pieces of the report, such as the specific model varieties of medium- and heavy-duty ZEVs, electric vehicle charger reliability, and more specific demographic information on ZEV owners. In these instances, ODOE identified the data limitations in the report. We strive to address data gaps for each new report we produce by identifying new data sources or developing proxies wherever possible. For example, in this report we used registration data from ODOT to describe medium- and heavy-duty ZEV adoption.

We are proud of the efforts that went into collecting and reporting the data used for this iteration of the Biennial Zero Emission Vehicle Report. We hope the contents of the report serve to support our mission to help Oregonians make informed decisions about their energy choices, and advance solutions that will develop and maintain a more equitable clean energy future.

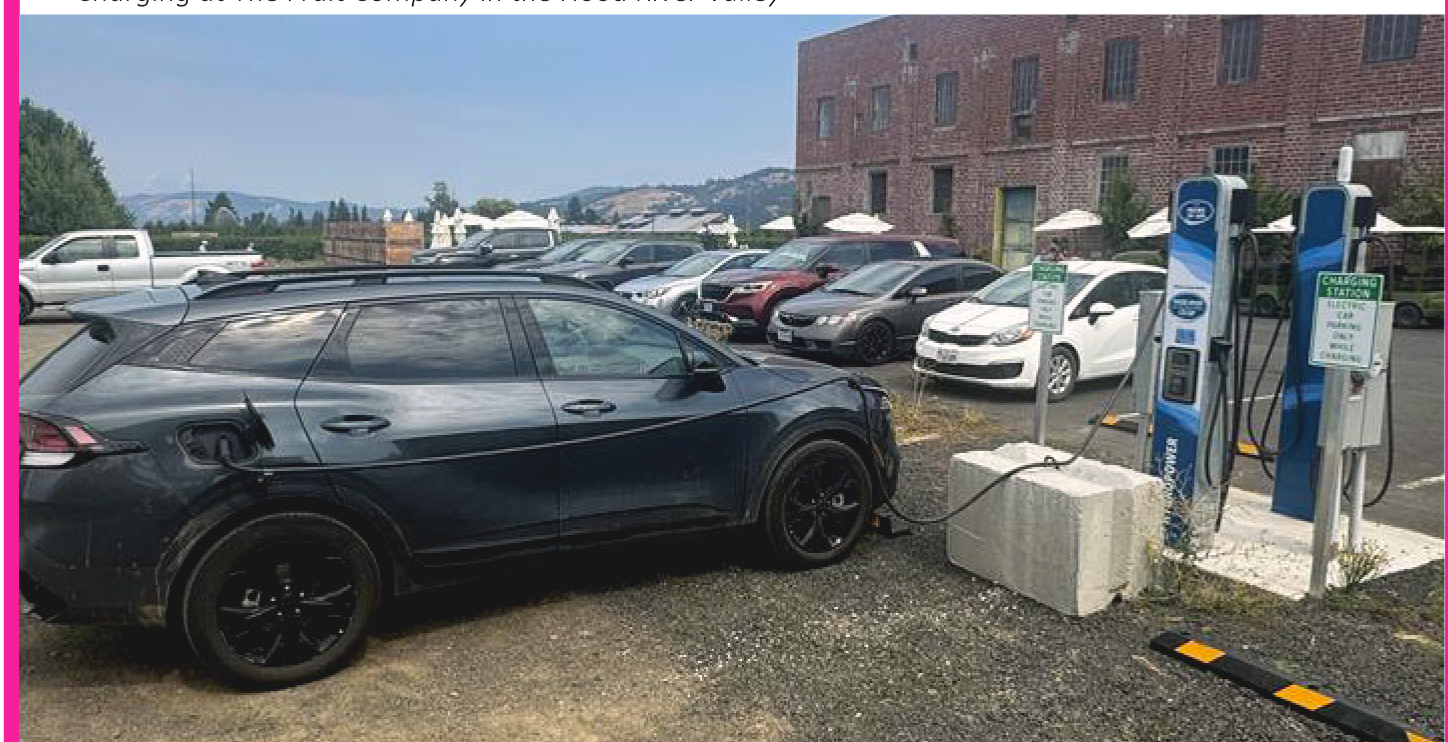
Charging at ODOE Headquarters in Salem

ZERO-EMISSION VEHICLES THE NUMBERS

This section of the report focuses on data-driven insights into the transition to zero-emission vehicles happening in Oregon. Readers will find:

- Information on how many ZEVs are registered, what kinds, where they are being used, and where public charging infrastructure is located.
- Analysis covering the purchase and operational costs of ZEVs compared to internal combustion engine vehicles.
- Survey data providing insight into Oregonians' perspectives on ZEVs.
- Information on how ZEV adoption is reducing Oregon's greenhouse gas emissions.

Charging at The Fruit Company in the Hood River Valley



ZERO-EMISSION VEHICLE ADOPTION

The Oregon Legislature identified widespread transportation electrification as a means to improve public health and safety because zero-emission vehicles improve Oregon's air quality, mitigate greenhouse gas emissions, and reduce energy use and consumer energy costs.[1] In Senate Bill 1044 (2019), the Legislature declared that transportation electrification must progress significantly by 2035, and established statewide adoption goals to achieve this transformation.[2] They directed the Oregon Department of Energy to produce this biennial report that includes analysis about Oregon's progress on these goals. This section of ZEVs By the Numbers will cover adoption trends for light, medium, and heavy-duty zero-emission vehicles.

Light-Duty Zero-Emission Vehicle Adoption

Zero-emission vehicle adoption continues to grow in Oregon, with 119,850 registered light-duty ZEVs as of May 2025, including 84,636 battery electric vehicles and 35,214 plug-in hybrid electric vehicles. ZEVs now make up 3.2 percent of the light-duty fleet.[3] Over the last two years, Oregon has averaged more than 2,000 new light-duty ZEV registrations per month. Currently, there are no light-duty hydrogen fuel cell electric vehicles registered in Oregon.

What's the difference between an electric vehicle and a zero-emission vehicle?

The short answer is: none. A distinction is sometimes made between battery electric vehicles and hydrogen-fuel cell electric vehicles, but both are zero-emission vehicles. Some may not immediately think of hydrogen fuel cell vehicles as "electric" because they are fueled by hydrogen rather than being charged from the grid. However, they are electric vehicles, because hydrogen in the vehicle's fuel cell is converted into electricity to power them. Oregon does not have any hydrogen fuel cell passenger vehicles but may someday if hydrogen fueling stations are built to support them. This report focuses primarily on zero-emission vehicles that can be plugged in (battery electric and plug-in hybrid).

Oregon ZEV sales, as a percent of the total light-duty vehicle market, more than tripled over the last five years, but have plateaued around 15 percent in the last two.[6] This matches national trends as well as other leading EV adoption states like Washington and California. Even with EV market share plateauing, Oregon's EV adoption rates are considerably higher than the 10 percent national average.[6]

Investment analysts find that the slowdown is due to several factors, including cost, lack of confidence in the technology, and not enough public charging or fueling options.[7–9] There is evidence that ZEVs have reached the point of the technology adoption curve where sales are moving from early adopters, who are more willing and able to try newer technologies, to more mainstream consumers, who need to feel comfortable about reliability and how to use new technologies.[10] This was seen in standard hybrid vehicles like the Toyota Prius, which were a popular new technology for early adopters in the mid-2000s, but are now more mainstream.[11,10] Mainstream consumers may also be more sensitive to price points, and there are few low to moderately priced ZEV options available in the market, which is discussed more in the Zero-Emission Vehicle Costs section.

Light-duty vehicles include passenger vehicles (cars, SUVs, pickups).

Medium- and heavy duty vehicles include large pickup trucks, box trucks, school and transit buses, and short and long-haul delivery trucks.

Hybrid vehicle adoption trends may provide insight into the future of ZEVs.[12] Vehicle manufacturers have been producing an increasingly greater number of hybrid vehicles over the last five years.[13] Hybrid vehicles have a battery associated with an electric motor, but that battery is charged through regenerative braking or the vehicle's gasoline engine while driving and not by plugging into an electrical outlet.

FIGURE 1: Cumulative Oregon Light-Duty Zero-Emission Vehicle Registrations[3]

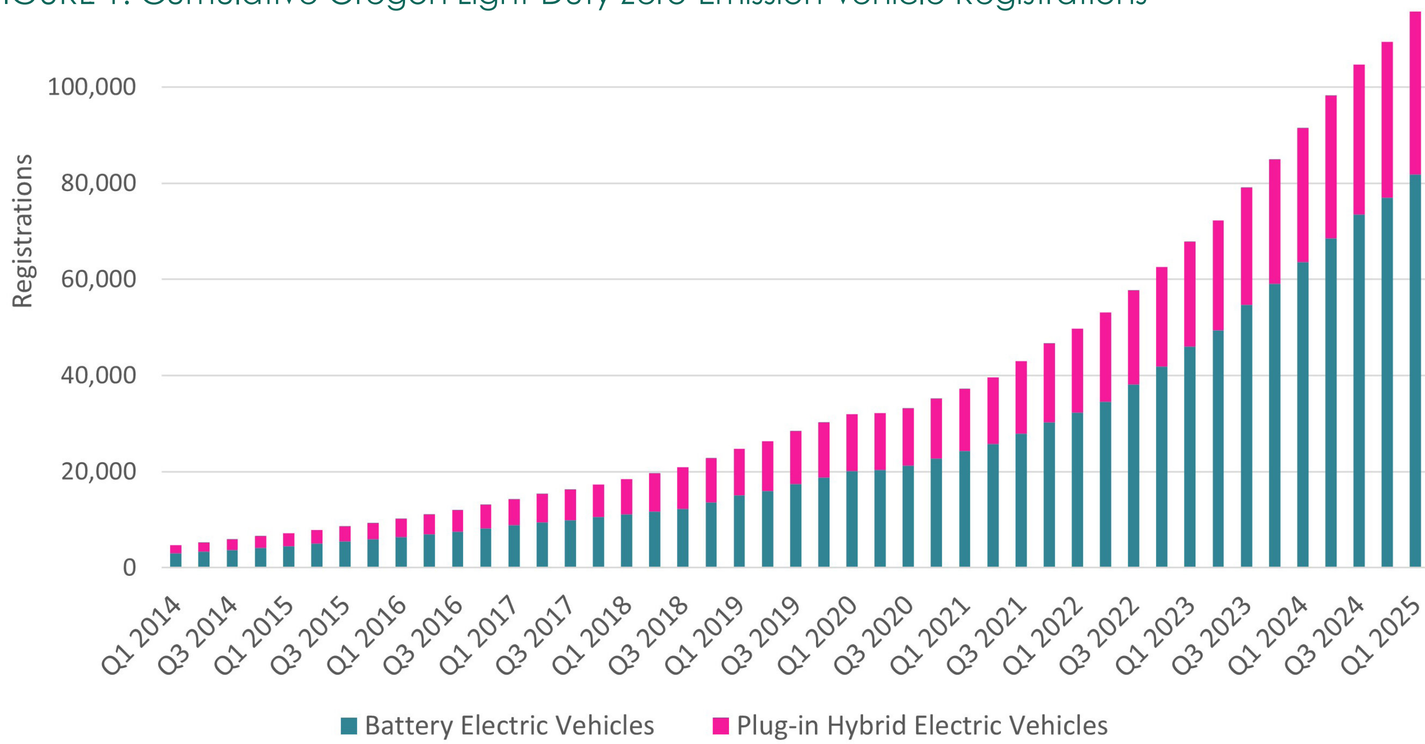
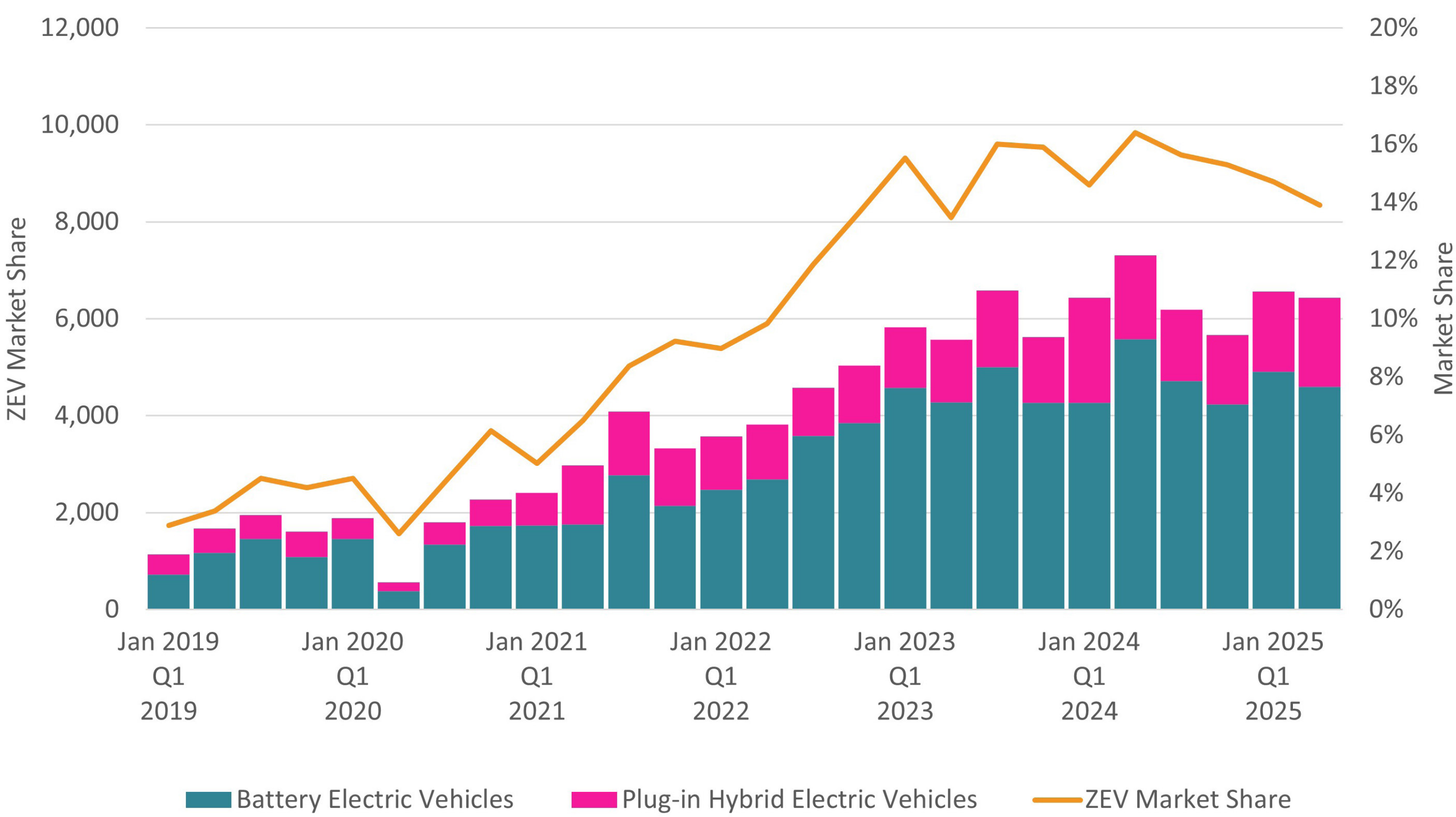


FIGURE 2: Oregon New Light-Duty Zero-Emission Vehicle Sales by Quarter[6]



Battery electric vehicles are powered only by a battery. Plug-in hybrid electric vehicles, or PHEVs, can be powered by the vehicle's battery or fossil fuel combustion.[i] These differ from standard hybrid vehicles because they are plugged in to recharge the battery.

i While plug-in hybrid electric vehicles are not technically zero-emission vehicles, in Oregon statute, the classification of PHEVs in relation to ZEVs depends on context. Under ORS 468.442, which provides technical definitions used in emissions standards and rebate eligibility, PHEVs are defined separately from ZEVs and are not considered true zero-emission vehicles since they rely in part on fossil fuel combustion that produces emissions.[4] However, in broader policy contexts, such as state ZEV and fleet procurement targets under ORS 283.398, PHEVs are included within the definitions of ZEVs alongside battery electric vehicles and fuel cell electric vehicles.[5] This distinction highlights the nuance in Oregon law: PHEVs may qualify as ZEVs for certain policy purposes, but are not treated as ZEVs in more precise, emissions-focused regulatory definitions.

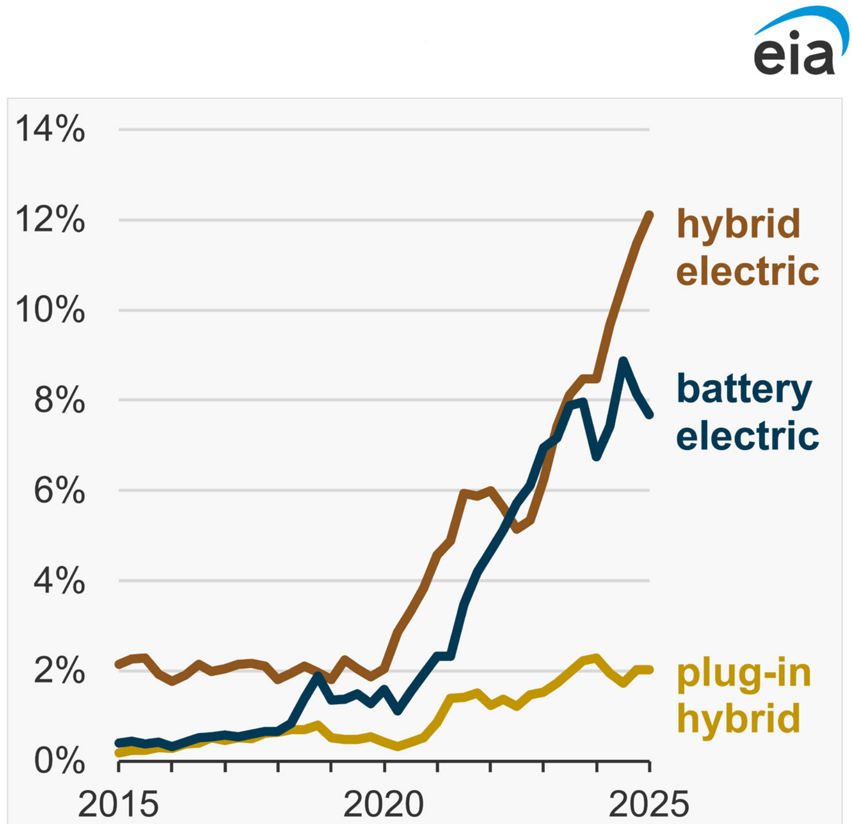


FIGURE 3: U.S. Light-Duty Vehicles Sales of Hybrid and Zero-emission Vehicles[16]
Graph: U.S. Energy Information Administration

While hybrids are not ZEVs, they do greatly improve a vehicle's fuel efficiency.[14] The first mass produced hybrid available in the U.S. was the 2001 Toyota Prius.[15] Adoption of this new hybrid technology remained relatively flat until 2020, when more manufacturers began adding this feature to existing vehicle models. Hybrids now make up about 12 percent of the U.S. light-duty vehicle market and this is expected to continue rising.[16] While adoption trends are uncertain, the popularity of hybrid vehicles may indicate that there is a lag time from the introduction of a new vehicle technology to when it becomes more widely accepted by manufacturers and consumers.

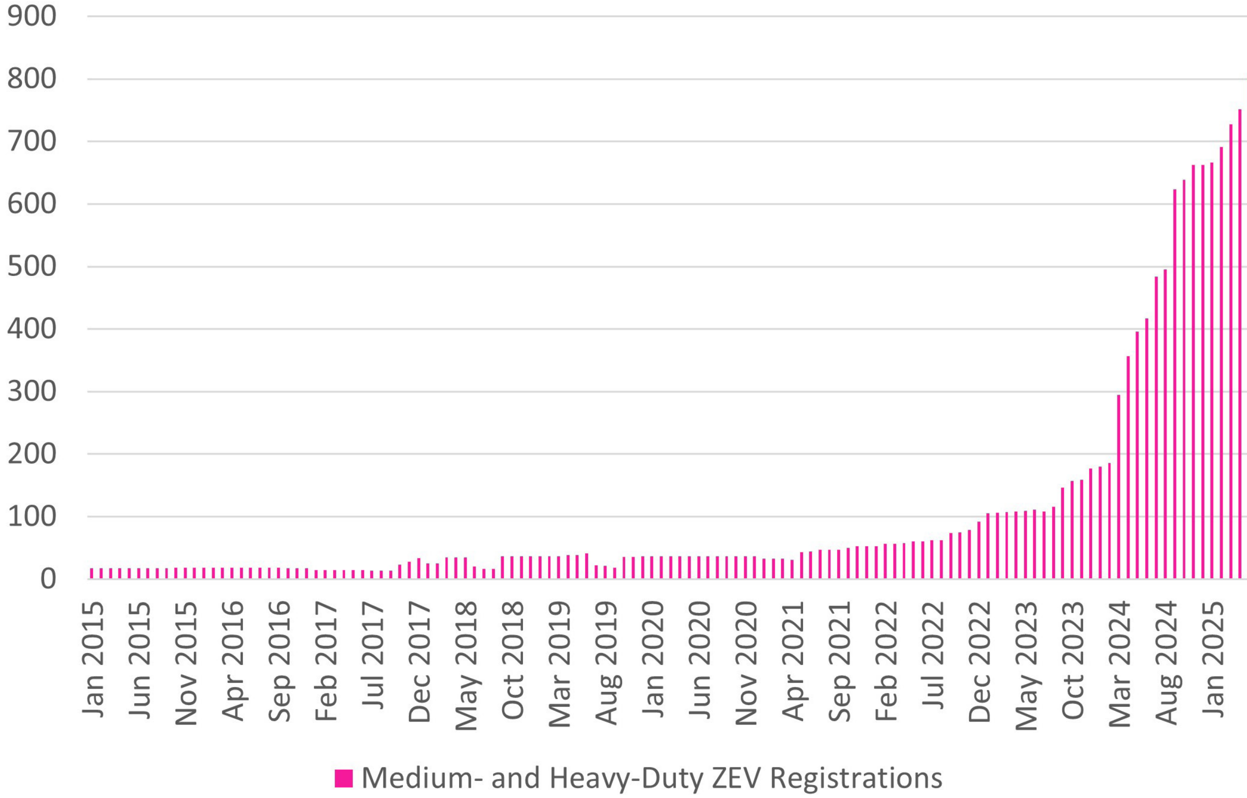
Medium- and Heavy-Duty Zero-Emission Vehicle Adoption

Medium- and heavy-duty zero-emission vehicle registrations more than tripled in Oregon from January to December in 2024, with 803 registered as of May 2025.[17] ZEVs represent only slightly more than half a percent of all medium- and heavy-duty vehicle registrations in Oregon.

The commercial viability and availability of medium- and heavy-duty ZEVs lags behind the light-duty sector, largely because improvements in battery performance were needed before they could effectively meet the needs of heavier vehicles.[18] Figure 4 shows cumulative MHD vehicle registrations in Oregon, which were very low until the 2020s, reflecting both limited model availability and operating experience. Registrations began picking up in late 2022, when MHD vehicle manufacturers were first eligible to earn credits for future compliance with the Oregon Department of Environmental Quality's Advanced Clean Trucks program.[19]

DEQ analyzed all models of Oregon medium- and heavy-duty vehicle registrations from 2017 through 2024 to better understand where electrification can scale most quickly. The analysis found that Class 2b-3 pickup trucks, passenger

FIGURE 4: Oregon Medium- and Heavy-Duty Zero-Emission Vehicle Registrations[17]



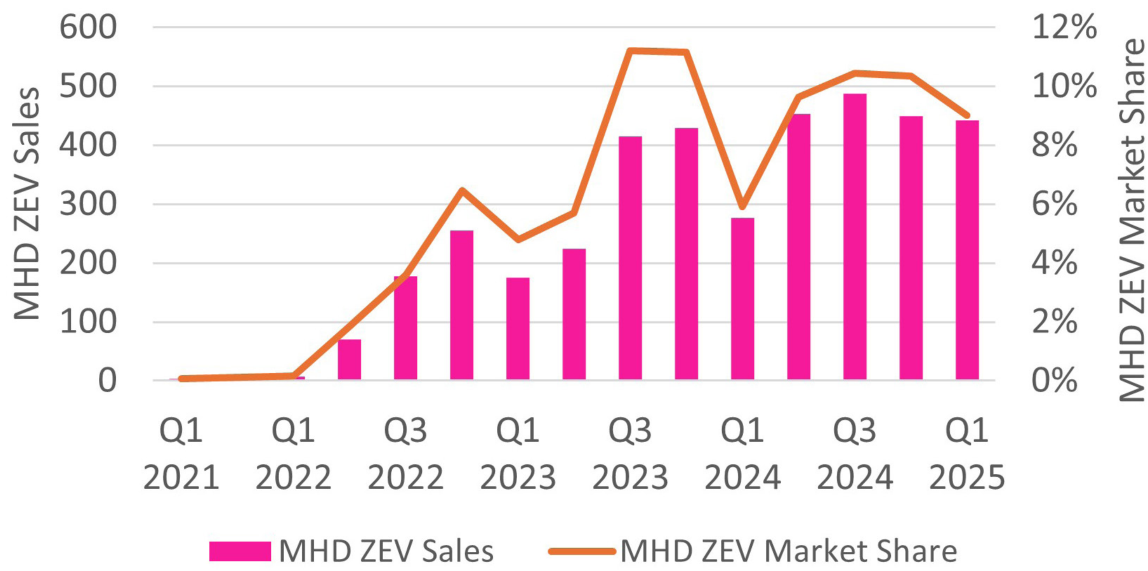
vans, and cargo vans comprised well over half of all MHD registrations during this period.[20] Importantly, these vehicles are also among the easiest to electrify under average operational conditions and range requirements. This trend is already evident in the market, as step vans used for local deliveries, such as Amazon delivery vans, comprise the largest portion of Oregon's MHD ZEV growth to date.[17]

Today, battery technology can support a wider range of medium- and heavy-duty vehicle operations, but adoption is still likely to take longer than the light-duty transition. Customization and specialized upfitting is often needed, and adding electric drivetrains can further complicate assembly, typically requiring major modifications to the chassis and manufacturing process, if not a complete ground-up redesign. This results in longer lead-times and higher costs which may be a barrier for buyers. Some manufacturers may not offer electric models in some or all vehicle classes. Fleet owners also must make investments in charging infrastructure, which further increases costs to add these vehicles to an existing fleet.

Figure 5 shows medium- and heavy-duty zero emission vehicle sales since Q2 2021. The market share has remained between 9 and 10 percent of all MHD vehicle sales since mid-2023.[6] Apart from step or delivery vans, many MHD ZEVs sold are being used to learn about operating and maintaining this new technology. Uptake could be relatively slow until fleet managers have more experience and comfort with these vehicles. Total costs to transition a fleet to electric are also a major barrier.

Changes in state and federal policy may slow medium- and heavy-duty ZEV adoption going forward. In May 2025, Oregon DEQ announced it would pause enforcement of the state's Advanced Clean Trucks Rule, which requires increasing proportions of MHD ZEV sales, due to federal uncertainty and pending litigation over the recission of California's waiver under the Congressional Review Act.[25,26] H.R. 1, the 2025 Congressional Budget Reconciliation Bill (referred to as the "One Big Beautiful Bill Act"), revoked incentives that offset the costs of MHD ZEV purchases and charging installations as well as regulatory requirements that incentivize more ZEV options from manufacturers and adoption by fleet owners.[23, 24]

FIGURE 5: Oregon New Medium- and Heavy-Duty Zero-Emission Vehicle Sales[6]



The loss of federal incentives and regulatory certainties is likely to have a significant effect on medium- and heavy-duty ZEV availability and affordability. The barriers to commercialization are greater than in the light-duty sector, including higher relative costs for the vehicles, significantly higher costs to add charging infrastructure, and limitations in viability for some vehicle uses.[29] Federal policy changes, coupled with unpredictable tariff announcements from the Trump Administration are creating market uncertainty for manufacturers who are in the early stages of developing business models for the production of ZEVs, which will have ramifications for fleet owners interested in or assessing their ability to electrify.

PROGRESS ON STATE ZERO-EMISSION VEHICLE ADOPTION GOALS

The Oregon Senate passed SB 1044 in 2019 to add the following zero emission vehicle goals into Oregon statute:

- 50,000 registered ZEVs on Oregon roads by 2020
- 250,000 registered ZEVs on Oregon roads by 2025
- At least 25 percent of registered vehicles and at least half of the new vehicles sold annually are ZEVs by 2030
- At least 90 percent of new vehicles sold annually are ZEVs by 2035.[2]

Although ZEV adoption has continued to grow, Oregon did not meet the 50,000 registered ZEVs goal until 2022 – two years behind the target – and is not on track to meet the 2025 target. Adoption will need to accelerate to meet the 2030 and 2035 goals. The popularity of DEQ’s Clean Vehicle rebates, boosted by additional federal funding for the program through the Climate Equity and Resilience Through Action grant, will help support growth. In addition, Oregon Department of Transportation electric vehicle public charging programs continue to advance, with new charging stations, including medium- and heavy-duty stations, being built today using state and federal dollars.[30] However, changes at the federal level – such as the elimination of the federal EV tax credit after Sept. 30, 2025, and the effects of federal tariffs – may slow growth. International policies and events that influence gasoline prices – such as the war in Ukraine or decisions by the Organization of Petroleum Exporting Countries regarding oil production – could also play a role in influencing car buyers.[31,32]

Oregon could be on track to meet the 2030 and 2035 goals if light-duty vehicle purchases meet DEQ's Advanced Clean Cars II sales targets. Figure 6 shows annual sales requirements for the program, including a requirement for 68 percent ZEV sales in 2030, which would exceed the SB 1044 sales goal of 50 percent.[33] The 100 percent target by 2035 would also exceed the statutory goal for that year. However, the future of the Advanced Clean Cars II regulation is uncertain due to the rescission of California's waiver by Congress, which affects state authority to enforce the program.[34] These factors could affect Oregon's progress on ZEV targets, putting its ability to meet the 2030 goal at risk.

FIGURE 6: Projected Annual Light-duty ZEV Sales to Meet Advanced Clean Cars II Targets[33]

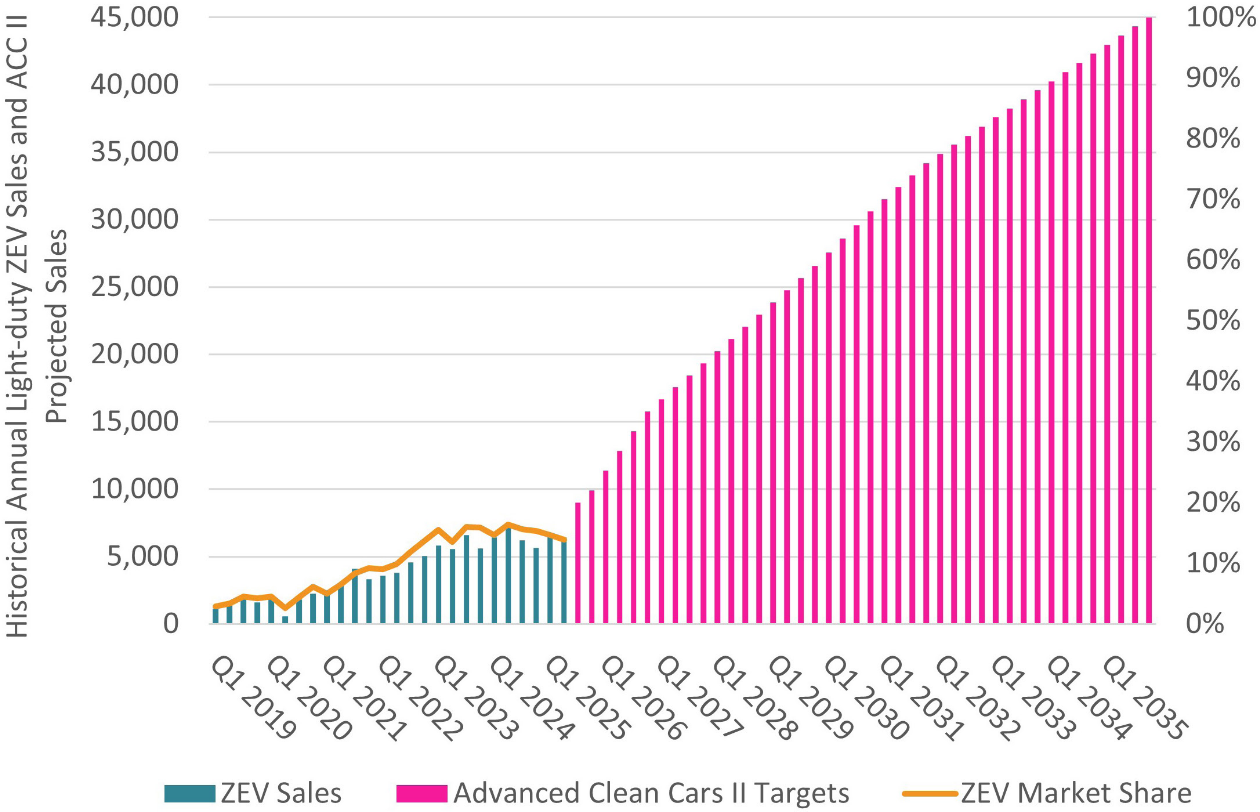
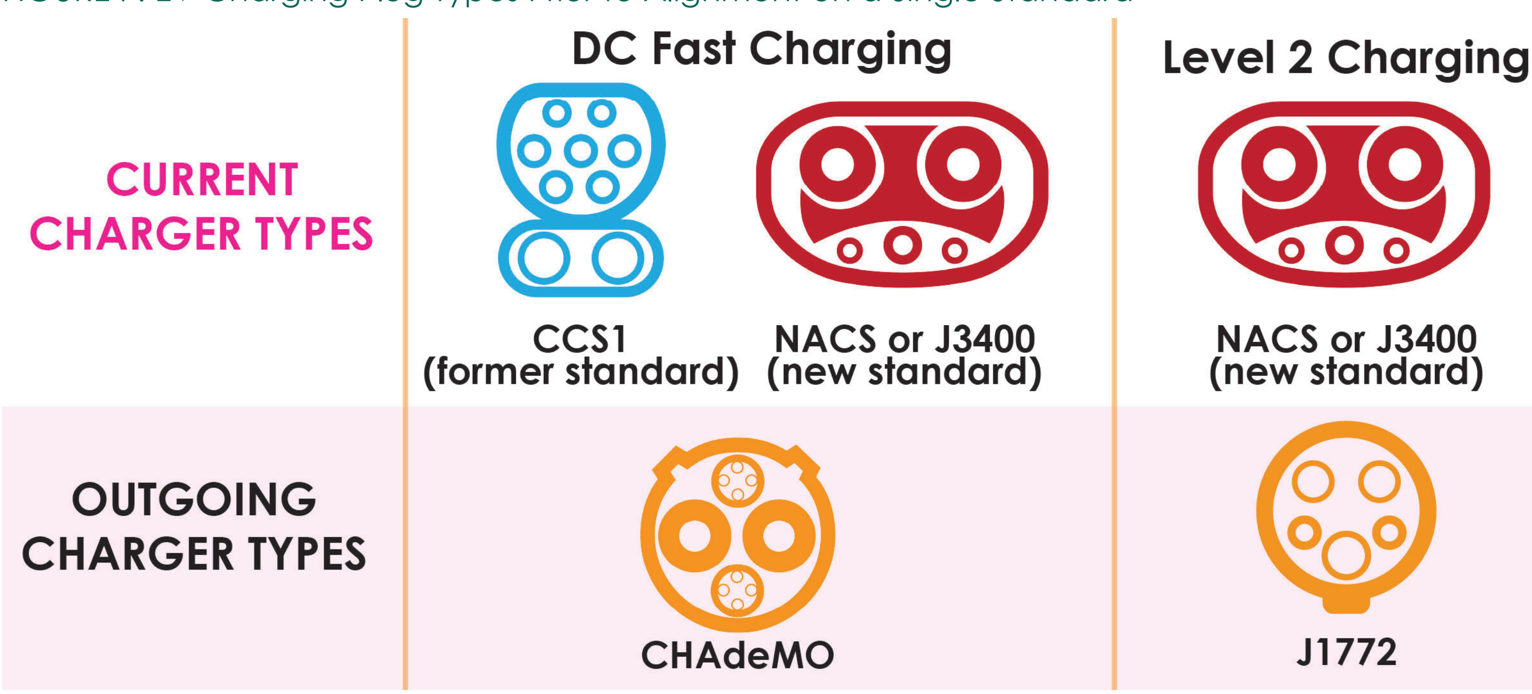


FIGURE 7: EV Charging Plug Types Prior to Alignment on a Single Standard



ELECTRIC VEHICLE CHARGING

The availability and reliability of public chargers is critical to more widespread EV adoption, especially for Oregonians living in rural areas, multifamily housing, and rental properties. The EV charging landscape has evolved significantly in the last two years, with EV manufacturers aligning around a single charger plug format in late 2023.[35] This change will alleviate confusion for EV drivers and simplify state EV charger planning efforts. At the same time, federal actions have removed incentives for private charging while also attempting to rescind awarded and, in some cases, contractually obligated funding, for states to support public infrastructure.[36] You can read a more in-depth analysis on EV charging activities in the Availability and Reliability of Electric Vehicle Charging chapter of this report.

Light-duty Electric Vehicle Charging

Oregon's public light-duty EV charging infrastructure is growing but not at the rate needed to support SB 1044 ZEV targets. In Figures 8 and 9, the bars for Level 2 and DC Fast Chargers show the total number of charging ports in Oregon by year through 2024, while the dotted line represents the business-as-usual scenario for future charger needs identified in the Oregon Department of Transportation's Transportation Electrification Infrastructure Needs Analysis study. The hockey stick uptick from existing chargers to TEINA modeling results shows that the growth rate of new chargers will need to increase significantly to meet future demand. The sharp rise in charger needs indicates that state support for charging infrastructure is essential to achieving ZEV adoption targets.

FIGURE 8: Historic and TEINA Study Business-as Usual Scenario Electric Vehicle Charging Port Needs for Level 2 Public Charging[37]

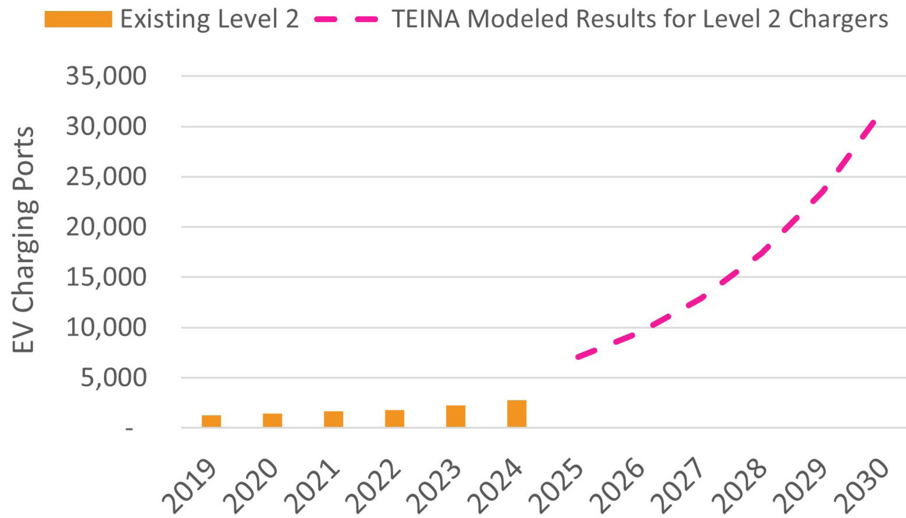
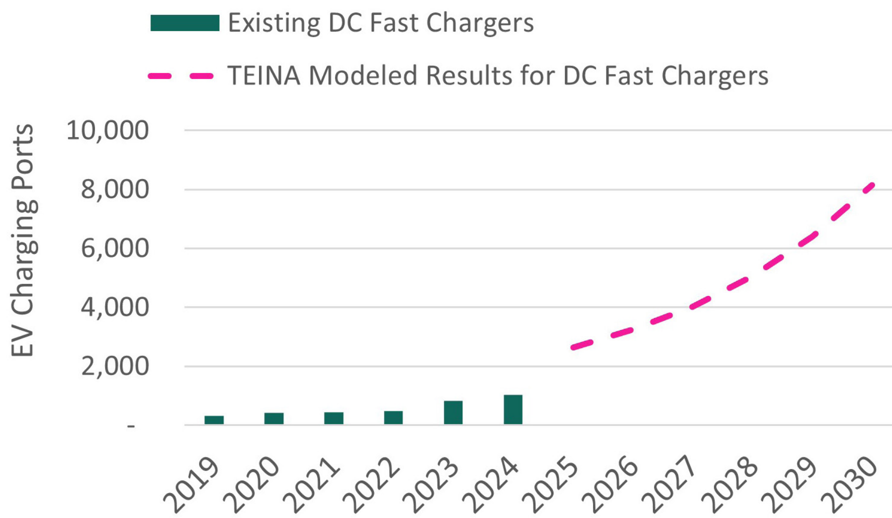


FIGURE 9: Historic and TEINA Study Business-as Usual Scenario Electric Vehicle Charging Port Needs for Public DC Fast Charging[37]



Public charging includes faster Direct Current Fast Charging and slower Level 2 charging. A fast charger can add over 100 miles of charge in an hour, while a Level 2 adds about 10-20 miles each hour.[ii]

ii Charging times vary based on both the vehicle and the charger; these times are generalizations.

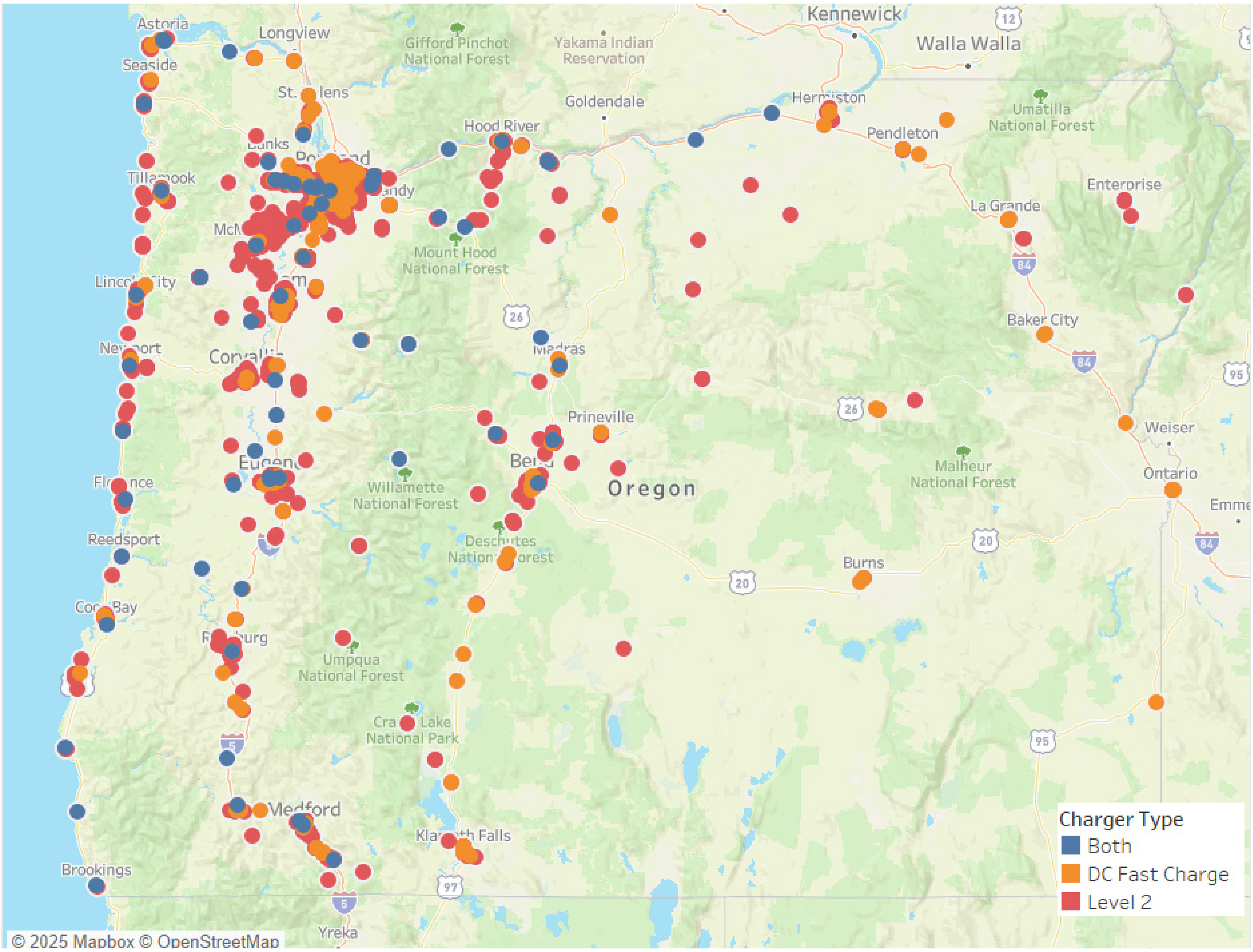


FIGURE 10: Public Electric Vehicle Chargers in Oregon[40]

Electric Vehicle charging infrastructure is available throughout the state, as shown in Figure 10, but the greatest concentration of chargers is still in the Willamette Valley, the Bend area, and along major thoroughfares like I-5, I-84, and U.S. Route 101. Charging availability has expanded significantly in recent years, underpinned by programs at ODOT and DEQ that provide funding for public and private charging infrastructure and the expansion of networks by private charging companies. In addition to general growth of chargers, Tesla is opening its Supercharger network[iii] to non-Tesla EVs, and Rivian announced in August 2025 that it is also retrofitting its existing charging sites to make them available for all EV drivers, with 75 percent already available to existing EV drivers.[38,39] This will provide more charging options for all ZEVs.

In addition to availability, drivers must have confidence that charging will be available whenever and wherever needed. Surveys show that drivers frequently encounter chargers that don't work, but in those that differentiate between brands, Tesla's network is often found to have more reliable chargers.[41] As Tesla opens its network to other EV brands, overall charging reliability may improve.[41,42]

Currently, there is very little specific data on the reliability of Oregon chargers because there is no requirement for charger owners to report reliability data for their equipment. Technical standards for charging reliability have been established, many of which focus on data reporting for real-time charger status, uptime metrics (the amount of time

iii Not all Tesla chargers are currently available for non-Tesla vehicles, but Tesla indicates they are working toward making the entire network available to all EVs.

that the charger is fully operational and available to use), and repair timelines.[43,44] In Oregon, entities administering state and federal EV infrastructure funding have begun embedding these reliability best practices into their programs, with several committing to implementing ongoing data reporting requirements in the future.[45]

Medium- and Heavy-duty Electric Vehicle Charging

Charging infrastructure for medium- and heavy-duty ZEVs has been expanding but not uniformally. Depot charging, or charging electric vehicles at a centralized location where the vehicles are stored or based overnight, has been increasing, with private investments from fleets as well as state funding through DEQ's Oregon Zero-Emission Vehicle Fueling Infastructure Grant. Publicly accessible chargers have expanded slowly, driven largely by stations designed for light-duty vehicles, with limited capability to accommodate some types of medium-duty vehicles. The 5-megawatt Electric Island facility on Swan Island in Portland is the only public charging site specifically designed for heavy-duty vehicles operating in Oregon.

According to an analysis by the Oregon Department of Environmental Quality, most of Oregon's medium- and heavy-duty trucks, including many delivery vehicles, garbage trucks, school buses, and local freight haulers, average about 100 miles per day and return to base each night.[46] This makes them well-suited for depot charging, which will play a central role in the near term as the most readily electrifiable fleets begin their transition. Over time, however, public charging will become increasingly critical to support broader adoption across more diverse and demanding use cases.

EFFECTS OF ZERO-EMISSION VEHICLE ADOPTION ON CLIMATE GOALS

The Oregon Energy Strategy model found that transportation electrification is critical to meeting state greenhouse gas emissions goals.[47] ZEVs produce far fewer greenhouse gas emissions than gasoline or diesel vehicles. For example, a 2025 Hyundai Kona Electric car driven 222 miles per week (the statewide average) can reduce emissions by roughly 8,400 pounds of CO2e annually compared to a conventional gasoline Kona.[iv,48] Driving an EV will also continue to get cleaner over time as Oregon's two largest utilities, Portland General Electric and Pacific Power, work to achieve the state's 100 percent clean electricity requirements by 2040.[49] Because some sectors will be harder – and more expensive – to decarbonize, the transportation sector may need to do more to help achieve Oregon's GHG reduction goals, with ZEV adoption likely to play a central role.[50]

iv This analysis assumes the EV is charged in the Portland General Electric service territory. Actual GHG reductions will vary across the state depending on vehicle mileage and the carbon intensity of the electricity used for charging.

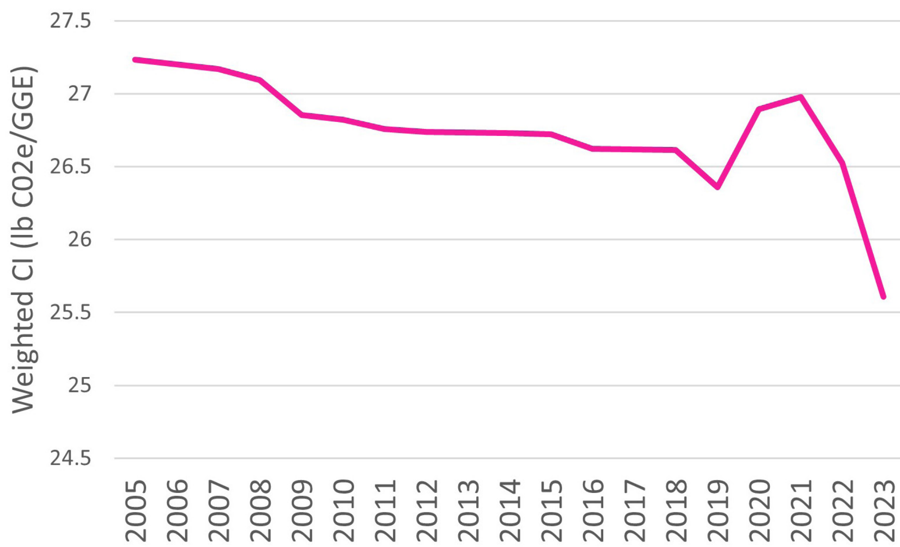
Different Ways Oregon Assesses Transportation Carbon Emissions

A fuel's carbon intensity represents carbon emissions (grams of carbon dioxide equivalent or gCO2e) per amount of energy used (megajoules). ODOE uses the Oregon Department of Environmental Quality's Clean Fuels Program carbon intensity values and converts the amount of energy used from megajoules to gasoline gallon equivalents – which is the amount of an alternative fuel (like electricity) needed to power a similar internal combustion engine vehicle using a gallon of gas.

Carbon intensity values include the ***lifecycle*** carbon content of different fuels, which differs from how the state tracks emissions to meet state goals. Lifecycle emissions include not only emissions from using the vehicle (i.e. tailpipe emissions), but also the greenhouse gases emitted from producing, refining, and transporting that vehicle's fuel.[57] Progress on Oregon's climate goals is tracked using ***sector-based*** emissions, which includes only vehicle tailpipe emissions or the GHGs released from generating the electricity that powers a ZEV.[58]

Oregon has many policies and programs driving ZEV adoption that, if fully implemented, will make significant progress on meeting state climate goals. For example, the Oregon Department of Environmental Quality's Clean Fuels Program and Climate Protection Program support ZEV adoption to reduce state dependence on fossil fuels and the greenhouse gases emitted from those fuels.[51,52] The following sections will cover the effect ZEVs have on achieving state objectives that support greenhouse gas emissions reductions.

FIGURE 11: Weighted[vii] Carbon Intensity for Oregon Transportation Fuels Over Time[61]



vii The Oregon Department of Energy assesses the carbon intensity of Oregon's transportation sector by using DEQ's individual fuel CIs combined with the amount of fuels used in Oregon to calculate a consumption-weighted transportation sector carbon intensity.[62]

Carbon Intensity

This section discusses the carbon intensity of fuel consumed by Oregon's transportation sector. Carbon intensity is the amount of greenhouse gas emissions emitted per unit of energy consumed, expressed in terms of carbon dioxide equivalent per megajoule[v] of energy. Because energy content differs between fuels, carbon intensity is used to provide an apples-to-apples comparison of carbon emissions for different transportation fuels.[54] For example, the carbon intensity of fossil-fuel based gasoline is generally higher than that of electricity[vi] in Oregon when used to fuel vehicles.[56]

The carbon intensity for Oregon's transportation sector has been declining since 2005, driven primarily by state and federal Renewable Fuels Standards and the implementation of Oregon's Clean Fuels Program in 2016.[59] The decline from 2016 to 2019 in Figure 11 shows the effects of the Clean Fuels Program in reducing transportation sector carbon intensity, spurred primarily by the growing use of lower-carbon renewable diesel in place of fossil diesel.

The bump in 2020 and 2021 reflects two changes in diesel consumption: increased overall diesel consumption coupled with decreasing renewable diesel use. During the COVID-19 pandemic, gasoline consumption dropped as people traveled less, but diesel consumption increased for shipping and deliveries in Oregon.[60] At the same time, supply chain issues led to less available renewable diesel. The average carbon intensity for renewable diesel is less than half that of fossil diesel. Because of renewable diesel supply shortages, more fossil diesel was consumed in Oregon in 2020 and 2021 than in 2019. This coupled with increased overall diesel use led to a higher sector-wide carbon intensity[viii] despite reduce gasoline consumption.

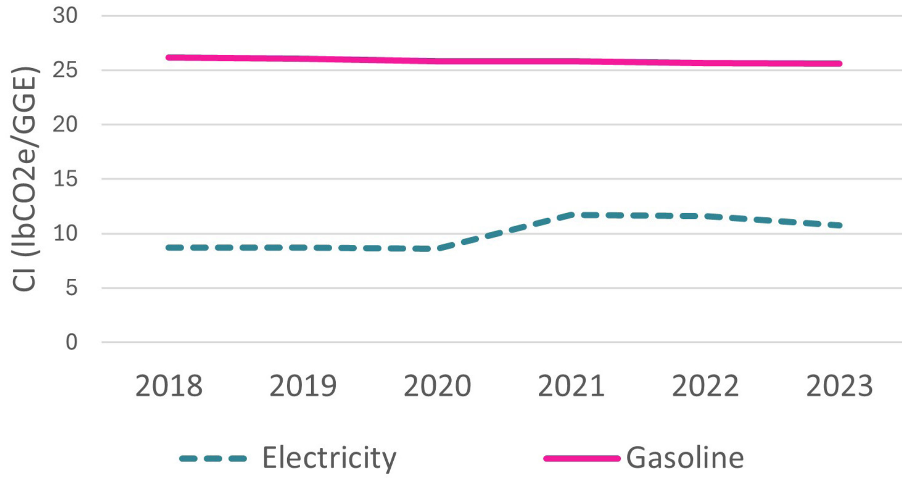
Zero-emission vehicle adoption also contributes to reductions in transportation sector carbon intensity. The primary driver of carbon intensity reductions in Figure 11 is from renewable diesel consumption, which grew 16-fold from 2021 through 2024.[61] However, transportation electrification will play an increasingly larger role in statewide carbon

v One megajoule is equivalent to 0.28 kilowatt-hours of electricity consumption.[53]

vi The carbon intensity of electricity includes a 3.4 Energy Efficiency Ratio adjustment, which accounts for the efficiency of electric motors compared to internal combustion engine vehicles.[55]

viii It is important to note that this increase is due to the amount of fuel consumed and does not reflect a change in the carbon intensity of specific fuels. The average carbon intensity of transportation fuels used in Oregon has been declining through the work of DEQ's Clean Fuels Program.

FIGURE 12: Weighted Carbon Intensity of Oregon Electricity Compared to Gasoline[x] Over Time[61]



x Gasoline refers to the most prevalent form of gasoline used by Oregon drivers, which is a blend of fossil gasoline with 10 percent ethanol, known as E10.[66]

intensity because Oregon gasoline consumption is about twice as much as diesel. ZEV use offsets gasoline demand, and the data show that Oregon may have reached peak gasoline consumption. Consumption rose in post-pandemic years as people returned to more normal travel routines, but overall consumption has not returned to pre-pandemic levels. This reduced usage may also reflect ongoing changes in work culture where more people work full- or part-time at home, reducing the amount of driving they need to do and consequently the amount of gasoline they consume.

As ZEV registrations increase and electricity displaces gasoline and diesel as a transportation fuel, the statewide transportation carbon intensity will decline even more. This is because the effective carbon intensity of electricity consumed in Oregon is lower than gasoline (no matter which utility provides the power), and it will further decline as Oregon's two major investor-owned utilities transition to zero-carbon generation like solar and wind to achieve state clean electricity targets.[49,63] Figure 12 shows the carbon intensities of gasoline and the statewide electricity mix.[ix, 64] From 2018-2024, gasoline's carbon intensity has been fairly constant at about 25.5 pounds carbon dioxide equivalent per gasoline gallon equivalent, about 2-3 times higher than electricity's carbon intensity, which ranged between 8.6 and 11.7 lbCO2e/GGE. Electricity carbon intensity varies from year-to-year depending on how much electricity the region's hydropower can supply.[65] The carbon intensity is higher in lower water years because the region often uses more natural gas generation to make up the shortfall.

Unlike electricity, there are few options to reduce the carbon intesity of gasoline and diesel. Most gasoline and diesel vehicles today use fossil fuels blended with lower carbon ethanol and biodiesel, respectively, which lower the overall carbon intensity of the fuel consumed.[67,68] However, there are limitations in the amount of the blend fuels that can be used in most existing vehicle models, which effectively constrains the carbon intensity reductions these fuels can yield. Electrifying vehicles, equipment, and industrial processes at drilling and refining operations or adding carbon capture technologies would also produce a lower carbon intensity for fossil fuels. In fact, using ZEVs at petroleum operations and for fuel transport could be a path to reduce gasoline and diesel carbon intensities. However, because gasoline and diesel are carbon-based fuels, they will always have some level of carbon intensity from tailpipe emissions.

Greenhouse Gas Emissions

Transportation is Oregon's largest source of greenhouse gas emissions by sector. In 2023, transportation emissions were 20.5 million metric tons of carbon dioxide equivalent, abbreviated as MTCO2e, and contributed 35 percent of total statewide emissions.[35] While transportation emissions fluctuate from year to year, they remained relatively constant from 1990 until 2018, when they began trending downward. In 2023, transportation sector greenhouse

ix ODOE used the statewide electricity mix to provide an approximation of all emissions from the electricity sector. This does not account for separate carbon accounting mechanisms through DEQ's Clean Fuels Program that can offset some or all of the emissions associated with ZEV charging. For example, the program allows for utilities to retire Renewable Energy Certificates for the power they provide to ZEVs, which effectively creates a carbon intensity value of zero.

gas emissions reached their lowest level since 2013.[58] On-road vehicles accounted for 84 percent of transportation-related emissions in 2023, primarily from the combustion of petroleum-based fuels and, to a lesser extent, from electricity generated to power ZEVs.[58]

Petroleum-based transportation fuels account for most of the fuel used in Oregon vehicles, with gasoline and diesel being the two largest sources of tailpipe emissions.[xi, 61] Over the past decade, petroleum combustion emissions in on- and non-road vehicles averaged to about 87 percent of all transportation sector emissions.[58,69] In 2023, emissions were about 84 percent, with 57 percent from gasoline combustion, and about 27 percent from diesel.[58]

Of the transportation fuels used in Oregon, gasoline creates the largest amount of greenhouse gas emissions — with over 11.6 million metric tons of carbon dioxide equivalent in 2023.[58] Diesel is the second largest contributor of emissions at nearly 5.5 MMTCO2e. The difference is largely attributable to the much higher number of gasoline-fueled light-duty vehicles on the road compared to diesel-powered vehicles.

In 2023, through the project known as TIGHGER – Transformational Integrated Greenhouse Gas Emissions Reduction – the Oregon Department of Energy assessed progress toward meeting state greenhouse gas reduction goals.[72] TIGHGER found that Oregon is on track to meet the 2035 goal of at least 45 percent below 1990 levels, assuming the continued implementation of existing climate programs and regulations.[73] Specifically, the assessment found that climate policies like DEQ's Advanced Clean Cars II and Advanced Clean Trucks rules,[xii] in conjunction

xi Nearly all motor vehicle emissions Oregon DEQ's Sector-Based Greenhouse Gas Emissions Inventory tracks toward state emissions goals are tailpipe emissions. This does not include emissions resulting from extracting, refining, or transporting fuels.

xii This modeling did not include federal actions to revoke the California waiver that underpins these policies.

FIGURE 13: 2023 Oregon Greenhouse Gas Emissions by Sector[58]

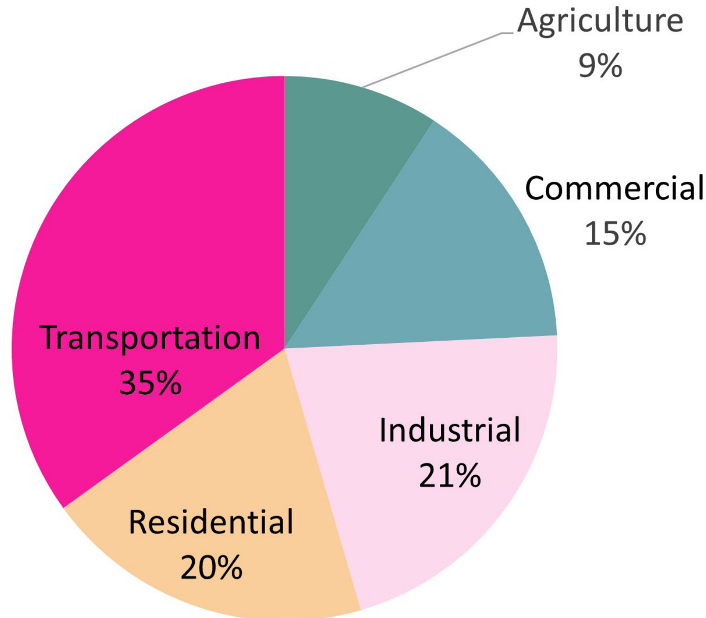
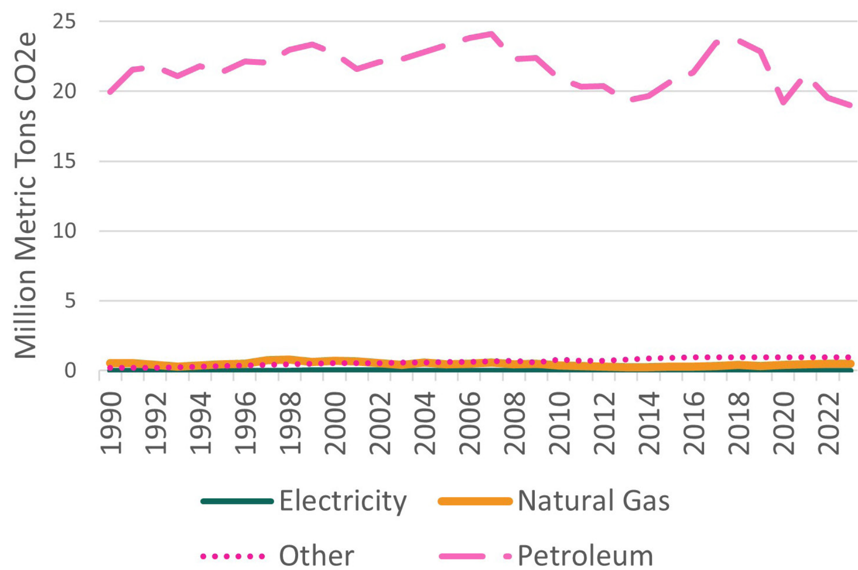


FIGURE 14: Oregon Transportation Sector Greenhouse Gas Emissions by Energy Resource Over Time[58]



Oregon's Greenhouse Gas Emissions Reduction Goals

In 2007, the Oregon Legislature established GHG emissions reduction goals, including achieving emission levels that are at least 75 percent below 1990 levels by 2050.[70] In 2020, Executive Order 20-04 added a 2035 interim goal to achieve at least a 45 percent reduction below 1990 levels and updated the 2050 goal to at least an 80 percent reduction below 1990 levels.[71]

TABLE 1: Percentage of Tailpipe Emissions by Vehicle Type of Transportation and Overall State Greenhouse Gas Emissions[70]

Vehicle	2023 Emissions (MMTCO2e)	Percent of Transportation Emissions in 2023	Percent of Overall State GHG Emissions in 2023
Light-duty Vehicles[xiii]	11.6	57%	20%
Medium- and Heavy-Duty Vehicles	5.5	27%	9%
Total	**17.1**	**84%**	**29%**

xiii This analysis considers that gasoline is mostly used by light-duty vehicles and diesel fuel is largely used by medium- and heavy-duty vehicles; over the last decade the shares of LD and MHD vehicle emissions have remained relatively constant.

with decarbonizing the electricity sector and using lower carbon fuels, are critical to driving down transportation emissions.[74] Recent federal action to invalidate these vehicle regulations would affect the ability of the state to achieve the 2035 goal, and new strategies would be needed to keep Oregon on track.

FIGURE 15: TIGHGER Projections of Emissions Reductions from Existing Programs and Regulations with Transportation Sector Highlighted[75]

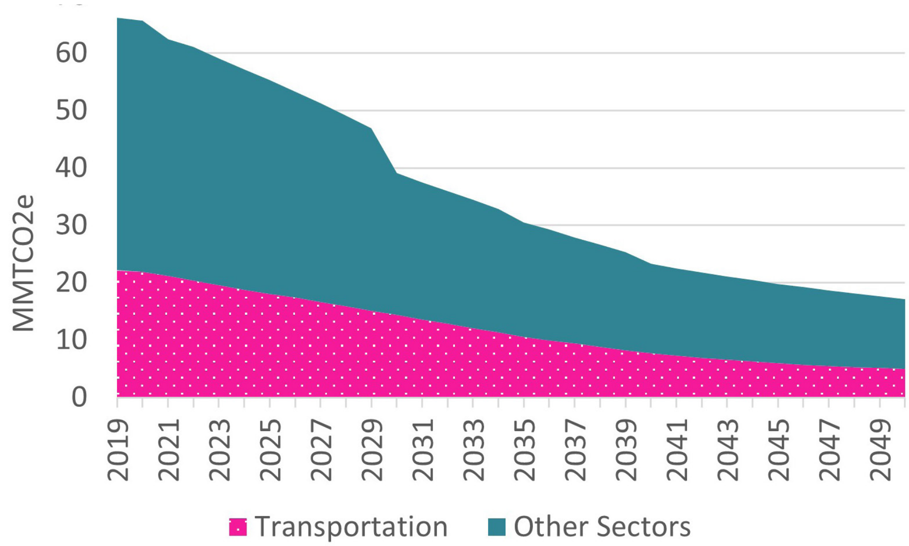


Figure 15 from the TIGHGER model's greenhouse gas emissions reductions forecast shows that addressing transportation emissions is necessary to achieve state climate goals. Assuming the state's existing climate programs and policies are implemented as planned, transportation emissions would be reduced by 48 percent over 2023 levels in 2035, to approximately 10.5 MMTCO2e.[75] By 2050, transportation emissions would be reduced by 76 percent over 2023 levels, to approximately 5 MMTCO2e.[75]

While the state is on track to meet the interim 2035 goal, more work is needed to achieve the 80 percent goal by 2050. According to the Oregon Energy Strategy model, the least cost way to meet this goal includes additional transportation electrification measures beyond existing state policies, including additional medium- and heavy-duty electrification, and potentially some off-road sectors like marine, rail, and aviation.[47]

DEMOGRAPHICS OF OREGON ZERO-EMISSION VEHICLE ADOPTION

Analyzing ZEV registrations by demographic groups is important for understanding where ZEVs are being adopted across the state and where ZEV adoption is lagging. Demographic analyses identify specific barriers to more widespread ZEV adoption by assessing how registration data compare across different income levels, geographic areas, and housing types. This information can guide more equitable policy development that helps all Oregonians share in the benefits of electrification as the state encourages more ZEV adoption.

The information presented in this section is intended to provide insight into EV ownership patterns across Oregon, but there are some significant limitations to the data collected. U.S. Census Bureau and state vehicle registration data were analyzed to better understand ZEV adoption across different groups of people, including by income level, race, and housing characteristics. Census data is useful in identifying potential patterns, but the data are aggregated. This means the level of specificity is broad and findings should be considered along with more specific information provided by communities and their representatives.

ODOE uses Census data to assess demographic differences by comparing registration data at the smallest geographical units of population data available: the Census block group. These typically include 600 to 3,000 people. An important limitation of this analysis is that ownership cannot be attributed to an individual but rather assessed against the characteristics of the entire block group. The results of this analysis are illustrative of general trends and useful for informing policy design that can improve equitable access to ZEVs and their benefits. However, they cannot fully evaluate the diverse nuances and highly community-specific variables that influence an individual's ability and desire to choose a ZEV.

In this edition of the Biennial Zero Emission Vehicle Report, ODOE is supplementing Census and Registration data with the results from a statewide Zero Emission Vehicle Awareness Survey conducted by Oregon State University's Survey Research Center in April-July 2025. The survey includes data from 736 respondents around the state, and provides additional insight into the barriers and challenges the state may need to address to meet statewide ZEV adoption targets and achieve climate goals.[9]

ZEV Registrations by Level of Urbanization

In this section, ODOE assessed state ZEV registration data across five different geographic areas defined by their relative level of urbanization. Four of the areas were characterized through the Oregon Sustainable Transportation Initiative to define geographic areas by assessing land use and transportation landscape characteristics that influence Oregonians' transportation choices.[76] This includes factors like population, housing, and job density as well as the available modes of transportation and how the land in the area is utilized. Geographic areas with similar characteristics were called place types, and they provide decisionmakers with a foundation for developing more targeted land use and transportation policies.[77–79] "Frontier" areas were added as a means for ODOE to assess ZEV adoption in areas that have even less population density than most rural areas. Frontier areas are defined by Oregon Health & Science University as having fewer than six people per square mile.[80]

The five geographic place types presented in these maps and their characterizations are:

- City Centers: dense, highly populated urban areas, such as commercial and industrial areas, downtown city centers, or a mixture of these
- Close in Community: urbanized areas generally near or within city centers with medium densities of housing and jobs
- Suburban: primarily residential communities near city centers that have a lower density of jobs and housing compared to Close in Community areas.
- Rural: low population communities with lower housing and job densities, and more undeveloped land.
- Frontier: the most remote areas, with very low population density and job density.

FIGURE 16: ZEV Registrations by Geographic Area[81]

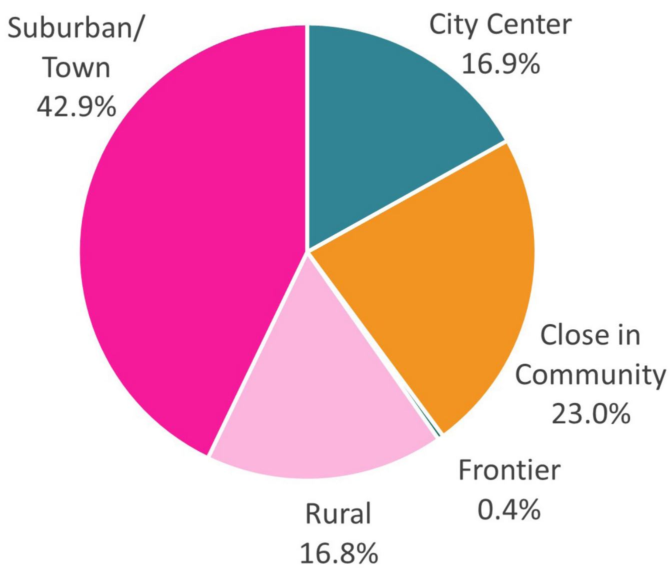
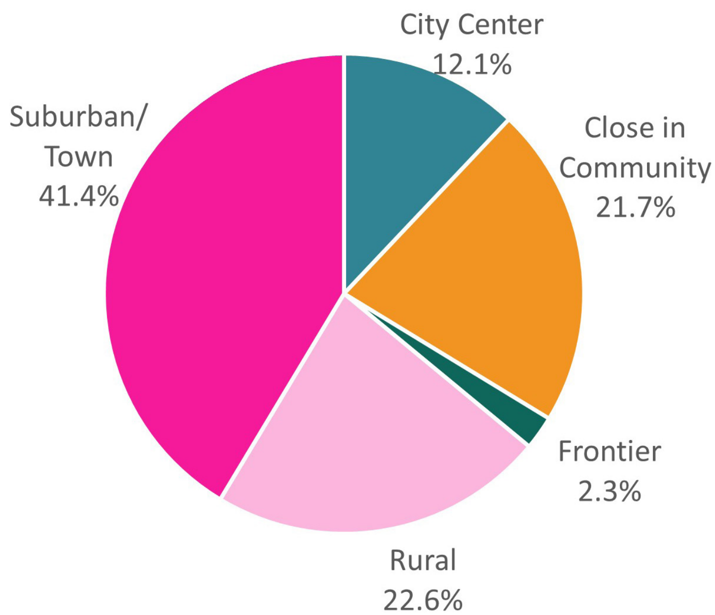


FIGURE 17: Percentage of Population by Geographic Area[9]



The data show higher rates of ZEV adoption relative to population in urbanized areas of Oregon. Previous Biennial Zero Emission Vehicle Reports had similar findings, although the methodology for classifying geographic areas changed since the last report, which does not allow for direct comparison. Figure 16 shows that about 83 percent of ZEV registrations are located in City Centers, Close in Communities, and Suburban areas, but only about 75 percent of Oregonians live in these areas. Conversely, about 25 percent of Oregonians live in the least urbanized Rural and Frontier areas of the state, but only about 17 percent of ZEVs are registered in these locations.

Zero-emission vehicles may be less prevalent in Rural and Frontier areas because the current ZEV formats don't meet the needs of rural Oregonians or fit consumer preferences. Rural Oregonians often need to drive farther than people living in cities to go to work or school, access essential services, or recreate, and there is less public charging infrastructure available in these areas.

EV Registrations Differentiated by Income Level

People with higher incomes are more likely to own a ZEV in Oregon. Figure 18 shows a correlation between county median household income (x-axis) and ZEV registrations per 1,000 people (y-axis). Counties with average household incomes less than the state's median annual income ($80,426)[xiv] only account for 24 percent of registered ZEVs despite representing 43 percent of the state's population.[81] A similar correlation was found in the ZEV Awareness Survey results, where the proportion of ZEV owners among respondents who earned $50,000 or more in annual income last year was nearly four times greater than those earning less than $50,000. The correlation between income and ZEV ownership is getting stronger, indicating this disparity is getting more pronounced.

The upfront cost of paying for a ZEV is significant, even when buying a used model, and may be insurmountable for many Oregonians. However, ZEVs save owners money over the lifetime of the vehicle because they cost less to fuel and maintain than a gas-powered car.[53–55] This finding was confirmed by the Energy Wallet analysis conducted for ODOE's Energy Strategy, which found all five sample households modeled saved money by switching to a ZEV in the least cost pathway to achieve Oregon's climate goals.[86]

xiv Reported in 2023 dollars and calculated as the five-year average from 2019-2023

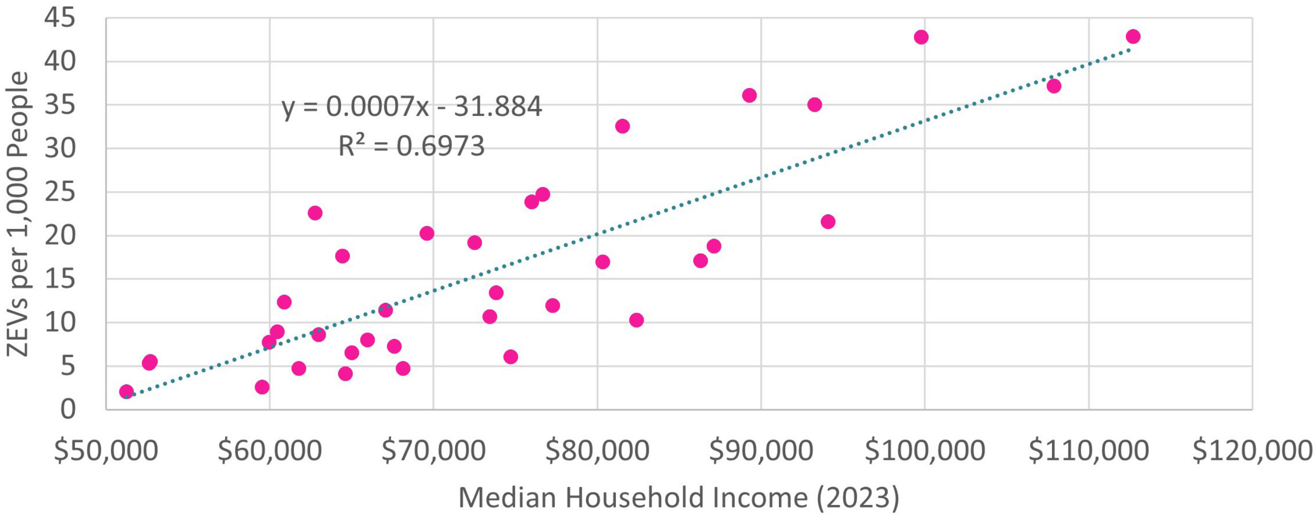


FIGURE 18: Proportion of ZEVs Registered in Oregon Counties Differentiated by Average Income[82]

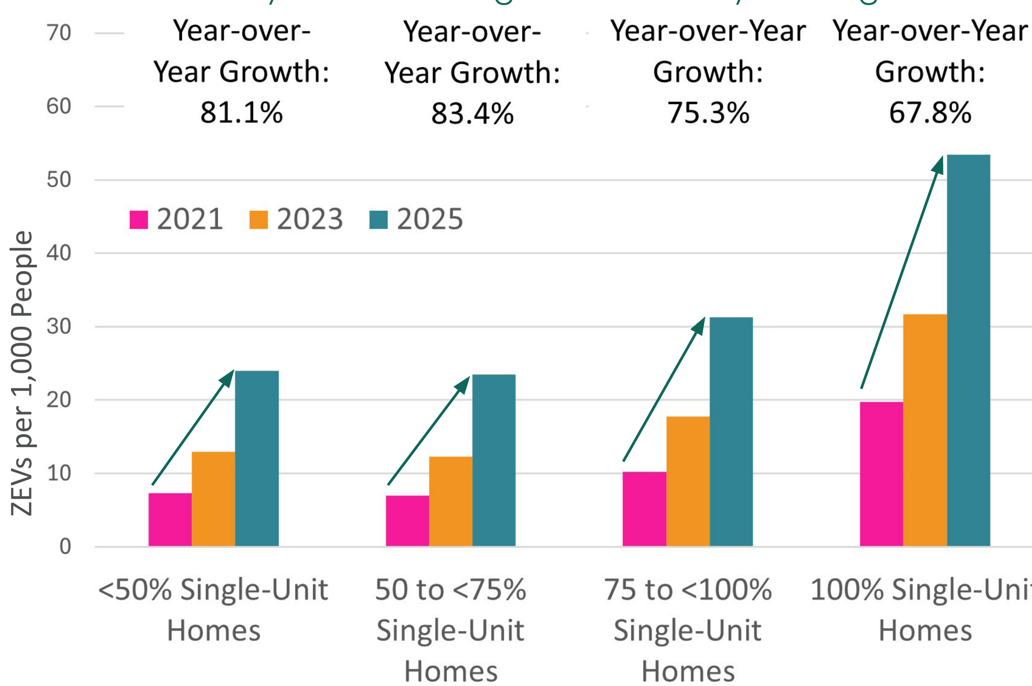
Programs like DEQ's Charge Ahead Rebate provide an essential resource to help low-income Oregonians overcome the upfront cost barrier and reap the operational cost benefits of driving a ZEV. However, Oregon survey data indicates that many Oregonians may not be aware of the cost-saving benefits of ZEVs or of the rebate program.[9] Only 45 percent of respondents who made less than $50,000 in annual household income were aware of the lower operational costs and only 26 percent of state vehicle rebates. Despite this, the survey results found both income-level groups have similar percentages of those who intend to buy or are considering buying a ZEV for their next vehicle.

EV Registrations Differentiated by Housing Type

EV registrations continue to be most prevalent in areas dominated by single-family housing, with more than twice as many registrations per 1,000 people compared to areas where single-family homes make up less than 75 percent of the housing stock.[81] Drivers living in multifamily housing are more likely to rely on public charging for their fueling needs, which costs more and requires a larger investment of time than people who are able to charge at home. These additional costs are even greater for low-income Oregonians, who likely comprise a larger percentage of multifamily housing residents.[xv]

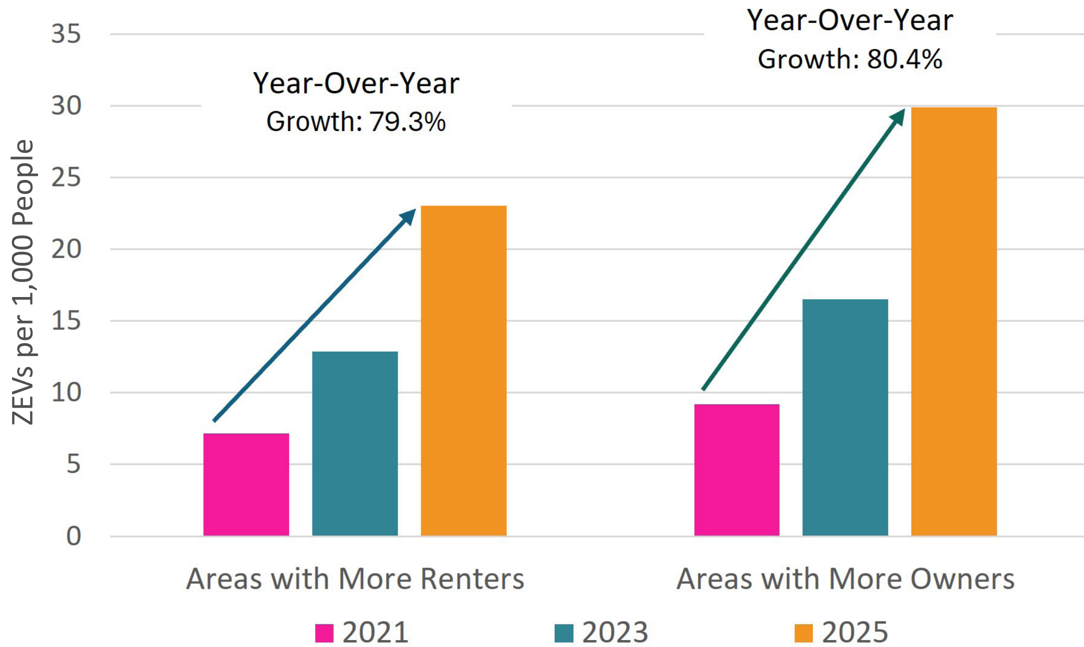
ZEV registrations are highest in areas composed entirely of single-family homes, followed closely by areas where 75-99 percent of homes are single-family.[81] The data are not granular enough to determine if registrations are specifically for multi-family homes or single-family homes in these areas, but Oregon Electric Vehicle survey results indicate that while respondents living in multi-family housing are 23 percent less likely to have access to charging at home, they are only about 7 percent

FIGURE 19: Comparison of ZEV Registrations per 1,000 Oregonians Differentiated by the Percentage of Multifamily Housing[81]



xv This is an assumption based on data showing low-income Oregonians are more prevalently renters than owners.[87]

FIGURE 20: Comparison of EV Registrations per 1,000 Oregonians Differentiated by Homeowners Compared to Renters[82]



less likely to own a ZEV.[9] This may indicate that these owners have access to and are willing to use other types of charging, like workplace or public charging.

When ZEV owners can charge at home, they not only benefit from lower costs through their home electricity rates but also save time by avoiding trips to public charging stations. Survey results indicate access to home charging may be a key barrier for the state to address. About two-thirds of multi-family housing respondents indicated that access to home charging would motivate them to purchase a ZEV. This suggests that programs like ODOT's Community Charging Program, which supports charging infrastructure in multifamily housing, is helping to address one of the key barriers residents face when considering a ZEV purchase.

EV Registrations Differentiated by Homeowners Compared to Renters

Individuals who own homes are more likely to own a ZEV than those who rent in Oregon, and this disparity is increasing. The highest ZEV adoption rate is in areas where all homes are owner-occupied, and it is nearly twice as high as the adoption rate in areas where more than 50 percent of homes are rentals. While ZEV adoption is generally trending upward in both, the share of ZEVs in areas that are predominantly renters has been trending downward since 2021, indicating homeowner adoption is outpacing renter adoption.

Many multifamily housing residents are also renters, and individuals in multifamily housing are less likely to own a ZEV. A little over a third of Oregon households are renters and two-thirds of Oregon renters are considered low-income. The lag in adoption growth in areas dominated by rental homes may reflect cost barriers experienced by low-income Oregonians. Renters of any property have more barriers to installing home charging because it requires the property owner to agree to the installation and possibly fund it.

EV Registrations Differentiated by Race

The data available to ODOE do not indicate a difference in ZEV registrations in non-white and white communities.[81] Historically, individuals in communities of color have had more difficulty accessing the benefits of newer technologies than white individuals.[88] ZEVs provide many benefits to local communities, including lower fueling costs and local air quality improvements.

The data used to assess racial diversity of EV ownership do not track the individual on the registration to their race. Instead, ODOE uses U.S. Census Bureau data to determine the percentage of non-white compared to white households in the state and then compares that to the number of EV registrations located in the area. About 23 percent of Oregonians are non-white, and the

FIGURE 21: Proportion of Oregon's Population Living in Census Block Groups Differentiated by Racial Diversity Compared to the Statewide Average[81]

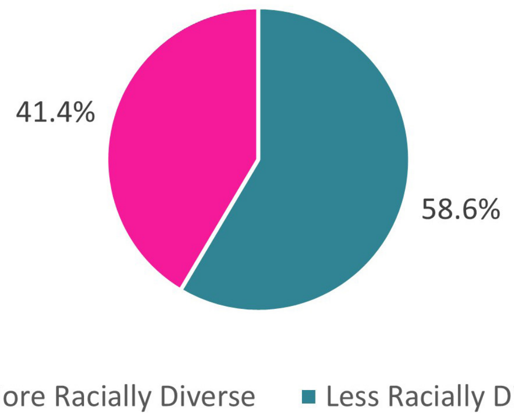
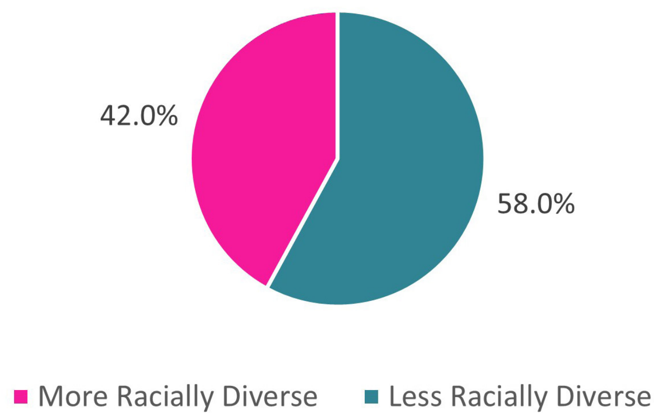


FIGURE 22: Proportion of EV Registrations in Census Block Areas Differentiated by Racial Diversity Compared to the Statewide Average[81]



remaining 77 percent are white. About 41 percent of census block groups in Oregon have more diverse populations than the state average, and 59 percent are less diverse.[81]

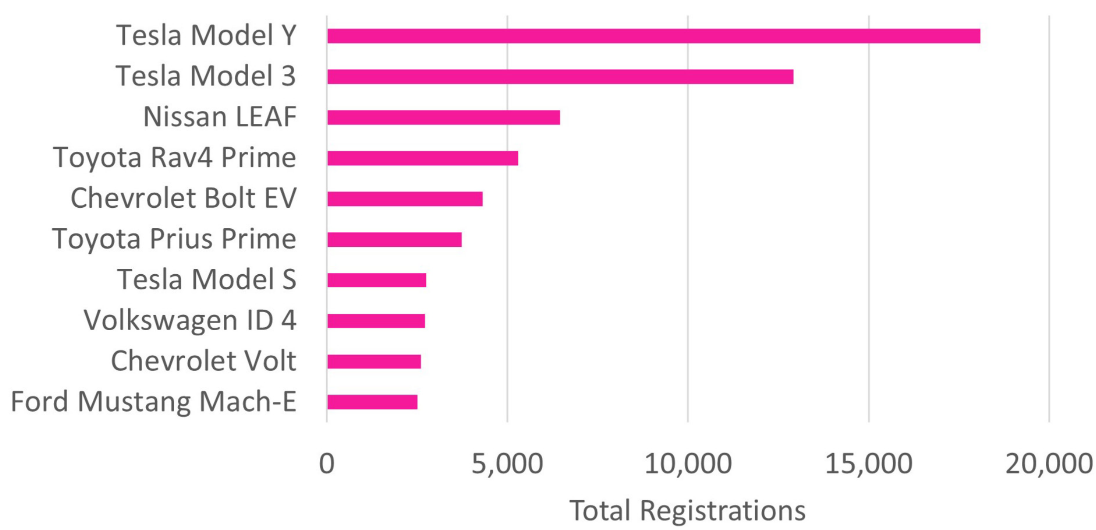
Zero-emission vehicle registrations in Oregon match closely with the statewide population diversity, indicating no significant differences in adoption between areas of the state that are more or less racially diverse than the statewide average.[81] Figure 22 shows that about 42 percent of EVs are registered in census block groups where the racial diversity is lower than the statewide average, which is similar to the 41 percent of the population that lives in these same areas.

While the data do not show lower ZEV adoption in more racially diverse communities, income-level data indicate there is a potential for it to be lower for non-white individuals. For example, 54 percent of the total black population in Oregon lives in Multnomah County, which happens to have second highest rate of ZEV adoption in the state. However, a 2019 Multnomah County report showed that the income and wealth disparities between black and white residents were immense, with over 35 percent of black residents facing poverty as opposed to 14 percent of white residents. Since income-level tracks closely with ZEV adoption, it is likely that ZEV adoption lags for non-white Oregonians.[89]

ZERO-EMISSION VEHICLE MODEL AVAILABILITY

Model availability is an important precursor to higher ZEV adoption. The number of light-duty ZEV models continues to increase, rising to 90 different models in 2024, a 28 percent increase from 2023.[90] Despite this, the top 10 most popular ZEV models in Oregon changed very little since the previous report, with the exception of the plug-in hybrid Toyota RAV4 moving into the fourth spot. There are still far fewer models of ZEVs than gas cars, particularly for economy, pickup truck, and sport-utility vehicle models.[91]

FIGURE 23: Top 10 Zero-emission Vehicle Models Registered in Oregon[3]



Electric step van. Photo Courtesy of Amazon

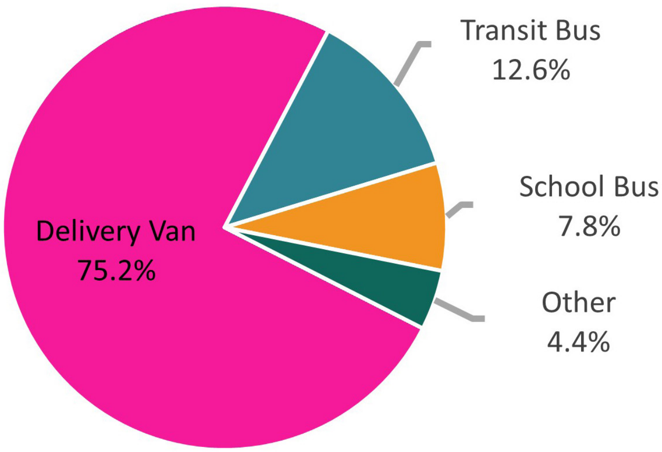
Medium and Heavy-duty Models

Many medium- and heavy-duty ZEV models are commercially available nationwide, with availability in Oregon continuing to expand. This section does not attempt to catalog every model; it highlights the formats becoming more widespread in Oregon.

Smaller medium-duty vehicle models show the strongest growth, specifically delivery vans, transit buses, school buses, and pickup trucks. Since the last report, there are now electric garbage trucks and street sweepers deployed in Oregon.[92–94]

A small number of heavy-duty ZEV models are operating in Oregon, including pilot or demonstration projects conducted by fleets willing and able to experiment with this new technology. Most heavy-duty and long-haul vehicle formats are not yet widely adopted because current electric formats are very expensive and do not meet the needs of some vehicle owners.

FIGURE 24: Percentage of Medium- and Heavy-Duty Zero-Emission Vehicles in Oregon by Format[17]



Demand for electric step vans is growing because many use them for local deliveries.[95] This type of vehicle operation is well-suited to electrification: routes are short, involve frequent stop-and-go driving, and vehicles can typically charge at depot facilities rather than relying on public infrastructure. Operating costs are lower than for gasoline or diesel vehicles due to greater energy efficiency and reduced maintenance needs, especially on stop-start routes.[96] Step vans currently make up about 75 percent of Oregon's medium- and heavy-duty fleet, so efforts to electrify these will make significant progress on electrifying these vehicles in the state.[17]

Trains, Aircraft, and Marine Craft

Electric formats of trains, light aircraft, and boats are growing, particularly for recreational boats, though they remain fairly niche and consist mostly of pilot projects studying the feasibility and challenges of electrification.[97–101] Ports are emerging as early adopters, expanding shore power for some berthed vessels and replacing select cargohandling equipment with electric alternatives.[102] The Port of Portland is using a $16 million grant from the Federal Aviation Administration to provide electricity at the gate for electric models of aircraft and support equipment like baggage tugs.[103] The Port has installed electric pre-conditioned air units on all its jet bridges, allowing aircraft to shut down their engines while at the gate. In October 2024, Port of Portland received $2.77 million through EPA's Clean Ports Grant program for a planning study to identify opportunities to decarbonize their marine terminal operations, including port electrification options.[103,104]

Zero-Emission Vehicle Costs

The cost to purchase a light-duty zero-emission vehicle has declined over time, but in the last two years the price gap between ZEVs and gas cars has remained fairly flat.[105] Until 2023, the price of a ZEV largely tracked with the cost to produce the battery, but from 2023-2024 battery costs in the U.S. dropped 15 percent while vehicle costs dropped only 3 percent. The purchase price for plug-in hybrid electric SUVs rose over that same time to 10 percent higher than similar battery electric SUVs and 35 percent higher than gas models.[106] This indicates that other cost factors, including manufacturing costs for other vehicle parts, trim level demand, and manufacturer pricing strategies, are increasingly influential.[107] In the last year, the price of a new ZEV in the U.S. remained flat at about 16 percent higher than other light-duty vehicles, with an average upfront cost of about $8,000 more.

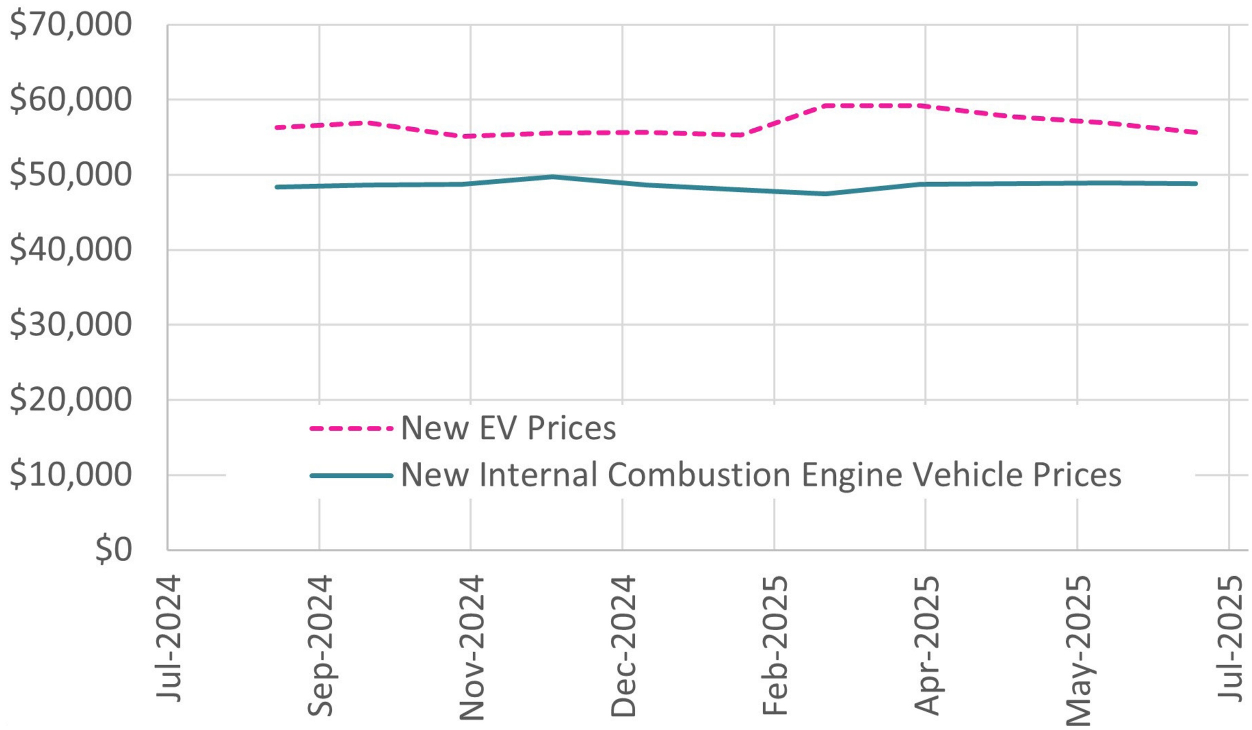


FIGURE 25: Price Comparison of the Average Cost of Light-duty ZEVs vs Gasoline Vehicles[xvi,108]

xvi Data available back to Sept 2024, however ODOE will continue to track this information.

There are far fewer low-cost ZEV models available to purchase in comparison to internal combustion engine vehicles, which skews average costs higher.[105] For 2025 model years, only one ZEV model was priced below $30,000 – the 2025 Nissan Leaf.[109] This contrasts with internal combustion engine vehicles, where over 20 percent of models are priced below $30,000. ZEVs remain more common in the luxury vehicle market,[13] where over 70 percent of current or announced new ZEV models through 2026 are expected to be be priced above $50,000.[70]

Expanding the availability of affordable ZEV models is critical to driving broader adoption. The bar chart on the right in Figure 26 shows about two-thirds of battery electric vehicles and plug-in hybrid EVs in the U.S. cost more than $50,000, whereas only about a third of internal combustion engine vehicles are in that price range. There are no plug-in hybrid EVs available that cost less than $30,000 and only one battery electric vehicle. The bar chart on the left shows the distribution of vehicle model price ranges for plug-in hybrid and battery electric vehicles in China is similar to their internal combustion engine vehicle cost distribution. Chinese market share is about six times the U.S., indicating that the availability of more affordable models would help support U.S. ZEV adoption.[110]

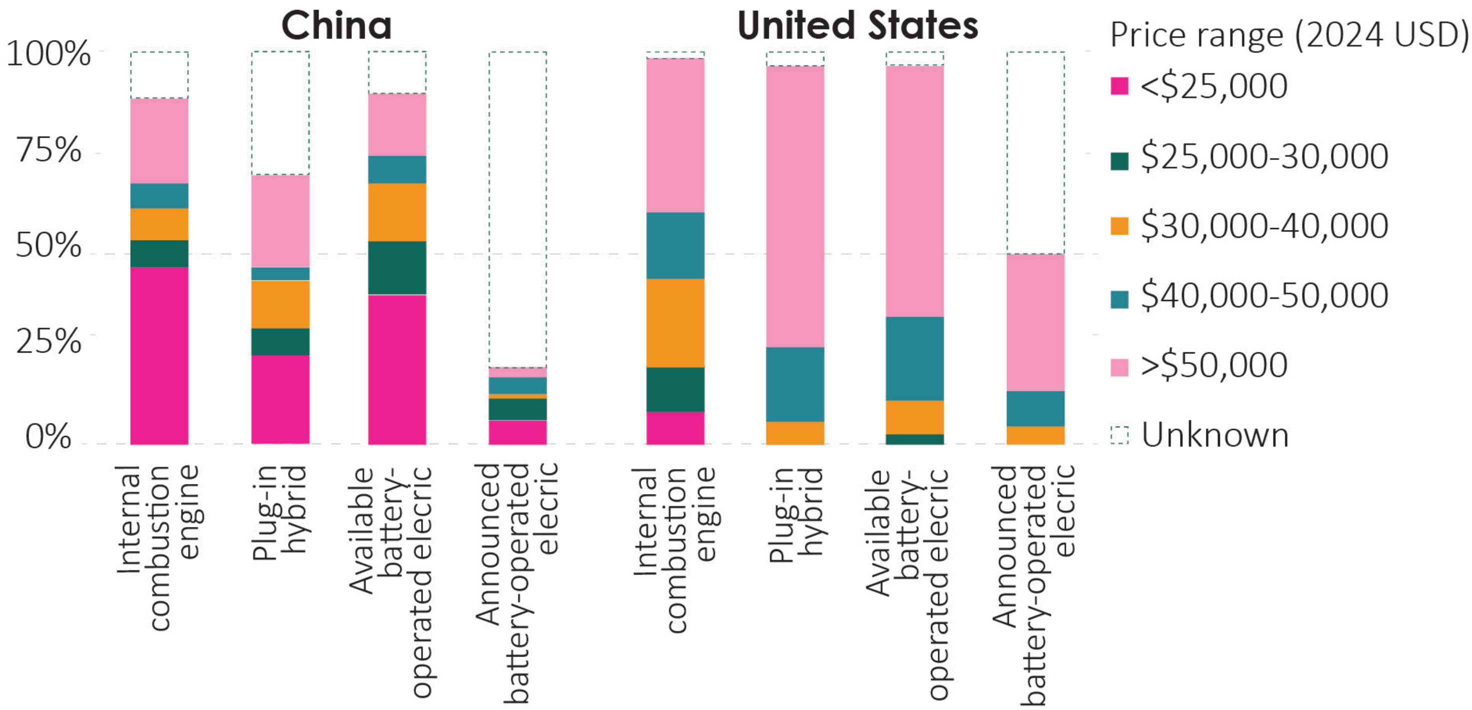
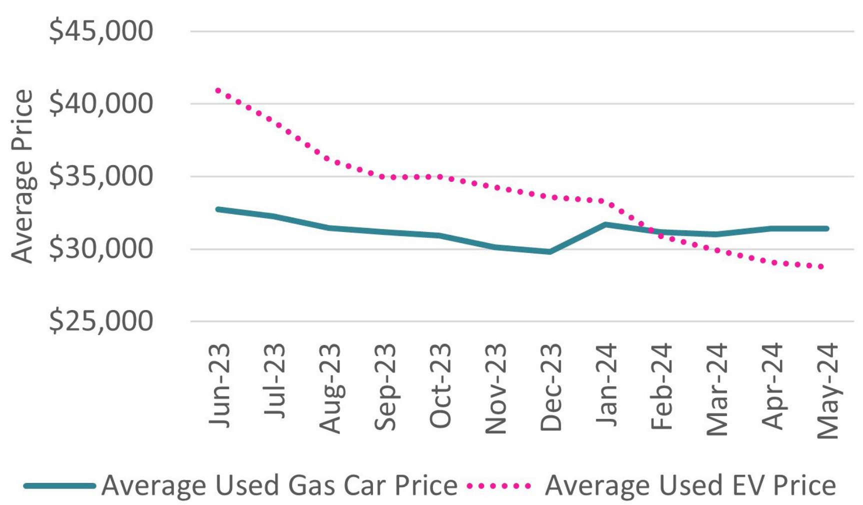


FIGURE 26: Price Range Distribution of Gasoline and ZEV Formats from 2024-2026 Model Years[107]

The used ZEV market tells a different story: in July 2024, the average price of a used ZEV fell below that of a used gas vehicle, and this trend has largely persisted through July 2025.[111] The drop in price was primarily due to an increasing number of used ZEVs flooding the market, stemming from high numbers of new Tesla sales in the years preceding the COVID-19 pandemic that are now entering the used market.[112] Used ZEV prices fell by more than 24 percent in the second half of 2024, but have since stabilized. Over the past six months, used ZEV prices, while still lower, have tracked closely with the prices of used gasoline cars.

FIGURE 27: Average Price of Used ZEVs and Gasoline Cars in the U.S.[113]



In 2017, the Oregon Legislature passed Senate Bill 2017, which included funding for the Oregon Clean Vehicle Rebate program to address the higher upfront cost for ZEVs.[114,115] DEQ has administered this program since 2018 to help make ZEVs accessible to more households.[114,115] In that time, the program has issued nearly 35,000 rebates to date, totaling over $100 million, with approximately 34 percent of this funding going to low- and moderate-income households. These rebates provide $7,500 for qualifying new ZEVs and $5,000 for used ZEVs to low- and moderate-income households.

Figure 28 shows the total number of rebates issued since the program began in 2018. Numbers rose sharply from 2018 to 2022 as the program gained popularity. Because funds were not fully exhausted in

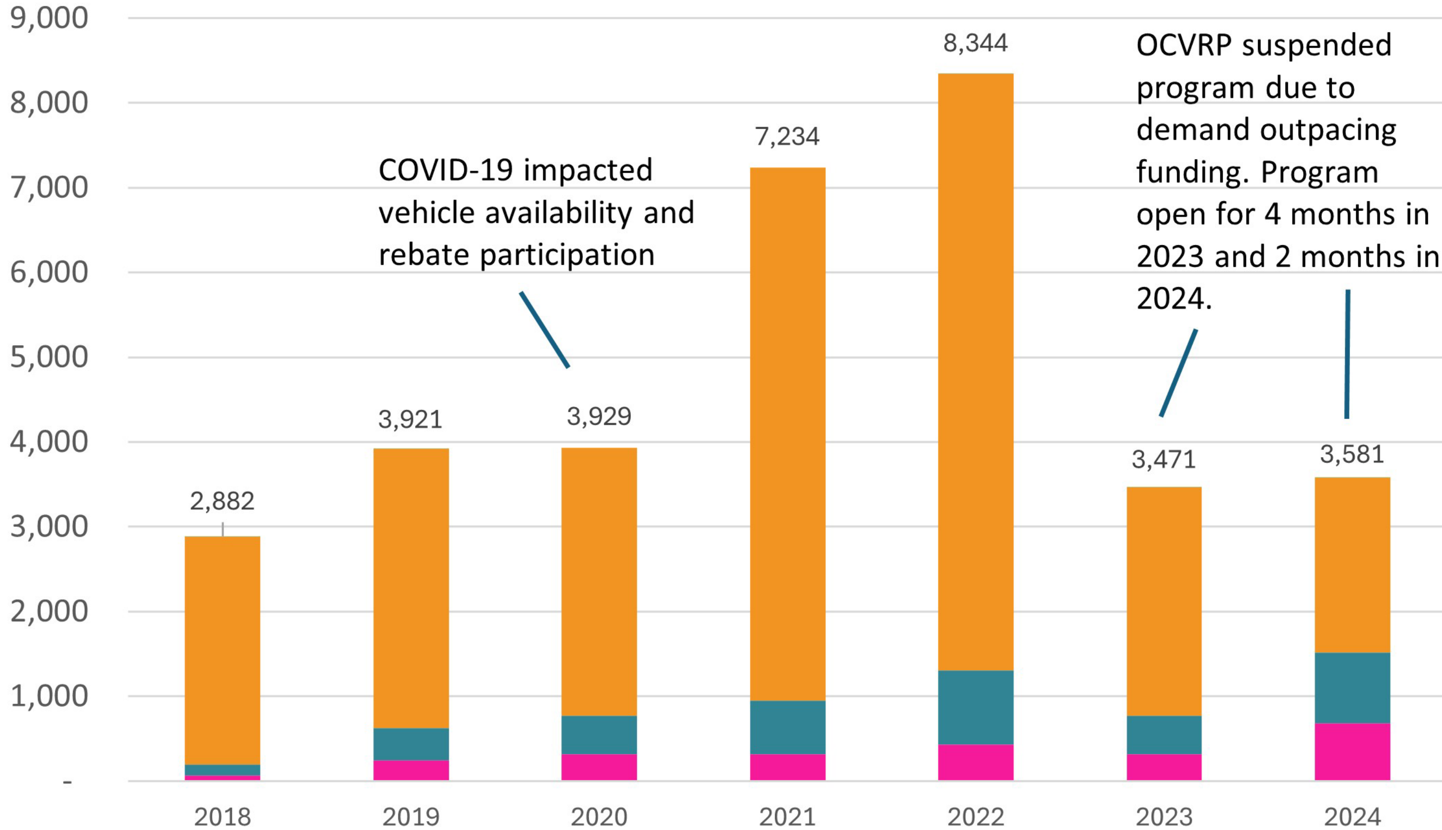


FIGURE 28: Total Rebates Issued Through Oregon Clean Vehicle Rebate Programs (2018 – 2024)[116]

earlier years, DEQ was able to disburse a large number of rebates in 2021 and 2022 using the remaining dollars. Since 2023, the number of rebates issued has dropped because the program is quickly oversubscribed and now expends all the revenues it receives annually within the first few months.

In 2024, Oregon was awarded $197 million through EPA's Climate Pollution Reduction Grant to support several programs at state agencies, including providing DEQ with an additional $31 million for Charge Ahead rebates.[117] In August, DEQ announced that the Standard Rebate was reaching full subscription and suspended the program in September 2025.[118] With the EPA grant funds, however, the Charge Ahead Rebate remains open. In the first 8 months of 2025 alone, DEQ received over 6,300 applications for Charge Ahead Prequalification with demand increasing over the summer to about 75 applications a day on average by August.[64] This is significantly higher than the 2,767 applications in the first two years of the program.

A higher purchase price is one barrier to ZEV adoption for some consumers. However, used ZEVs are now more affordable than ever – so much so that they often cost less than comparable used gasoline cars, as discussed above. When combined with the DEQ Charge Ahead rebate, this can substantially reduce the upfront cost of purchasing a ZEV. For example, the average used ZEV sells for approximately $27,000, and when the rebate is applied, the cost could be reduced to $22,000. Used ZEVs for sale under $10,000 dollars could bring costs down to less than $5,000 if the vehicle is eligible for the DEQ rebate.[119]

Medium- and Heavy-duty Zero-Emission Vehicles

The upfront cost of a battery electric medium- or heavy-duty truck remains two to three times that of a diesel truck in 2024.[120] While the total operating cost is important for overall business profitability, the upfront costs can be particularly challenging for small businesses (approximately 95 percent of U.S. haulers) that may have less access to financing. As discussed above, many models are customized and not yet built on assembly lines. These factors contribute to the substantially higher upfront cost of medium- and heavy-duty ZEVs.

According to research conducted by the California Air Resources Board, the average additional cost of a heavy-duty zero emission truck beyond the price of a comparable diesel truck is $279,937.[121] In addition, fleets also need to invest in depot-based charging infrastructure to support any electric vehicle deployments. The cost of charging varies based on whether vehicles are able to charge overnight and therefore can rely on less expensive Level 2 charging or if fast charging is required.

Oregon fleets can access multiple grant and incentive programs to reduce these upfront purchase costs. DEQ's Zero Emissions Rebates for Oregon Fleets reimburses the lesser of 33 percent or $130,000 toward the purchase of a new medium- or heavy-duty ZEV.[122] This coupled with their Zero Emissions Fueling grant helps offset vehicles and charging infrastructure costs. Portland General Electric's Fleet Partner program also provides financial incentives and technical assistance to install new charging facilities for fleets in their service territory.[123]

OREGONIANS' AWARENESS OF ZERO-EMISSION VEHICLES AND THEIR BENEFITS

ODOE collaborated with the Oregon State University Survey Research Center to collect input from a random sample of Oregon households about their views on zero-emission vehicles.[9] The survey, open from April through July of this year, asked Oregon households if they drive a ZEV, what types of ZEVs they are aware of, what benefits and incentives for driving a ZEV they are aware of, and what would motivate them to consider acquiring a ZEV as their next vehicle. Three demographic questions (housing type, geographic area, and household income) were also asked to compare opinions from different households. For a copy of the full survey results please refer to Appendix A.

FIGURE 29: Respondents' Relationship to Electric Vehicles

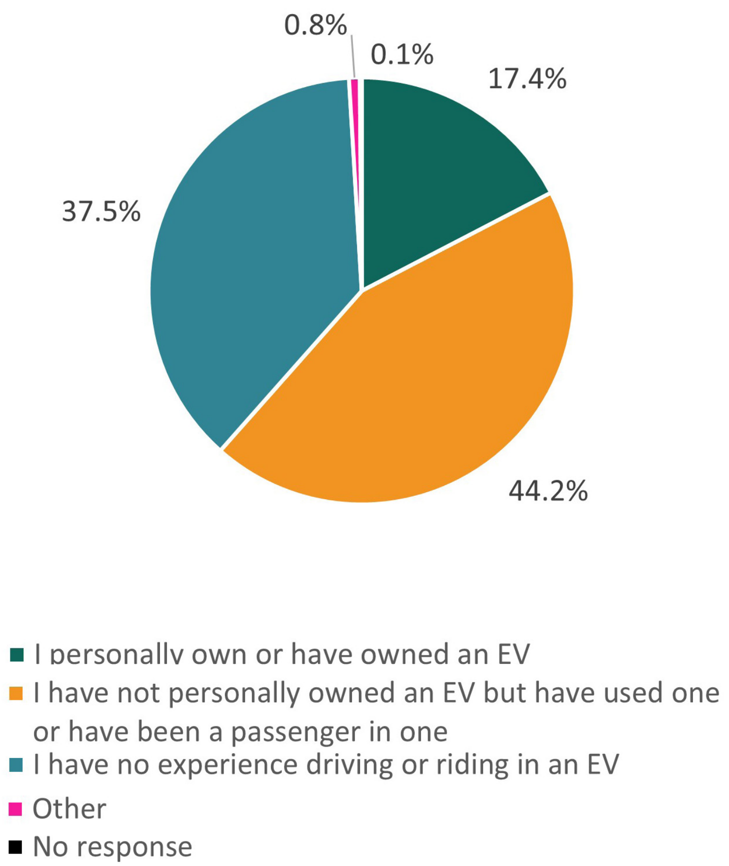
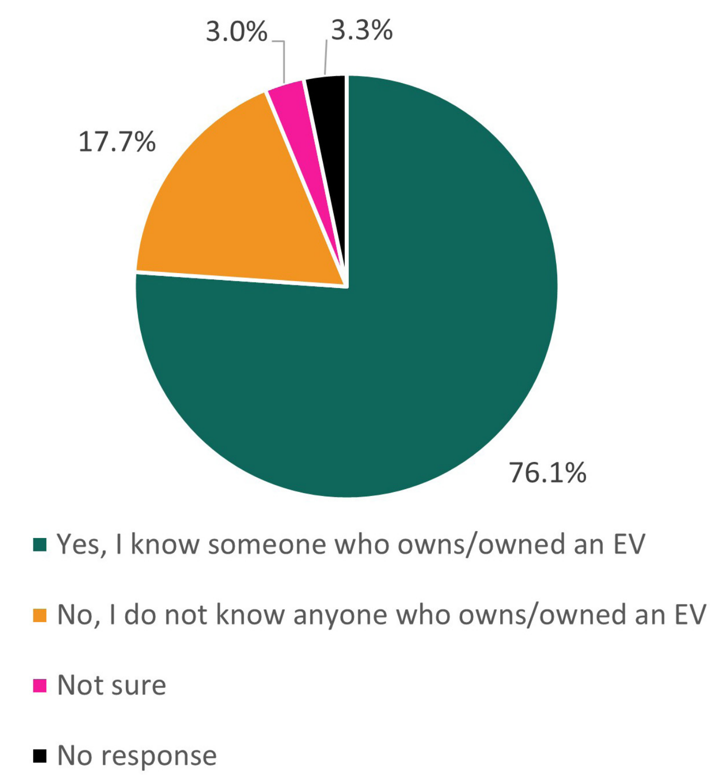


FIGURE 30: Percentage of Respondents who Know an EV Owner



In the survey, ODOE used the term electric vehicles or EVs because this term and abbreviation are more commonly known than zero-emission vehicles. These will be used throughout this section so that it clearly reflects what respondents were asked. For the purposes of this section, zero-emission vehicle is synonymous with electric vehicle.

Awareness of Electric Vehicles

More than 60 percent of Oregonians surveyed have either owned, driven, or ridden in an EV, with 17 percent reporting they own or have owned one. This contrasts with a 2024 national survey conducted by Gallup that found only 7 percent of respondents owned an EV.[124] A little over a third of Oregonians have had no direct experience with an EV, but over three-quarters of respondents indicated they knew someone who owned one.

Survey results indicate that current EV owners are more likely to have higher incomes, live in urban or suburban areas, and live in single-family homes. This tracks closely with ODOE's analysis of U.S. Census data provided in the Demographics section above. The largest disparities are by income level and geographic location. Oregonians making more than $50,000 annually were over three times more likely to own an EV than those making less than $50,000, and those living in suburban or urban areas were six times more likely than those in rural areas. Oregonians living in multi-family housing are less likely to own an EV, compared to 36 percent of owners in single-family homes.

The disparities by income level and geographic area are present but less pronounced when considering whether respondents simply know someone who owns an EV rather than owning one themselves. The largest gap is by income: respondents earning more than $50,000 annually were about 19 percentage points more likely to know an EV owner than those earning less, suggesting that exposure to EVs – through friends, family, or colleagues – still skews toward higher-income households.

FIGURE 31: Percentage of Respondents who are EV Owners by Housing Type, Annual Income, and Geographic Area

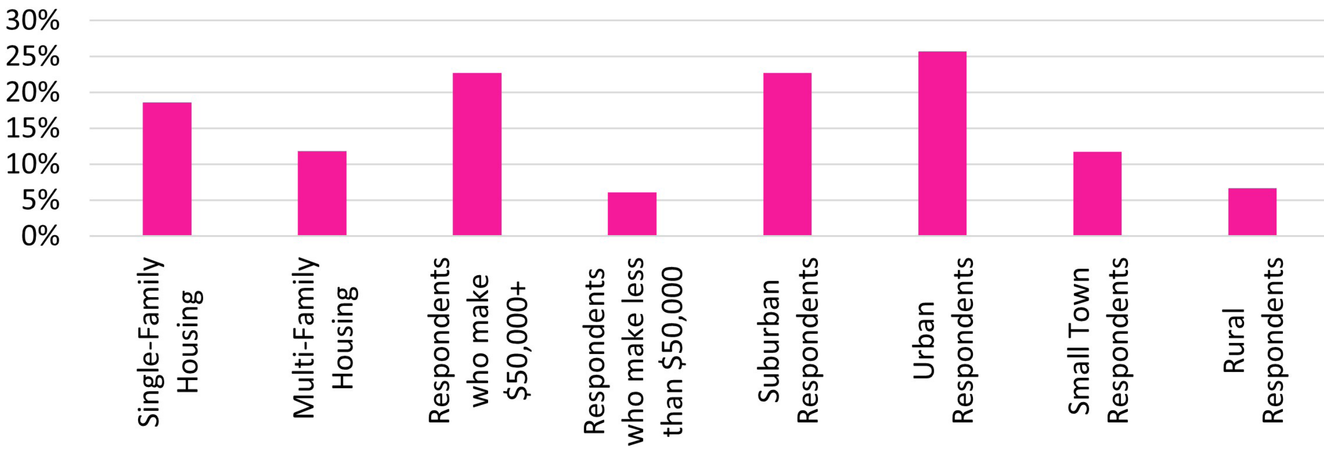


FIGURE 32: Percentage of Respondents who Know an EV Owner by Annual Income and Geographic Area

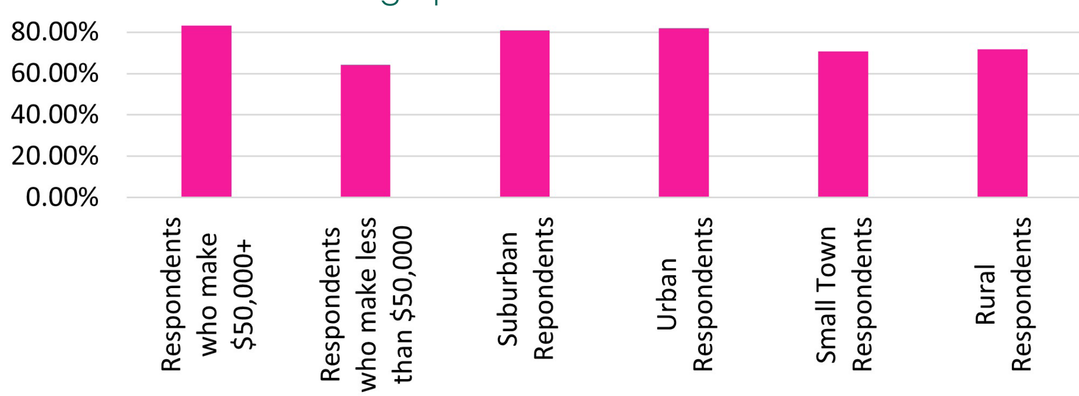
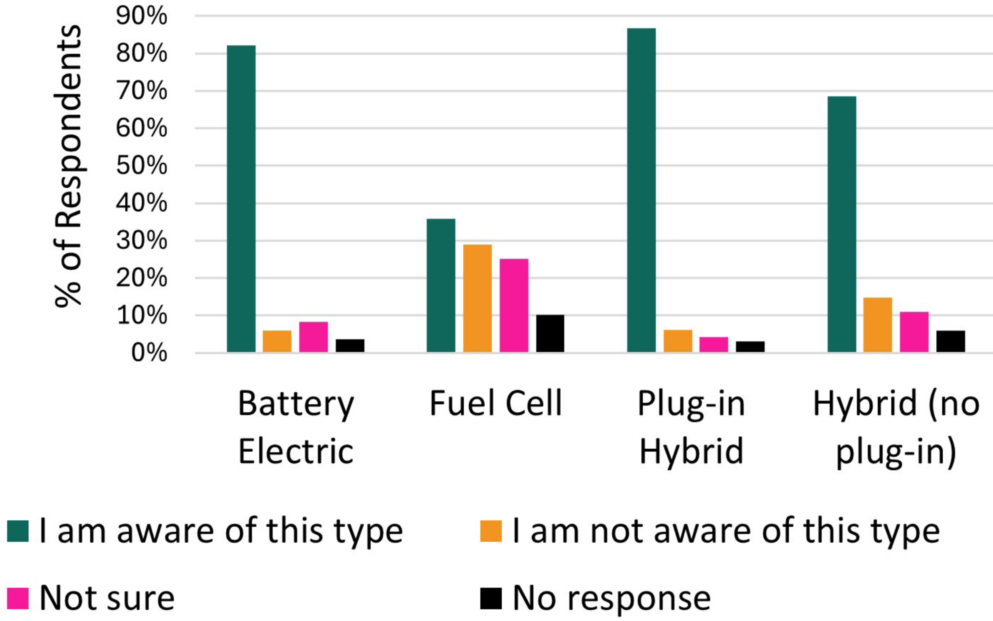


FIGURE 33: Survey Respondent Awareness of Different EV Types



Survey respondents showed broad awareness of the three most common types of electric vehicles – battery, plug-in hybrid, and standard hybrid vehicles – with battery and plug-in hybrid electric vehicles being recognized by over 80 percent of respondents. Awareness varied only slightly by geography but was again more noticeably divided by income level.[9] By contrast, fuel cell electric vehicles remain relatively obscure, with more than half of respondents being unaware or unsure of them. This is unsurprising given that no fuel cell electric vehicles are currently registered in Oregon, making it unlikely that most residents have ever seen or driven one.

Awareness of Electric Vehicle Incentives

Incentives to purchase or install an electric vehicle and a charger are a key policy to address the higher upfront costs of going electric. While federal EV tax credits are sunsetting on Sept. 30, 2025, the state and some utilities continue to provide rebates, grants, and other incentives for vehicles and charging.[125] These programs fill a critical gap for residents who may not otherwise be able to afford the transition to clean transportation.

The gaps in adoption and awareness of EVs described earlier underscores the importance of Oregon's Clean Vehicle Rebate to create more equitable access to EVs for all Oregonians. The Charge Ahead Rebate, which provides $7,500 for qualifying new EVs and $5,000 for used EVs to low- and moderate-income households, is particularly important because it addresses the upfront costs that can be a barrier to purchasing an EV.[126] DEQ developed the program to allow buyers to apply the rebate at the time of purchase, so they do not have to foot the full bill and seek reimbursement.[xvii, 127] As of July 29, 2025, DEQ had provided nearly $37 million in rebates to low- and moderate-income Oregonians for EV purchases.[64]

Despite their importance, awareness of EV incentives remains limited. A 2023 Consumer Reports survey found that only 39 percent of Americans have heard about any EV incentives, and a 2023 Gallup survey found that about 18 percent of EV owners reported difficulties finding incentive information.[41,128]

Oregon survey data reflect similar trends. About 63 percent of respondents were aware of the Federal EV Tax Credit, which is higher than the Consumer Reports survey findings. This may reflect heightened public attention following recent news coverage of congressional efforts revoking the credit. Less than half of respondents were aware of the state rebate and less than 20 percent of utility incentives. Awareness was especially low among Oregonians earning less than $50,000 annually.

xvii Buyers must first apply for and be issued a Charge Ahead Prequalification Voucher and purchase the vehicle through a participating dealership as defined by DEQ.

FIGURE 34: Survey Respondents' Awareness of Different EV Incentives

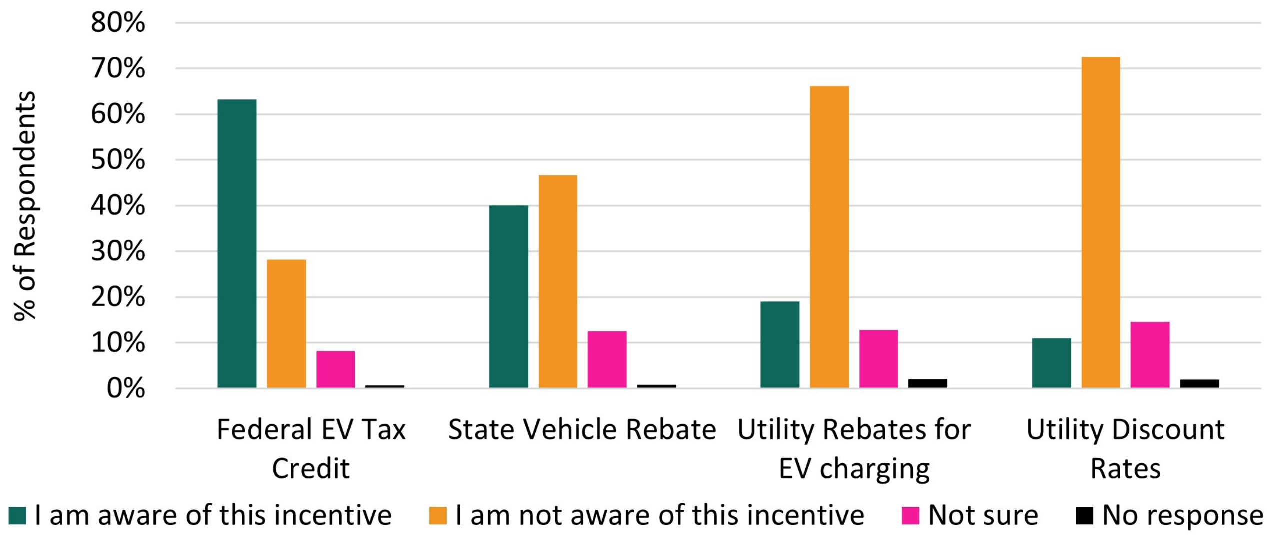
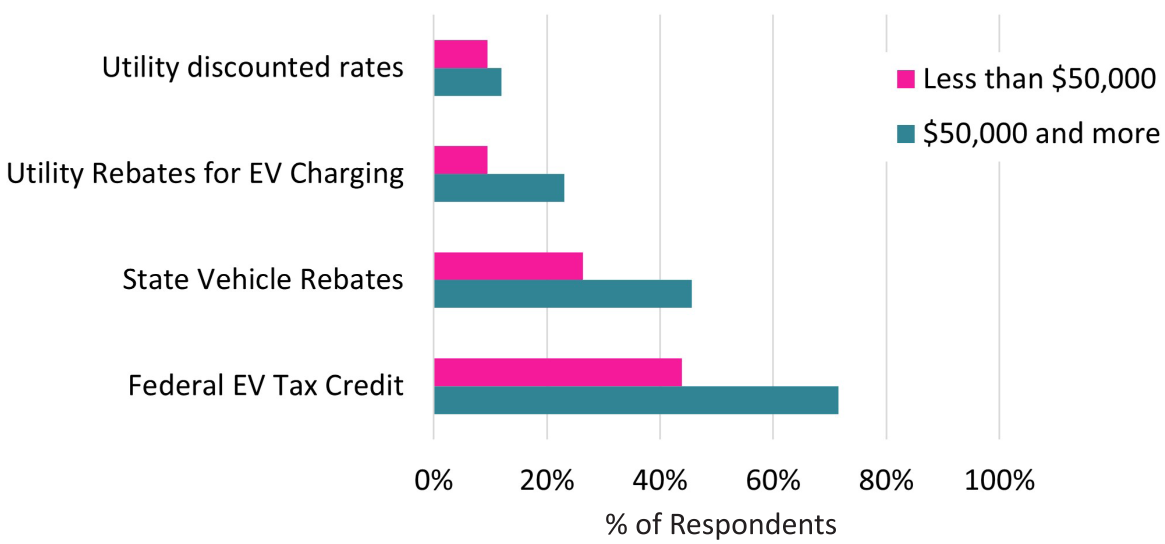


FIGURE 35: Survey Respondents' Awareness of Different EV Incentives Differentiated by Income Level



DEQ pairs financial assistance with targeted outreach through community-based organizations and dealers to address this gap.[64] At the time of this report, the program had issued over 34,000 Charge Ahead rebates, and these vehicles are now operating in low-income areas. Drivers share their experiences and knowledge with others in their communities and have a strong influence on the decisions of friends, neighbors, and co-workers to purchase an EV.[129] The groundwork DEQ has laid in the last few years through community engagement will foster more awareness in low-income communities about the state rebate and EVs in general.

Awareness of Electric Vehicle Benefits

Electric vehicles provide a number of benefits for drivers, communities, and the environment. In the EV survey, respondents were asked to share their awareness of five of the most commonly referenced benefits. Most survey respondents indicated they were aware of the "zero/low exhaust emissions" and "quiet operation," and 77 percent indicated they were aware of an EV's high fuel efficiency. In a 2024 national survey of existing EV owners, environmental benefits were a primary motivator to purchase their EV.[130]

FIGURE 36: Survey Respondents' Awareness of Different Benefits of Electric Vehicles

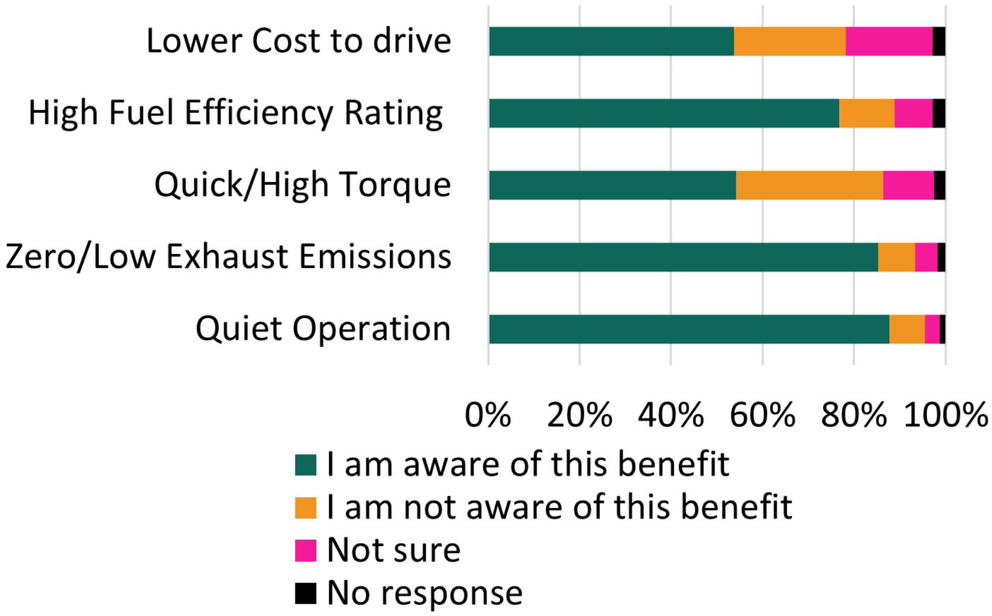
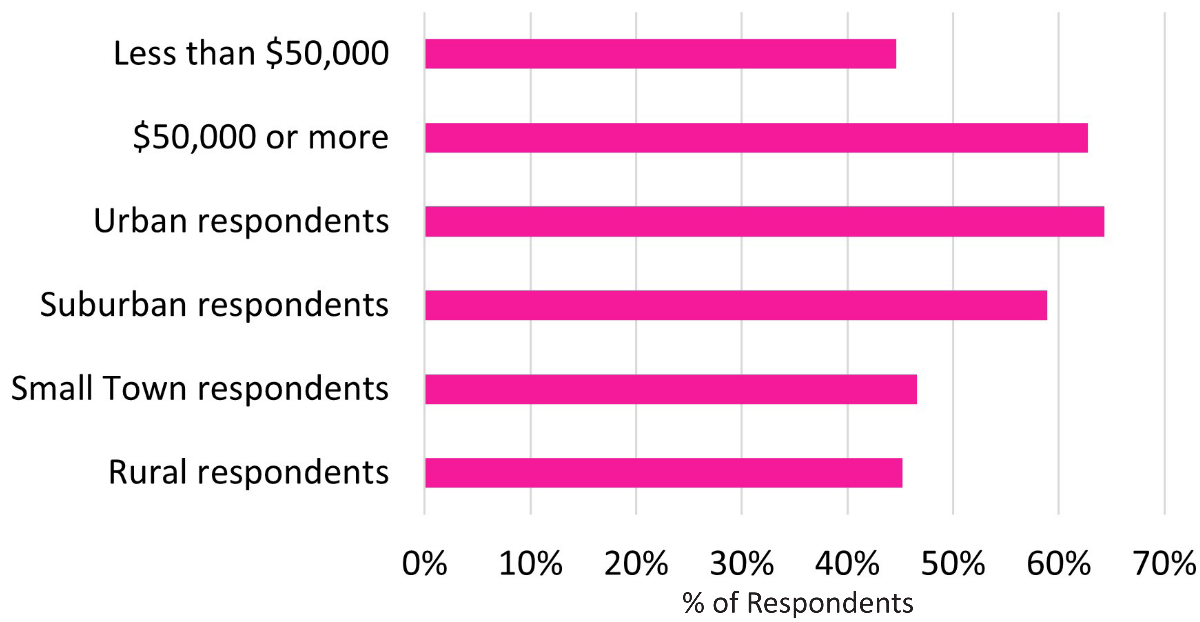


FIGURE 37: Awareness of Low Driving Costs of EVs by Demographic Group



Awareness of the "low cost to drive" an EV ranked the lowest in the survey results, followed closely by "Quick/High Torque." While still recognized by more than half of respondents, these findings indicate a significant information gap. A 2024 national survey conducted by Pew Research Center found that 28 percent of respondents indicated EVs cost more to fuel than gas vehicles, 31 percent indicating costs were about the same, and 36 percent indicated EVs cost less.[131] Since EVs are generally cheaper to fuel than gasoline vehicles, no matter where you charge in the U.S., this likely reflects a gap in consistent and accurate information, leading some drivers to overestimate the cost of driving an EV.[132]

The lower cost of owning an EV can reduce energy costs for Oregon drivers and could be particularly beneficial for low-income drivers. Low-income households in Oregon spend four times as much on energy costs as non-low-income households.[133] Driving an EV in Oregon can reduce transportation fuel costs to 50-75 percent compared to fueling a comparable gas vehicle.[134,135] However, survey results indicate that just 45 percent of respondents making less than $50,000 were aware of the lower costs of driving an EV.

Indications of Future EV Adoption Patterns

Oregon has very ambitious zero-emission vehicle adoption goals and meeting them is a cornerstone of Oregon's efforts to reduce greenhouse gas emissions. While the state is behind on achieving the 2025 goal of 250,000 ZEVs, as described earlier, Oregon may be on track to meet the percentage sales goals in 2030 and 2035. Although not a forecast of expected adoption rates, the following survey analysis sheds some light on how many Oregonians are considering an EV for their next vehicle purchase.

About a third (33 percent) of all respondents indicated they plan to or are considering buying an EV for their next vehicle. In 2024, Oregonians bought about 136,000 new internal combustion engine vehicles, which would translate to about 45,000 new EVs purchased if a third of car buyers chose an electric option. ZEV purchases are likely to be higher in Q3 2025 as prospective buyers rush to meet the deadline before the federal EV tax credit ends in September 2025. However, 45,000 is about twice as many vehicles as were sold in Oregon in 2024. Thirty-two percent of respondents were either unsure or might consider purchasing an EV, and 32 percent indicated they would not buy an EV.

Survey data show that some existing trends are likely to perpetuate in the future. The highest number of survey respondents who definitely would or are considering purchasing an EV for their next vehicle were those in urban areas and those making more than $50,000 annually.

FIGURE 38: Survey Responses to "Would You Consider an EV as Your Next Car?"

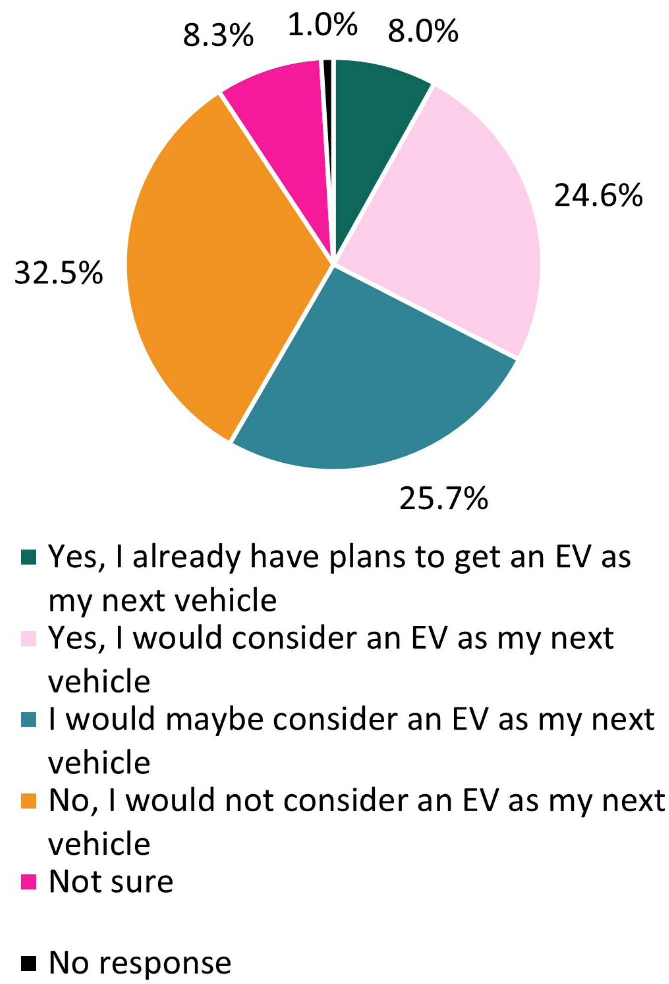
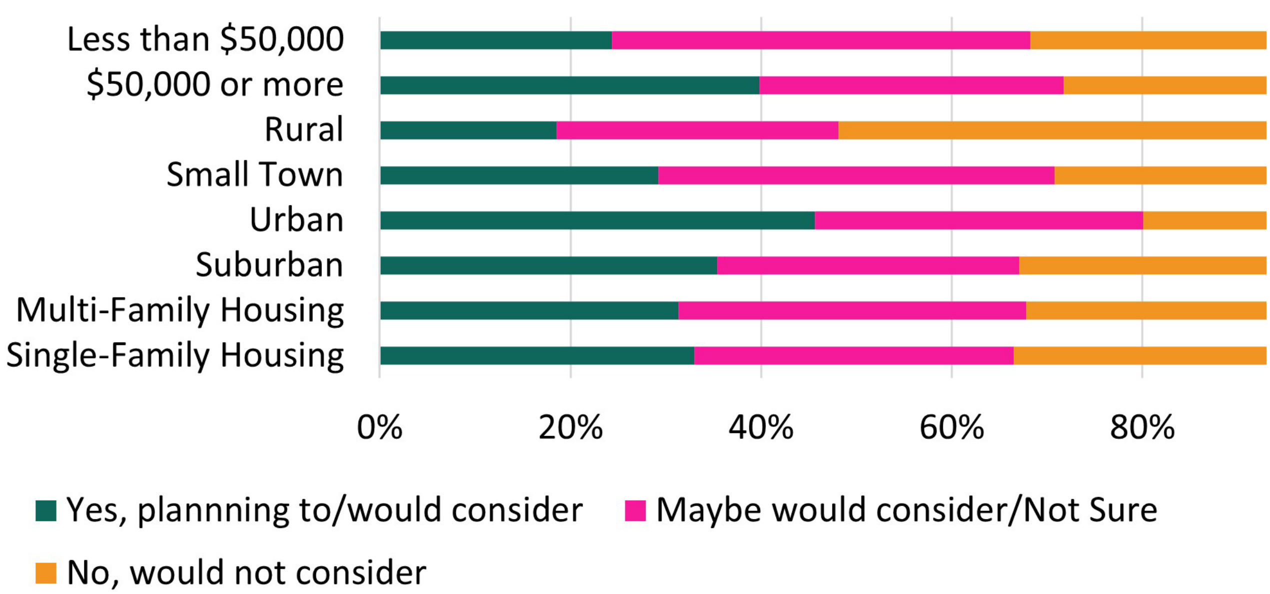


FIGURE 39: Survey Responses to: "Would You Consider an EV as Your Next Car?" Differentiated by Income Level, Geographic Area, and Housing Type



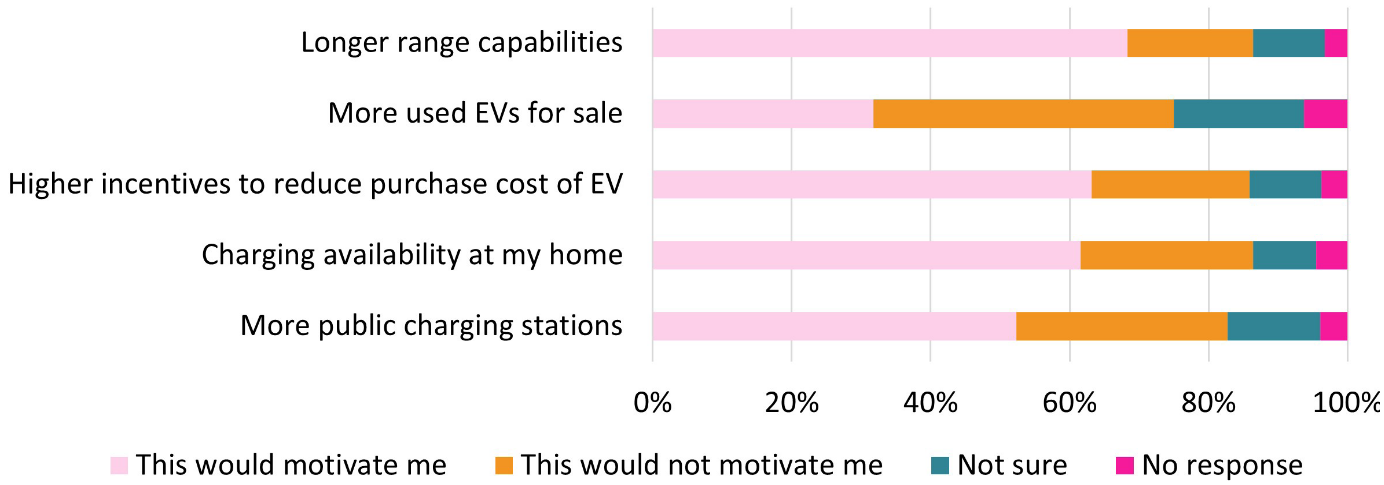


FIGURE 40: Survey Responses to Different Suggested Motivators to Encourage EV Adoption

Fifty-one percent of rural respondents indicated they would not consider an EV as their next vehicle, and less than 20 percent are planning to or would consider an EV.

Some trends appear to be changing. There was little difference across responses for those in single-family and multi-family housing, which may indicate that concerns about charging are declining for multi-family housing residents. In addition, while those making $50,000 or more per year had a higher proportion of those intending to or are considering buying an EV, when including those who might consider or aren't sure about their next purchase, the results are nearly the same. This indicates that lower income respondents don't consider an EV completely out of reach.

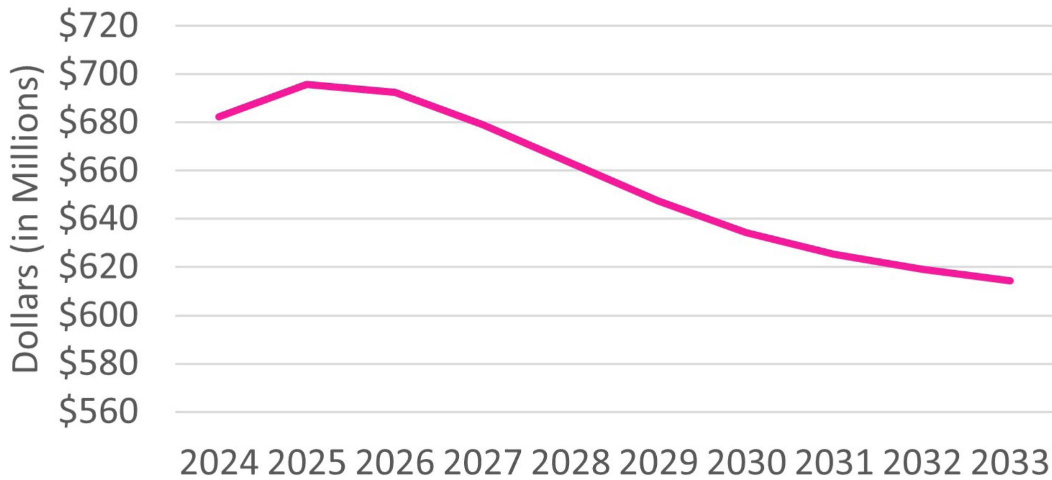
Longer range capabilities was the top motivator across all demographic groups. According to a 2023 survey by Recurrent Auto, drivers have more anxiety about range for long trips than daily use.[136] Drivers may need to see more visible charging along travel corridors, and although the Tesla charger network is now becoming available to most new EVs, non-EV drivers may not realize that those chargers would be available to them. Interestingly, more used EVs was the least motivating factor among all demographic groups.

EFFECTS OF ZERO-EMISSION VEHICLE ADOPTION ON THE STATE HIGHWAY FUND

The expansion of more fuel efficient andzero-emission vehicles, as well as record inflation, are creating a funding gap for how Oregon pays for maintaining roads and bridges.[137] Revenues deposited into the State Highway Fund from state fuel taxes, heavy truck weight-mile taxes, and driver and motor vehicle fees serve as the primary source of funding for state and local transportation operations and maintenance.[138] Fuel taxes are a proxy for how much drivers use Oregon roads — the more a person drives, the more fuel they need to purchase, and the more they contribute to maintaining Oregon roads through the fuel taxes they pay. Taxes on gasoline comprised 85 percent of the motor fuels tax in 2024.[139]

The primary reasons for the anticipated decline in revenues over time are improved fuel efficiency for internal combustion engine vehicles coupled with the growing number of electric vehicles.[137] Fuel efficiency gains are driven largely by federal standards, with the National Highway Traffic Safety Administration setting Corporate Average Fuel Economy, or CAFE standards, and the Environmental Protection Agency setting greenhouse gas emissions standards

FIGURE 41: Forecast of State Highway Fund Revenues from Motor Fuels[142]



under the Clean Air Act.[xviii,140] In the last five years the average fuel efficiency for non-battery electric light-duty vehicles in Oregon increased from 22 miles per gallon to nearly 25 mpg on average.[3] With higher fuel efficiency comes reduced need to purchase fuel (and associated taxes). Battery electric vehicles have an even greater effect on revenues, because they do not use gas. In its April 2025 Transportation Revenue Forecast, ODOT found that "[m]otor fuels will continue to decline as the combined effect of increasing number of electric vehicle registrations and improvements to the internal combustion engine fuel efficiency outweighs any positive economic growth."[141]

In 2017, the Oregon Legislature included a tiered registration fee structure for internal combustion engine vehicles and a new registration fee for battery electric vehicles to help address the gap in transportation revenues. ODOT estimates that the average Oregon driver spends about $320 every two years in gas taxes, and with the 2017 bill fee structure battery electric drivers currently pay a $190 additional registration fee.[xix,143,144] In this structure, more fuel efficient vehicles, including plug-in hybrid EVs, pay a higher registration fee and battery electric vehicles pay the highest.

While the increase in registration fees helps address some of the shortfall, it also creates some potentially negative outcomes. The fee adds to the upfront cost of an EV and can be a burden, especially for low- and moderate-income drivers, because EV drivers must pay their road usage costs in a single lump sum, rather than spreading it out over the course of two years during fuel purchases. In addition, a single, one-time fee removes a price signal to encourage less driving because people who drive more than the statewide average are essentially using the roads without contributing their share to maintain them.

In order to address the shortfall, ODOT has proposed a diversity of funding mechanisms that would support more sustainable funding streams, including a per mile road usage charge. ODOT's OReGO program was the first per mile road usage charge program in the country, and collects a two cents per mile charge in lieu of paying the state gas tax.[145,146] Eligible vehicle owners can reduce their registration fee when they opt in to the program, reducing the up-front cost burden and ensuring drivers pay for the miles they drive. The cost per mile is slightly more than the average internal combustion engine car pays in Oregon in gas taxes ($0.019 vs $0.016 per mile[xxi]), but the registration fee is $115 less.

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xix All light-duty vehicles pay a $126 standard registration fee. The $190 represents the additional registration fee battery electric vehicle owners must pay.
xxi This assumes a fuel efficiency of 25 miles per gallon.

As of the the writing of this report, Governor Tina Kotek had convened a special legislative session on Aug. 29, 2025, to address Oregon's growing transportation funding shortfall, which threatens ODOT staffing levels and urgent infrastructure needs.[147] As part of the package, lawmakers proposed a six cent gas tax increase and higher vehicle registration and title fees, including additional fees for highly fuel efficient gas and zero-emission vehicles. It also included mandatory enrollment in the OReGO road usage charge program for all electric, plug-in hybrid, and standard hybrid vehicles.[147]

A road usage charge is an important step toward a sustainable and equitable transportation funding system because it bases fees on how much people drive, rather than what fuel they consume. However, under the proposed bill, electric and hybrid electric vehicles will almost always pay more in taxes and fees than comparable gas vehicles, creating a disincentive for ZEV adoption. Zero-emission vehicles play a critical role in achieving Oregon's climate and clean energy goals. A road usage charge that distributes costs across all vehicle types would both support the resources needed to maintain Oregon roadways and better align funding policy with the state's commitment to expanding zero-emission vehicle adoption.

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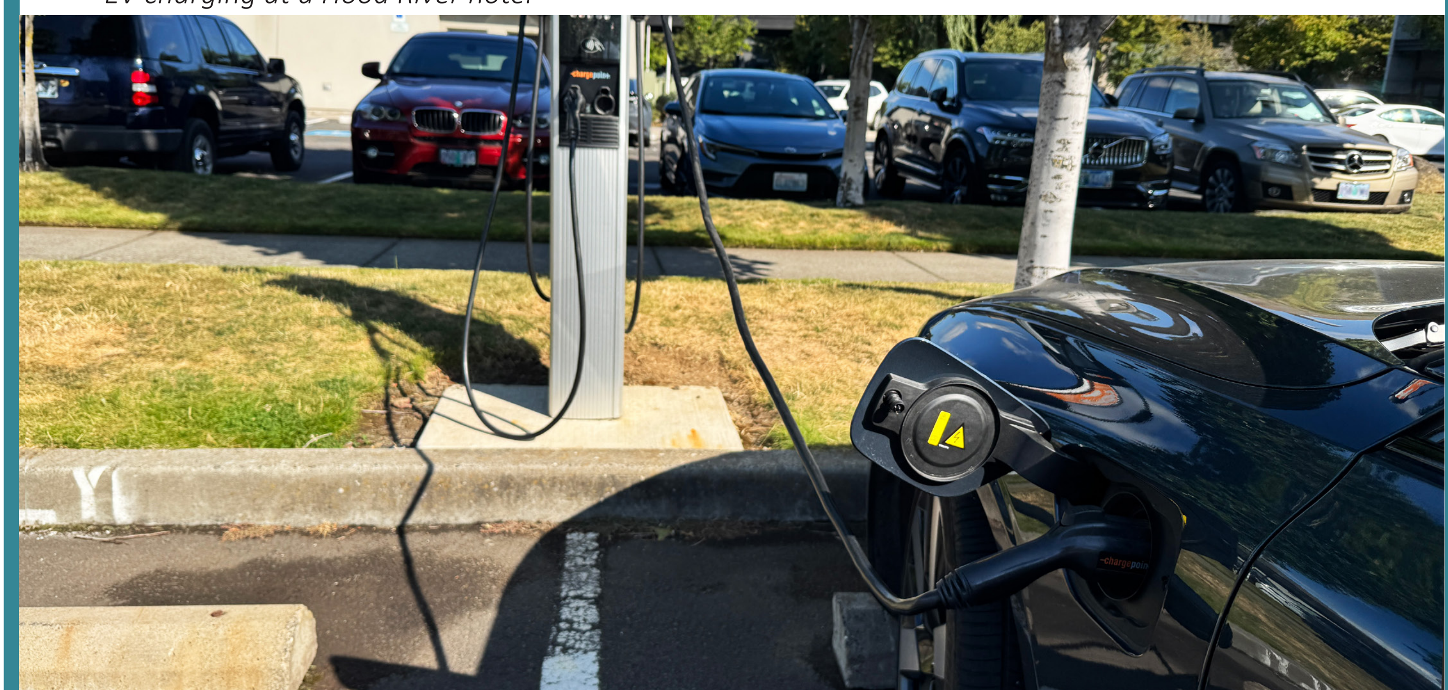
AVAILABILITY AND RELIABILITY OF ELECTRIC VEHICLE CHARGING

KEY TAKEAWAYS

- Charging infrastructure in Oregon continues to expand, but growth has slowed relative to the national pace and risks slowing further amid diminishing federal support – highlighting the need for expanded state leadership.
- Public fast charging is critical for widespread EV adoption and equitable access, serving as an important solution for long-distance travel, drivers without home charging, and commercial or ride-hailing fleets
- While public charging reliability is beginning to show improvement, with recent surveys indicating growing user confidence, charger malfunctions remain the most reported issue among EV drivers. The introduction of the National Electric Vehicle Infrastructure program standards is driving a shift in the industry toward greater accountability, improved performance, and more consistent user experiences.
- Emerging technologies – such as J3400, Universal Plug & Charge, and the Megawatt Charging System – are poised to improve and simplify the EV charging experience, making it faster, more seamless, and more accessible for light, medium, and heavy-duty vehicles.

EV charging at a Hood River hotel



INTRODUCTION

As electric vehicle adoption accelerates, the availability and reliability of public charging infrastructure have emerged as significant challenges for both drivers and policymakers. Although the number of charging stations is growing rapidly – particularly in Oregon and other leading states – reliability issues and accessibility gaps continue to hinder the full potential of transportation electrification. This section offers a detailed overview of charging infrastructure growth, regional disparities, evolving technology standards, and the policy environment affecting both passenger and heavy-duty vehicle charging. It also highlights the efforts by Oregon and federal agencies to enhance the EV charging experience through investments, regulations, and public-private coordination.

CURRENT STATE OF CHARGING STATION AVAILABILITY

Electric vehicle charging infrastructure in the United States continues to expand at a rapid pace. Since the release of the 2023 Biennial Zero Emission Vehicle Report, the number of public Level 2 and fast-charging ports nationwide has grown by 48 percent, reaching 210,459 ports as of June 2025.[1] While Oregon has long been a national leader in EV infrastructure, consistently outpacing the national average, growth in the state has tapered slightly in recent years. Since the 2023 edition of this report, the number of public Level 2 and fast-charging ports in Oregon

Charging Type Definitions

TABLE 1: Characteristics of Different EV Charger Types by Power Level[3]

Charger Type	Input Voltage	Output Power Level	Typical Light-duty Vehicle Charging Time	Use Cases
Level 1	110 or 120V	1 to 2 kW	up to 12+ hours	Residences and limited workplaces
Level 2	208, 220, or 240V	3 to 19 kW	6 to 8 hours	Residential, commercial, workplace, fleets
DC Fast Charger	480 to 1000V	20 to 350 kW	20-45 minutes	Highway refueling stops, recreational areas, shopping centers, fleets

EV chargers in the United States are categorized into three distinct types based on their output power levels – Level 1, Level 2, and Direct Current Fast Chargers.[3]

Level 1

Level 1 charging is as simple as plugging an EV into a standard household wall outlet. It's the least expensive type of EV charging, but also the slowest, offering just 1-2 kW of power.

Level 2

Level 2 charging is more complicated and expensive to install than Level 1, but offers a faster charging speed, with power output levels from 3 to 19 kW. This is the type of charger most likely installed at homes or public locations where vehicles will be parked for longer periods.

Direct Current Fast Charger (sometimes referred to as Level 3)

Direct current fast chargers, also known as DCFC, provides the fastest charging, at 20 to 350 kW of power for light-duty vehicles. DCFC are the most complicated and expensive to install, often requiring electric service upgrades.

increased by 45.5 percent (from 2,636 to 3,836 ports) a strong gain, though slightly below the national average for the same period.[2]

The following sections break down the growth of public EV charging ports in Oregon by charging type, power level, connector, and region.

By Charging Type

Level 2 charging ports make up most public chargers in both the U.S. and in Oregon. Level 2 ports are well-suited for locations where vehicles are parked for extended periods, including at homes, workplaces, or longer-duration stops like shopping centers, hotels, or public parking lots. Because they are significantly less expensive to install than direct current fast chargers and are less likely to require significant distribution system upgrades, Level 2 ports can be deployed more widely, especially in multi-family housing, rural communities, fleet depots, and small businesses where fast charging is often impractical. Level 2 ports are not a replacement for DC fast charging but rather complement them by filling in the gaps where fast charging is not needed or is not practical.

Since 2023, DC fast charging ports have grown at a faster rate than Level 2 charging ports in Oregon (see Table 2). Public DC fast charging ports grew by 53 percent[5] since March 2023, representing an additional 382 ports. Public Level 2 ports grew by 42.5 percent, representing an additional 818 ports.

While Level 2 chargers form the foundation for everyday EV charging, a robust and accessible network of DC fast chargers is essential for driving EV adoption.[4] This is true for several reasons:

- **It reduces range anxiety:** Fast chargers can add a significant amount of range in a relatively short time (100-200 miles in 30 minutes, depending on the characteristics of the charger and the vehicle), making electric vehicles more viable for long-distance travel. This eases a major concern for prospective EV drivers: fear of being stranded without power.
- **It supports transportation equity by ensuring EVs are an option for a more diverse population:** Many people – especially those in multi-family housing, rental homes, or without dedicated parking – do not have access to or cannot install at-home charging. Public fast charging provides essential access to convenient charging, ensuring all communities can participate in the EV transition.
- **It enables fleet electrification:** Many commercial fleets operate long hours and need to recharge quickly. Fast charging supports high-mileage vehicles that can't afford long downtimes.
- **It accelerates market confidence:** Visible, accessible fast chargers help normalize EV use and signal to consumers that infrastructure is ready. It makes EV ownership feel practical and supported, reinforcing broader consumer confidence.

TABLE 2: Percent Increase in Level 2 and DCFC Ports in Oregon Between 2023 and 2025[2]

Type of Charging Port	2023	2025	Percent Increase
Level 2 Ports	1,922	2,740	42%
DC Fast Charger Ports	714	1,096	53.5%

By Power Level

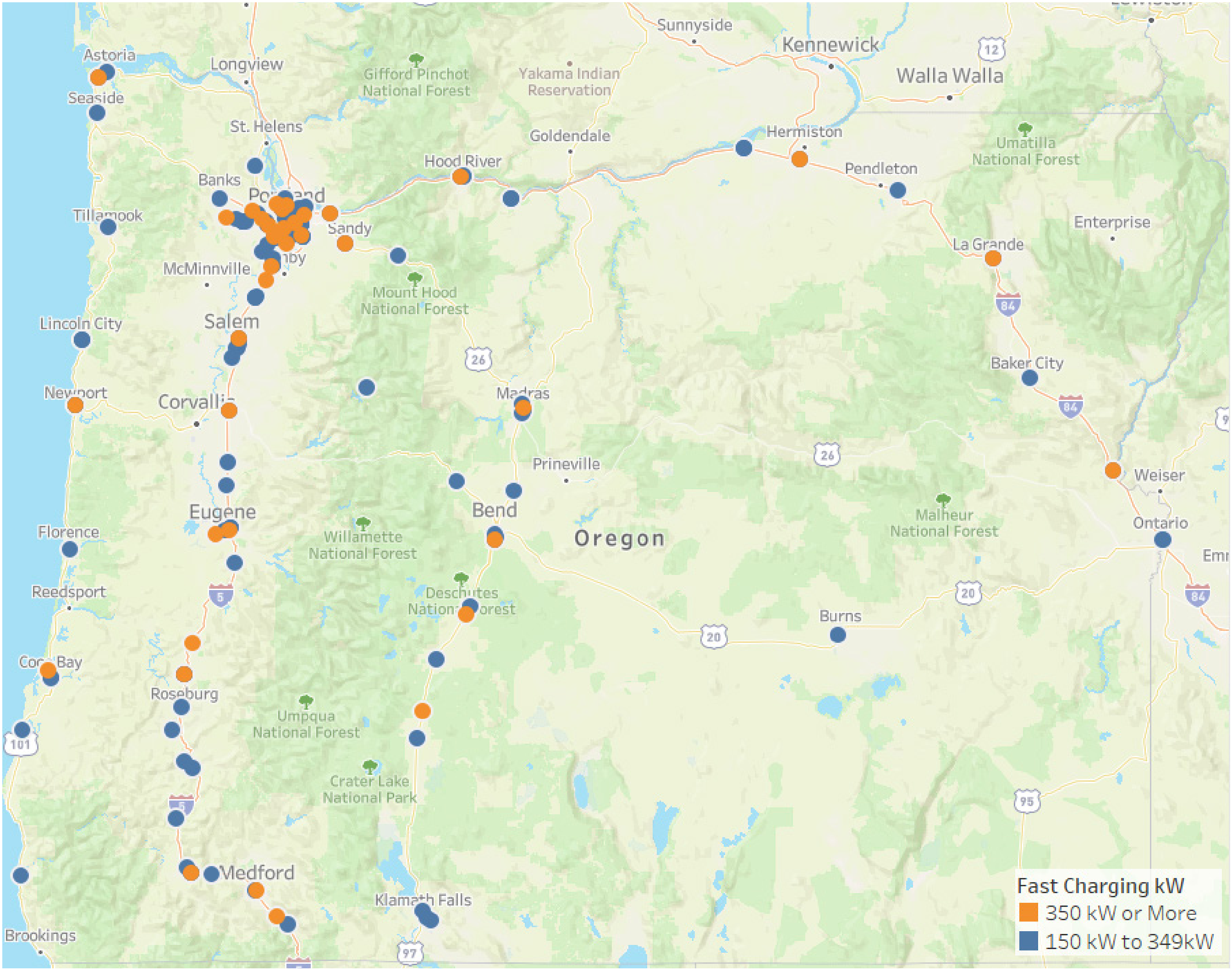
Fast charging stations designed for light-duty vehicles typically deliver between 50 kilowatts and 350 kW of power. While 50 kW was once the standard, Oregon is now seeing a shift toward higher-powered installations, with a growing share of new fast chargers rated at 150 kW or above. According to the Alternative Fuels Data Center, there are 37 locations across Oregon equipped with at least one 350 kW ultra-fast charging port.[5] Statewide, 32 stations have at least one charging port rated above 150 kW, which equates to 42 percent of all fast-charging stations in Oregon[6] (see Figure 1).

By Type of Connector

There are currently three types of connectors used by DC fast chargers: CCS1, J3400 (formerly known as the Tesla North American Charging Standard), and CHAdeMO. As noted in previous reports, not all EVs are compatible with every connector type. Most non-Tesla EVs on the road today use the CCS1 connector, while CHAdeMO is limited to certain Nissan and Mitsubishi models. Until recently, only Tesla vehicles could use the J3400 connector. In 2022, however, Tesla opened its charging network and proprietary connector to other manufacturers and charging station providers, which triggered a wave of commitments

[i] *See Page 111 of ODOE's 2021 BiZEV for more explanation on the standard charging connector types.*

FIGURE 1: Fast Charging Locations in Oregon with One or More 150 kW Ports[5]



from most major automakers to adopt the J3400 connector for their North American EVs beginning with the 2025 model year. Mitsubishi remains the only legacy automaker that has not announced plans to adopt J3400.[7]

The adoption of the J3400 charging standard by major automakers marks a significant step toward unifying the EV industry around a common fast-charging interface. However, the transition presents a challenge for the many electric vehicles already on the road that use the CCS1 connector. For these vehicles, an adapter is required to access J3400 fast-charging stations. Adapters offer a cost-effective solution to enhance the use of existing charging infrastructure, promote interoperability between charging technologies, and ensure that both legacy and new EVs can access public charging networks.[8]

However, many adapters currently available were developed before formal safety standards were created and may pose serious risks, including electric shock, arc flash, fire, or damage to the vehicle's battery.[9] To address these concerns, Underwriters Laboratories

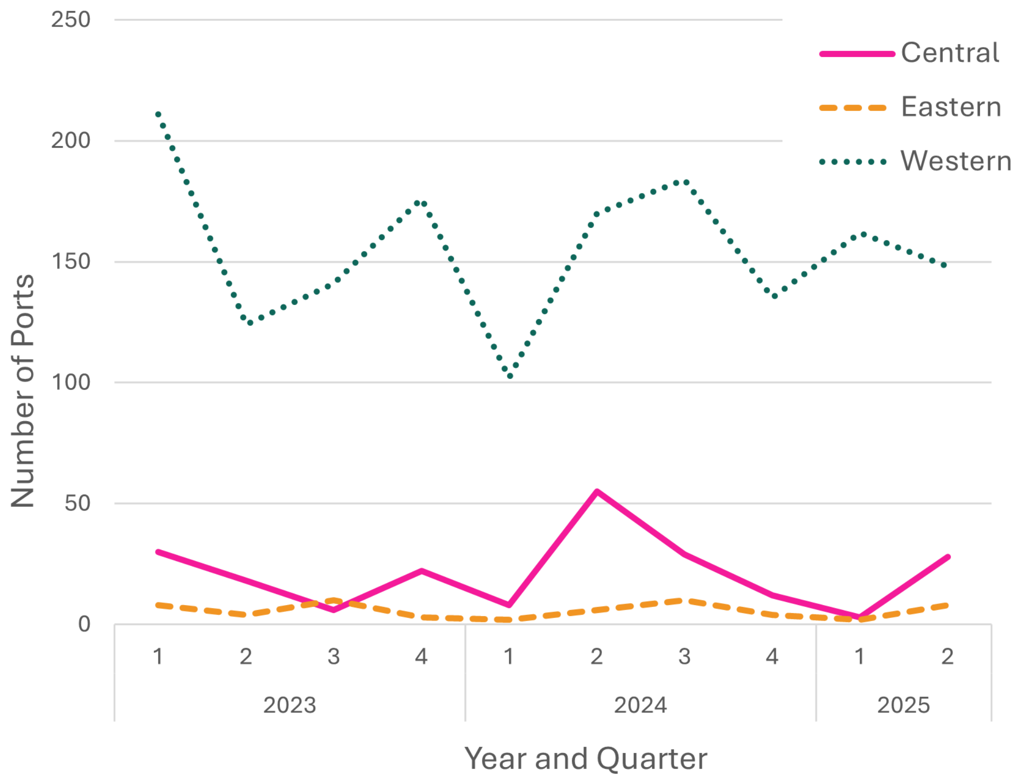
TABLE 3: Number of EV Charging Station Locations in Oregon by DCFC Connector[2]

DC Fast Charger Connector Type	Station Locations in Oregon
CCS	251
CHAdeMO	185
J3400	57

developed UL 2252, a new safety standard specifically for high-power DC charging adapters.[10] It sets rigorous requirements for the design, construction, and safety testing of these adapters. A UL-listed adapter has been independently tested and certified to meet industry standards for high-voltage DC power transfer, making it a necessary safeguard for reducing the risk of injury, equipment failure, or vehicle damage.

Tesla is widely recognized for operating the most expansive and reliable EV charging network, as indicated by its consistent ranking as the top performing network in public charging surveys.[11,12]

FIGURE 2: Level 2 and DCFC EV Charging Ports Installed in Oregon by Region (2023-2025)[2]



The expansion of access to Tesla stations for non-Tesla drivers is a significant step toward improving the overall availability and reliability of public EV charging in Oregon.

By Region

Public charging in Oregon is expanding most rapidly in Western Oregon, as shown in Figure 2. Since April 2023, 85 percent of new charging station installations have occurred in the Western region, compared to 11.5 percent in Central Oregon and just 3 percent in Eastern Oregon.

Rural EV drivers face distinct challenges compared to their urban and suburban counterparts. They often travel longer distances to access work, healthcare, and essential services, yet public charging infrastructure in rural areas is much sparser. Longer gaps between chargers means a greater risk of being stranded if a station is broken or in use, with few or no nearby alternatives. Bridging these infrastructure gaps is essential to ensuring equitable access to EVs and achieving widespread adoption across the state.

The Oregon Department of Transportation's 2021 Transportation Electrification Infrastructure Needs Analysis highlighted the vital role of public funding in supporting EV infrastructure, particularly in areas that are unlikely to attract private investment due to lower population density, longer return on investment timelines, or limited existing infrastructure.[13] In response, Oregon has prioritized investments in rural and under-served regions through publicly funded EV infrastructure programs. For example, ODOT's Community Charging Rebates program reserves 70 percent of its funds for rural or disadvantaged communities and has expanded outreach in Central and Eastern Oregon to boost program participation.[14] These efforts demonstrate how public investment can fill critical gaps left by the private market to ensure all communities can benefit from the transition to clean transportation.

CHARGING INFRASTRUCTURE FOR HEAVY-DUTY VEHICLES

The 2023 edition of this report highlighted the importance of meeting the operational needs of medium- and heavy-duty battery electric vehicles, which will require a combination of private depot and public charging infrastructure. Private depot charging is best suited for fleets with extended periods of downtime or that return to a centralized base each night. Public charging – including both opportunity charging during short stops and en-route charging along longer routes – will be essential for fleets with limited downtime or operating over longer distances.[ii]

Most of the charging infrastructure installed to date for medium- and heavy-duty vehicles in Oregon has been private depot charging. Private depot stations are not typically reported on the Alternative Fuels Data Center, the central repository for alternative fueling stations in the U.S., so it is difficult to assess the extent of deployment in Oregon.

[ii] *See Table 6 (Page 164) in the 2023 Biennial Zero Emission Vehicle Report for more information on the categories of MHD EV charging infrastructure.*

A 2022 event at Electric Island with former U.S. Department of Energy Secretary Jennifer Granholm

Some information can be gleaned by looking at the grant awards for various state and federal funding programs, discussed in detail later in this chapter.

There is currently just one publicly accessible EV charging station in Oregon specifically designed for heavy-duty vehicles: Electric Island in Portland. A partnership of Portland General Electric and Daimler Trucks North America, Electric Island debuted in 2021 as the first U.S. charging site designed for medium and heavy-duty electric commercial vehicles. While it initially launched with eight 150 kW charging ports, the site was designed to support up to 5 megawatts of charging capacity and now has 15 fast-charging ports at this location.[15] PGE has announced plans to incorporate megawatt chargers once they are commercially available.

THE MEGAWATT CHARGING SYSTEM (MCS)

The Megawatt Charging System is a new, ultra-powerful charging standard developed through the global alliance Charging Interface Initiative, or CharIN, specifically for electric trucks, buses, and other large commercial vehicles. It's designed to deliver up to 10 times more power than today's fastest car chargers (up to 3.75 MW), which is enough to fully charge a semi-truck during a driver's legally required rest break.[16] MCS is widely viewed as a significant enabler of widespread adoption of battery electric vehicles in the commercial fleet market due to its significantly increased charging speed and improved communication systems.

A Brief History of MCS

2018-2019: As heavy-duty electric trucks enter development, manufacturers realize existing chargers aren't powerful enough. A group of automakers, charging companies, utilities, and grid experts begin working together through CharIN to design a new system.

2020-2021: Engineers create the first prototype designs for a new megawatt scale connector and begin testing at the U.S. National Renewable Energy Laboratory to ensure safety, durability, and fast communication between vehicles and chargers.[17]

2021: The MCS connector is officially adopted, capable of delivering up to 1.2 MW of power. That's enough power to charge a heavy-duty EV in under 45 minutes.

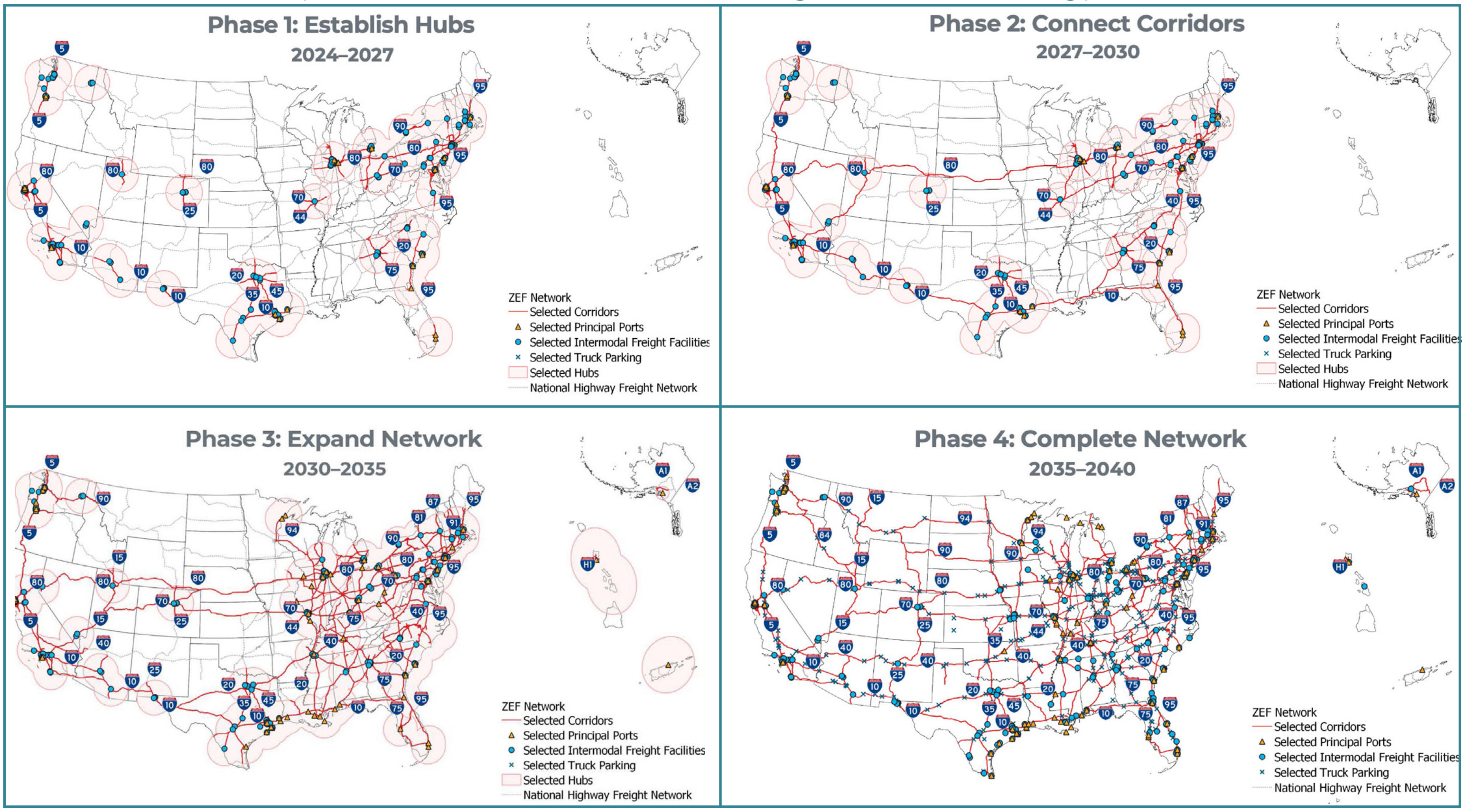
2022: Charging companies and truck manufacturers start real-world pilot projects, testing the system at logistics hubs in Europe and the U.S. In Portland, an Electric Island interoperability testing event attracts nearly 300 attendees.[16] Initial testing begins of prototype connectors capable of delivering up to 3.75 MW of power.

2023: The IEA and U.S./E.U. authorities formally acknowledge MCS in their Global EV Outlook, endorsing harmonization between regions and recognizing the adoption of MCS by international standards organizations such as SAE International and the International Organization for Standardization (ISO).[18]

2025: In March 2025, SAE International publishes J3271, the first system-level U.S. standard for MCS, covering hardware, communication, control systems, and grid interfaces.[19] International Electrotechnical Commission, or IEC, standards are expected later in 2025.

2025-2027: Commercial electric trucks with MCS ports are expected to begin hitting the market.

FIGURE 3: Phased Implementation of National ZEV Freight Corridor Strategy[20]



The National ZEV Emission Freight Corridor Strategy

In March 2024, the federal Joint Office of Energy and Transportation released its National Zero Emission Vehicle Freight Corridor Strategy, a blueprint for building a nationwide network of charging and hydrogen fueling stations to accelerate the adoption of medium- and heavy-duty ZEVs. The strategy lays out a phased roadmap to electrify freight transport by prioritizing infrastructure deployment in regions with the greatest immediate need and market readiness, then expanding access to areas likely to follow.

The strategy aims to align investments, planning, utility upgrades, and deployment by sequencing infrastructure buildout where freight activity, technology adoption, and enabling policies are strongest.

It incorporates several key criteria to guide this phased approach:[20]

- Freight corridors with the highest volume on the National Highway Freight Network.
- Regions with the largest ports (by tonnage), intermodal facilities, and major truck service hubs.
- ZEV market forecasts where medium- and heavy-duty vehicles show favorable total cost of ownership.
- Communities that bear a disproportionate environmental burden from truck emissions.
- States with supportive ZEV policies and regulations.
- Areas engaged in commercial ZEV corridor planning through U.S. Department of Energy grants.

The strategy is organized into a four-phase implementation plan, shown in Figure 3, beginning with high-impact freight hubs and expanding to establish a national network by 2040.

While the Joint Office of Energy and Transportation has not been formally dismantled under the Trump Administration, by May 2025 it no longer had any full-time federal staff,[21] casting uncertainty over the future of its initiatives, including the implementation of the National ZEV Freight Corridor Strategy. Even if the federal government does not actively pursue the strategy, its findings, deployment criteria, and phased framework offer valuable guidance for state policymakers, planners, and industry leaders working to advance a national ZEV freight network. Using the guidance of this phased approach, Oregon would prioritize initial development along the northern I-5 corridor, gradually extend coverage to the entire I-5 corridor, expand eastward to include the western section of I-84, and complete buildout of both I-84 and I-82 by 2040.

POLICIES AND PROGRAMS ADDRESSING CHARGER AVAILABILITY

Charging infrastructure in the United States – and Oregon in particular – is expected to continue growing in the near term, driven by ongoing private sector investment and the deployment of previously awarded federal funding. Leading EV charging providers such as Tesla, Electrify America, EVgo, ChargePoint, and IONNA are actively expanding to meet rising customer demand.

- In 2024, Tesla announced a commitment to invest over $500 million in expanding its Supercharger network,[22] and by Q1 2025, it had added approximately 2,200 new supercharger stalls globally – a 17 percent year-over-year increase.[23] By Q3 2025, Tesla plans to begin rolling out 500 kW Superchargers, which will reduce charging times, particularly for vehicles like the Cybertruck.[24]
- Electrify America is pursuing similarly ambitious growth and is on track to add 1,000 new chargers in 2025 following major gains in 2024.[25,59] Its strategy includes developing larger charging hubs equipped with battery energy storage systems to better manage peak loads and site capacity.
- EVgo is scaling up and has secured several financing facilities to support its nationwide infrastructure buildout. EVgo expects to rapidly expand its network over the next five years, accelerating deployment to reach more than 15,000 fast charging stalls across the country by the end of 2029.[26]
- In December 2024, ChargePoint and General Motors announced a joint initiative to install up to 500 ultra-fast charging ports across the U.S., branded under "GM Energy."[27] The new locations are expected to be open to the public by the end of 2025.
- Lastly, IONNA, a joint venture founded by eight major global automakers[iii] to build a high-powered EV fast-charging network across North America, has announced plans to deploy at least 30,000 fast chargers by the end of 2030, including several sites in Oregon.[28]

Oregon state agencies are scaling up charging deployment primarily through federally funded programs supported by the Infrastructure Investment and Jobs Act and the Inflation Reduction Act. Much of this public investment is strategically focused on areas and market segments the private sector is less likely to serve – such as rural and disadvantaged communities or multi-family housing – to fill critical gaps in the state's charging network. The majority of Oregon's EV charging programs have relied heavily on federal funding, with minimal state investment to date. As a result, once these federal funding streams are exhausted, the long-term sustainability of these programs – and the continued expansion of charging infrastructure in Oregon – remains uncertain.

The following sections outline key policies and programs currently advancing charging infrastructure across the state.

[iii] *The eight founding members of IONNA include BMW, General Motors, Honda, Hyundai, Kia, Mercedes-Benz, Stellantis, and Toyota.*

Tesla chargers at Columbia Gorge Premium Outlets in Troutdale

Federal Policies and Programs

Federal programs supporting ZEVs and ZEV infrastructure launched under the Infrastructure Investment and Jobs Act and the Inflation Reduction Act have created historic opportunities for nationwide investment and rapid deployment. However, actual implementation has fallen short of expectations, hindered by administrative delays, infrastructure bottlenecks, and growing political uncertainty. The lack of stable policy support has disrupted the flow of federal grants and created confusion among public agencies, private developers, and other stakeholders. Clean energy industries are facing funding and personnel cuts as well as the effects of regulatory rollbacks. Recent actions have ended numerous federal policies and programs that support electric vehicle adoption.

Notable actions to remove support for EV adoption in 2025 include:

Revocation of the federal EV adoption target

In an inaugural executive order called "Unleashing American Energy," it was proclaimed policy of the United States to "eliminate the 'electric vehicle mandate' and promote true consumer choice."[29] This repealed the non-binding goal of achieving 50 percent EV sales by 2030, previously established by the Biden Administration.

Freezing of federal charging infrastructure funds

In the same executive order, federal agencies were directed to immediately pause the disbursement of funds appropriated through the IRA and IIJA, "including but not limited to funds for electric vehicle charging stations made available through the National Electric Vehicle Infrastructure Formula Program and the Charging and Fueling Infrastructure Discretionary Grant Program."[29] Disbursement of National Electric Vehicle Infrastructure program formula grants was halted, delaying hundreds of state-planned charging projects for six months. In May 2025, Oregon joined a coalition of 15 other states, the District of Columbia, and various environmental and advocacy groups in filing a lawsuit against the Trump administration over its indefinite suspension of the grants.[iv] In August 2025, the U.S. Department of Transportation issued updated program guidance to begin unfreezing these funds, paving the way for states to regain access to funding.[31]

Rescission of Clean Air Act waivers

Using the Congressional Review Act, the Administration revoked California's authority to exceed federal pollution limits and enforce the Advanced Clean Cars II, Advanced Clean Trucks, and Heavy-Duty Low-NOx programs. This action affects the dozen states that follow California's standards, including Oregon, stripping them of their authority to enforce the zero emission vehicle sales targets and heavy-duty truck emissions rules.[v] California, along with Oregon and nine other states, are litigating the revocation, citing the U.S. Government Accountability Office (a nonpartisan congressional watchdog) and the Senate parliamentarian ruling that California's air quality standards cannot legally be blocked using the Congressional Review Act.[33]

Proposed rescission of EPA's 2009 Greenhouse Gas Endangerment Finding and all GHG standards for light, medium, and heavy-duty vehicles and engines

In July 2025, the EPA formally proposed rescinding its 2009 Endangerment Finding under Section 202(a) of the Clean Air Act, which established that six greenhouse gases (including carbon dioxide and methane) pose a danger to human health and welfare, and that motor vehicle emissions contribute to this threat.[34] This finding is the legal foundation for federal GHG emissions standards and

[iv] *On June 25, 2025, a preliminary partial injunction was issued prohibiting the Trump administration from withholding roughly $1 billion in NEVI funding for 14 of these 16 states, including Oregon.*[30] *The injunction went into effect on July 1, 2025, allowing the release of NEVI funds to affected states. The court case is expected to come to trial in 2026.*

[v] *Oregon is part of a multi-state legal challenge filed by California and joined by 10 other states against the use of the CRA to invalidate California's Clean Air Act waivers.*[32] *If successful, the lawsuit would restore Oregon's legal authority to adopt those California-aligned emissions and ZEV standards under Section 177 of the Clean Air Act.*

regulations supporting EV adoption and fuel efficiency. Its removal would eliminate EPA's authority to regulate GHG emissions from light, medium, and heavy-duty vehicles, undermining current and future clean vehicle standards.

Elimination of the EV tax credit

The federal budget reconciliation bill (H.R. 1), which was signed into law on July 4, 2025, repealed the $7,500 light-duty Clean Vehicle Credit (Section 30D) as well as the $40,000 Commercial Clean Vehicle Credit (Section 45W) for purchases made after Sept. 30, 2025.

Removal of enforcement mechanisms for federal fuel economy standards in Section 40006 of H.R. 1 eliminated civil penalties for noncompliance with the Corporate Average Fuel Economy standards.[35] While the statute and its implementing mechanisms remain in place, automakers will no longer face financial consequences if they fail to meet requirements.

Rollback of federal fleet electrification policies

Directives requiring the electrification of federal agency fleets are under review or being rescinded, stalling expected demand for EVs and charging infrastructure. In March 2025, the U.S. General Services Administration suspended all new ZEV purchases for federal fleets. Further, the General Services Administration issued a directive halting all installation of new ZEV chargers on federal property. Existing chargers on federal property not deemed "mission critical" were ordered to be shut off and associated contracts canceled.[36]

Changing public messaging

The Trump Administration has repeatedly denounced EVs and clean transportation policy. This withdrawal of federal support further contributes to uncertainty for industry and consumers.[37–39]

The impact of recent federal actions on electric vehicle adoption and charging infrastructure deployment remains uncertain. Some companies appear to be scaling back or pivoting, such as BP Pulse, which announced in March 2025 that its EV charging unit will reduce annual spending to below $500 million, concentrating investments in fewer markets.[40] Despite broader industry uncertainty, most major charging providers – including Electrify America, Tesla, EVgo, ChargePoint, and IONNA – have not publicly signaled a retreat from their commitments to expand their networks.

State Policies and Programs

This section outlines Oregon's progress with current state-funded ZEV infrastructure programs. Most state programs that have already secured federal funding are expected to continue without disruption, but new federal funding opportunities are unlikely in the near term. Establishing a dedicated state revenue source to supplement federal funding would help ensure the continued impact and long-term sustainability of these programs.

Community Charging Rebates Program

The Oregon Department of Transportation's Community Charging Rebates program is a statewide initiative aimed at expanding access to charging infrastructure in Oregon communities to encourage more widespread EV adoption. The program offers rebates of up to $5,500 per port to support the installation of qualified Level 1 and Level 2 chargers at strategic locations, including public parking areas, workplaces, and multi-family housing complexes. Seventy percent of funds are reserved for projects located in disadvantaged and rural communities.

TABLE 4: ODOT Community Charging Rebates Round Awardees[vi]

Round	Funding Awarded	Public Sites	Public Ports	Multi-Family Housing Sites	Multi-Family Housing Ports	Workplace Sites	Workplace Ports
1	$1,048,936	36	127	24	114	-	-
2	$1,629,849	34	116	24	138	18	87
3	$3,373,500	53	258	36	294	23	118
Total	**$6,052,285**	**123**	**501**	**84**	**546**	**41**	**205**

[vi] *Data retrieved from ODOT as of June 2025.*

Since its inception in June 2023, ODOT has launched three rounds of this program, funding the installation of 1,252 charging ports at 248 locations (see Table 4). Round 3 included just over $4 million in funding and closed in June 2025. ODOT anticipates launching another round of funding in September 2025.

ODOT's next round of the program will be funded with federal dollars through a competitive grant award from the Environmental Protection Agency's Climate Pollution Reduction Grant program. Of the total $197 million awarded to Oregon under this grant for its Climate Equity and Resilience Through Action program, ODOT will receive $10.9 million to be used for rebates to support Level 2 and DC fast charging stations within Low-Income and Disadvantaged Communities.[41]

National Electric Vehicle Infrastructure Program

Oregon's National Electric Vehicle Infrastructure program is a federally funded initiative designed to expand the state's public EV fast-charging network along major highways. Administered by ODOT, the program aims to accelerate the adoption of electric vehicles by making public charging infrastructure more convenient, accessible, affordable, and reliable. Through NEVI, ODOT expects to receive $52 million to build out and expand Oregon's fast-charging network along eleven highways designated as "EV corridors" through the Federal Highway Administration's Alternative Fuel Corridor program.

Following a yearlong effort led by ODOT's Climate Office, including extensive outreach and engagement with partners across the state, ODOT released its inaugural Oregon National Electric Vehicle Infrastructure Plan. The plan outlines a five-year strategy for investing in EV charging infrastructure across key transportation corridors under the NEVI program. For Round 1, the agency prioritized three high-traffic corridors: Interstate 205 in the Portland Metro region, Interstate 5 from south of Eugene to the California border, and the full length of U.S. 97 (see Figure 4. In December 2024, ODOT awarded $10.3 million in grants to three private charging station companies to construct 13 new charging stations along these corridors:[42]

- Electrify America (two stations on I-205).
- EV Gateway (four stations on I-5).
- EVCS (seven stations on U.S. 97).

FIGURE 4: Oregon's Round 1 NEVI Corridors[43]

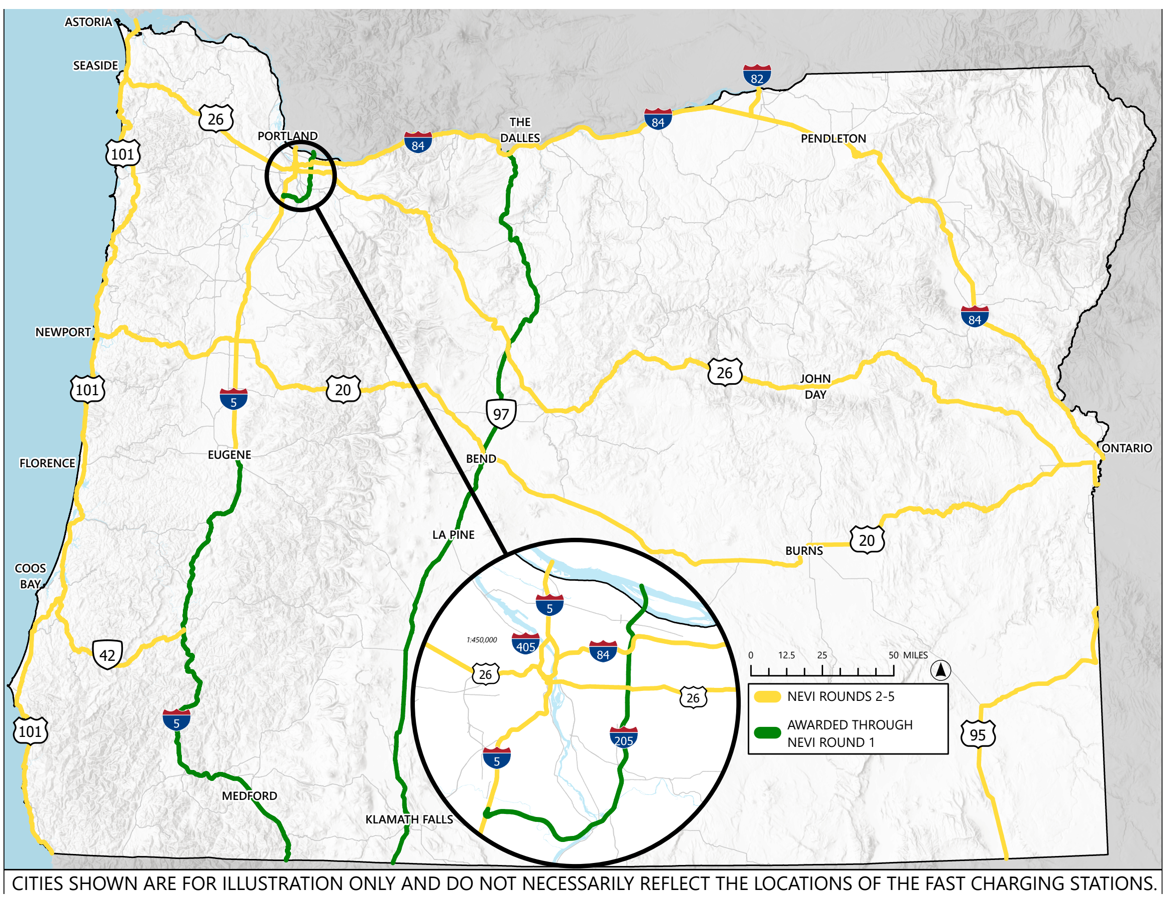


Figure courtesy of ODOT

Each station will include a minimum of four 150 kW CCS fast-charging ports, accessible parking, and convenient proximity to traveler amenities. Select sites will feature higher powered charging (up to 350 kW), pull-through charging to accommodate larger vehicles, and 110-volt outlets to serve e-bikes and other electric mobility devices. Detailed station locations and program updates are available on ODOT's NEVI webpage.

In February 2025, the federal government placed an indefinite pause on the NEVI program, with the Federal Highway Administration rescinding program rules and instructing states to suspend further EV infrastructure deployment.[44] Following a partial injunction in June 2025 in the multistate lawsuit that Oregon joined, ODOT obligated all remaining unobligated Fiscal Year 2022 to Fiscal Year 25 funds.[vii] This action brought the total obligations to $41.1 million, covering all Round 1 projects already underway and adding $30.8 million for future projects.[43,45] In August 2025, U.S. DOT issued updated program guidance requiring states to submit Fiscal Year 2026 NEVI plans. ODOT submitted its plan on Sept. 10, 2025. Pending FHWA approval, ODOT will gain access to the remaining $11.1 million in NEVI funding.

Charging and Fueling Infrastructure Program

The Charging and Fueling Infrastructure grant program is a $2.5 billion federal initiative established under the 2021 Infrastructure Investment and Jobs Act aimed at expanding publicly accessible EV charging and alternative fueling infrastructure across the United States. Unlike the NEVI program, which provides formula funding to states for fast-charging along federal interstates, CFI is a competitive grant program designed to support both community-based and corridor-based projects. It also accommodates a wider range of fuels, including hydrogen, propane, and compressed natural gas, in addition to EV charging.

Securing CFI funding is a highly competitive and resource-intensive process. As a result of extensive planning, staff effort, and strategic partnerships, Oregon has successfully secured three awards totaling $120 million.[46] These wins reflect significant coordination across agencies and stakeholders, as well as the sustained staff capacity needed to develop strong, compelling applications.

These projects include:

West Coast Truck Charging and Fueling Corridor Project ($102 million)

A partnership between the transportation departments in Oregon, California, and Washington, as well as the California Energy Commission, to deploy EV charging and hydrogen fueling stations for zero-emission medium- and heavy-duty vehicles along 2,500 miles of key freight corridors in the three states. Oregon's $21.1 million portion of the award will support the construction of two medium- and heavy-duty EV charging stations and one hydrogen fueling station along the I-5 corridor. The charging stations will have a minimum of eight ports and 2.5 MW site capacity and hydrogen fueling stations will have a minimum of two fueling nozzles and 1,000 kg hydrogen/day fueling capacity.[47]

Tualatin and Neighbors Charging Up Program ($15 million)

A collaborative effort led by the City of Tualatin and 16 neighboring cities to install approximately 1,000 publicly accessible Level 2 EV charging ports across 125 sites in Oregon's North Willamette Valley, including Portland, Beaverton, Gresham, King City, and Lake Oswego. Charging stations installed under this program will primarily serve low- and moderate-income residents who do not have access to at-home charging. Charging will be built at multi-family housing and at publicly accessible facilities such as libraries, parks, and community centers.

City of Albany's 2024 Charging and Fueling Infrastructure Project ($1.8 million)

A project that will plan, design, and construct EV charging stations at four locations in Albany.

[vii] *An "obligation of funds" is a legally binding commitment to spend federal funds, typically within a specified time. In this case, it refers to approval provided by the Federal Highway Administration for work to start and expenditures to be reimbursed.*

Photo courtesy of ODOT

On January 20, 2025, after the release of an executive order entitled "Unleashing American Energy," grant recipients received notice that all Charging and Fueling Infrastructure Program grants were on pause until further notice.[48] Any projects without executed grant agreements or those with unobligated funds are indefinitely paused, whereas any funds obligated prior to this date may be spent. As of the publishing of this report, ODOT has obligated $3.1 million of its CFI award and is moving forward with project planning. The Cities of Albany and Tualatin were unable to execute grant agreements prior to the funding pause, and their programs are currently on hold.

Carbon Reduction Program

Oregon's Carbon Reduction Program, administered by ODOT, is a federally funded initiative established under the 2021 Infrastructure Investment and Jobs Act. Oregon received $82 million to support projects that reduce greenhouse gas emissions from the transportation sector. Funding is distributed across three geographic areas:[49]

- Transportation Management Areas – Oregon's three largest urban areas: Portland, Eugene, and Salem ($28.5 million)
- Small Urban and Rural Areas ($24.1 million)
- Statewide Projects ($29.8 million)

Transportation Management Area funding is administered by the respective Metropolitan Planning Organizations, while ODOT oversees project selection and administration for Small Urban, Rural, and Statewide investments. These decisions are guided by criteria developed in collaboration with Metropolitan Planning Organizations, Transportation Management Areas, and other partners.

In November 2023, after extensive outreach, coordination, and research, ODOT released its Carbon Reduction Strategy, which highlighted ongoing efforts to decarbonize transportation in Oregon and laid out a framework for allocating Carbon Reduction Strategy funding.[49] A central focus of the strategy is to promote adoption of fuel-efficient and zero-emission vehicles.

Of the $53.9 million administered by ODOT, $34.7 million has been awarded to projects that support electric vehicles and EV charging infrastructure, representing 26 of 39 projects.[49] These include:

- Procurement of zero emission transit vehicles
- ZEVs and charging infrastructure for ODOT's own fleet
- Deployment of Level 2 and fast chargers in multiple communities across the state, including direct transfer of funding to Tribes via the Bureau of Indian Affairs for more efficient project management
- Zero-emission equipment and charging for heavy-duty applications

Notably, $4.3 million was awarded to ODOT's Transportation Electrification team to install public medium- and heavy-duty charging infrastructure along the Interstate 84 corridor – the primary freight and transportation route through the Columbia River Gorge and Eastern Oregon.[49] This public charging station will feature higher output chargers as well as parking that can accommodate large trailers.

As of June 2025, 90 percent of Carbon Reduction Strategy funds have been assigned to projects. If ODOT receives additional funds via a continuing resolution, ODOT may issue another call for projects for the remainder of the funding.

Photo courtesy of ODOT

Oregon Zero Emission Fueling Infrastructure Grant Pilot Program

The Oregon Department of Environmental Quality's Zero-Emission Fueling Infrastructure Grant program, launched in 2022, aims to accelerate the transition from diesel-powered medium- and heavy-duty vehicles to zero-emission vehicles by funding the development of supporting charging and fueling infrastructure. In March 2023, DEQ awarded approximately $13.3 million to 14 projects statewide, representing a broad range of applications, including refuse fleet charging, public medium-duty charging stations, and government fleet electrification.[50]

Initially established as a one-time, $15 million pilot in 2022 through House Bills 5202 and 4139, the Zero-Emission Fueling Infrastructure Grant received an additional $3 million in federal funding through Oregon's Climate Equity and Resilience Through Action grant. This supplemental support enabled the launch of a second round of funding, extending the program's impact and further expanding Oregon's EV infrastructure. The second round of funding will provide up to 80 percent of eligible costs for the installation of DC fast chargers for private businesses, public municipalities, and Tribal fleets based in Oregon, and will continue to prioritize fleets operating in or near communities disproportionately affected by diesel pollution. The application period for Round 2 closed on Sept. 3, 2025, with award announcements anticipated in mid-October 2025.[51]

Oregon Clean Fuels Program

The Oregon Clean Fuels Program, administered by DEQ, is a market-based program designed to reduce the carbon intensity of transportation fuels used in the state. Established in 2016, the Oregon Clean Fuels Program incentivizes the production and use of cleaner fuels, helping to reduce Oregon's reliance on petroleum-based fuels and cut greenhouse gas emissions from the transportation sector. The program operates through a credit-and-deficit system. Fuel providers that supply fuels with carbon intensity values below the annual benchmark generate credits, while those with fuels that exceed the benchmark incur deficits. The credits can be bought, sold, or banked, creating a flexible, market-driven framework that encourages investment in cleaner fuel technologies.

The Clean Fuels Program actively supports transportation electrification by allowing EV charging station operators to participate in the credit market. This creates an additional revenue stream that helps offset the cost of installing and operating EV charging equipment and spurs further transportation electrification, as revenue from credit sales is often reinvested into additional EVs and chargers. For example, electric utilities are eligible to generate credits from EV charging at the residences of their customers. The credits are sold and used to fund utility transportation electrification programs that install chargers, provide grants to businesses to convert their fleets, or conduct education and awareness programs. Each utility is required to submit an annual report summarizing how revenue from the sale of their credits was spent. These reports can be found on the Clean Fuels Program webpage. Any unclaimed utility credits are collected by DEQ's backstop aggregator and distributed through programs that promote and support transportation electrification across the state. Forth is in its fifth year as the Clean Fuels Program Backstop Aggregator. Information on how Forth spends the funds can be found on the Backstop Aggregator webpage.

In 2022, the program introduced a new provision called Advance Crediting to accelerate the adoption of electric vehicles. Advance Crediting allows public and certain private fleet operators to receive up to six years' worth of credits up front once they deploy an electric vehicle, if they can show commitment to electrify their entire fleet in 15 years. This functions as a financial bridge to support the high initial costs of fleet electrification, including vehicles and charging infrastructure. While the provision was announced in 2022, it is expected to become available to eligible fleets in 2025, unlocking a valuable new tool to help Oregon meet its zero emission vehicle goals.

Public Purpose Charge Schools Program

The Public Purpose Charge is a portion of revenues collected from Oregon's two largest electric utilities – Portland General Electric and Pacific Power – dedicated to enhancing energy efficiency and sustainability. Established in 1999 by Senate Bill 1149, the law was amended in 2019 by Senate Bill 1044 to include electric vehicle and charging infrastructure projects for school districts. Today, the Public Purpose Charge is set at 1.5 percent of electricity revenues, with 20 percent of the funds dedicated to eligible school districts for energy-related improvements. This portion, known as the Public Purpose Charge Schools Program, is administered by the Oregon Department of Energy and supports a wide range of energy projects, including vehicle fleet audits, procurement of zero emission vehicles, and the installation of EV charging infrastructure. Eligible K-12 schools in PGE or PAC territories that would like to use Public Purpose Charge funding for ZEVs and/or charging stations must first conduct a fleet audit to assess the energy use in their fleets.

Since the law was amended to include transportation electrification measures, the program has funded zero-emission buses and EV chargers for three school districts:

- Bend-La Pine School District: One zero-emission bus and one Level 2 EV charger ($247,831 in Public Purpose Charge funds and revenues created from participating in Oregon's Clean Fuels Program).
- Beaverton School District: Four light-duty EVs, two zero-emission buses, and seven Level 2 EV chargers ($537,877 in Public Purpose Charge funds and revenues from participating in Oregon's Clean Fuels Program).
- Tigard-Tualatin School District: Four Level 2 EV chargers ($56,197 in Public Purpose Charge funds)

To learn more about projects funded with public purpose charge funds, see ODOE's interactive map of Public Purpose Charge funded projects since 2012.

Energy Efficiency and Conservation Block Grant Program

The Energy Efficiency and Conservation Block Grant Program is a formula award provided to states and Tribes under the Infrastructure Investment and Jobs Act, aimed at reducing energy use, improving energy efficiency, reducing greenhouse gas emissions, and promoting renewable energy and conservation. Oregon received an allocation of $1.9 million for this program, which is being administered by the Oregon Department of Energy. In addition to the funds administered by ODOE, the U.S. Department of Energy directly awarded about $3.8 million to larger Oregon cities and counties.[52] Per federal guidelines and ODOE's program design, eligible activities include supporting municipal electric vehicle fleets and installing EV charging infrastructure in communities across the state.

On Sept. 16, 2024, ODOE announced $1.2 million in grant awards to local governments across Oregon, including close to $500,000 to support the installation of EV charging stations in Woodburn, Philomath, West Linn, Redmond, and the Port of Tillamook.[53]

Other Efforts to Expand EV Charging Availability in Oregon

In addition to federal and state programs, Oregon's utilities and local governments play a vital role in supporting EV charging infrastructure through financial incentives, technical assistance, and policy development. Oregon's investor-owned utilities – Portland General Electric, Pacific Power, and Idaho Power – are required to submit Transportation Electrification Plans to the Public Utility Commission every three years. These plans outline utility programs funded through mechanisms such as the System Benefit Charge and the Oregon Clean Fuels Program and are designed to accelerate EV adoption and grid readiness. For example, both PGE and PAC offer rebates to residential and commercial customers for the installation of Level 2 EV chargers.

EV charger in Arlington

Local governments are also advancing EV charging through direct funding and supportive policy. A leading example is the Portland Clean Energy Community Benefits Fund, which is a climate justice initiative established by Ballot Measure 26-201 in 2018, applying a 1 percent surcharge on large retailers (those with over $1 billion in national revenue and at least $500,000 in Portland sales).[54] The Portland Clean Energy Community Benefits Fund expects to invest approximately $1.6 billion over five years, and with the adoption of its 2023 Climate Investment Plan and subsequent amendment in 2024, it allocated approximately $359.4 million specifically for transportation decarbonization, making it the second-largest funding category in the plan.[55]

Together, these state, utility and local programs are increasingly important as uncertainty grows around future federal funding and support for EV infrastructure. Their continued investment and coordination will be essential to maintaining momentum and ensuring equitable access to EV charging across Oregon.

Past EV Charging Efforts in Oregon

While this chapter highlights recent program developments and new initiatives launched since the last publication, the 2023 BiZEV report provides a broader overview of earlier efforts to expand the availability and reliability of EV charging across Oregon. For additional background and context, refer to the 2023 BiZEV.

CURRENT STATE OF EV CHARGER RELIABILITY

Charging station reliability is critical to the success of electric vehicles and the broader transition to clean transportation. When chargers are out of service or fail mid-session, drivers can face unexpected delays, detours, or even become stranded – undermining trust in EVs as a viable alternative to gas-powered vehicles. Repeated negative experiences with public chargers can lead EV drivers to discourage others from making the switch. For commercial fleet operators, even brief charging outages can result in lost productivity and revenue. Reliability is especially important in rural or underserved areas, where charging coverage may already be limited, and a single malfunctioning station can severely limit mobility.

In the last few years, much has been done to improve the reliability of public charging stations in the U.S., and this effort appears to be paying off. According to Plug in America's fifth annual EV driver survey – the largest to date – drivers expressed less worry about the reliability of public charging than in past surveys. Specifically, 34.9 percent of EV drivers noted public charging reliability as a top concern in the 2025 survey, a nearly 6 percent decrease from 2024.[11]

However, when asked to rate what problems they have consistently experienced at their most-used fast charging network, non-Tesla respondents were most likely to say they've consistently experienced nonfunctional or broken chargers over the past year (Figure 5).[11] Similarly, J.D. Power's E-Vision Intelligence Report found that while overall customer satisfaction with fast and Level 2 charging improved slightly or remained steady through the fourth quarter of 2024, the number of failed charging attempts rose; 20 percent of public charging attempts ended in failure, leaving drivers unable to charge due to issues such as station outages, equipment malfunctions, long wait times, or payment errors.[12]

FIGURE 5: EV Driver Experiences from Plug in America's 2025 EV Driver Survey[11]

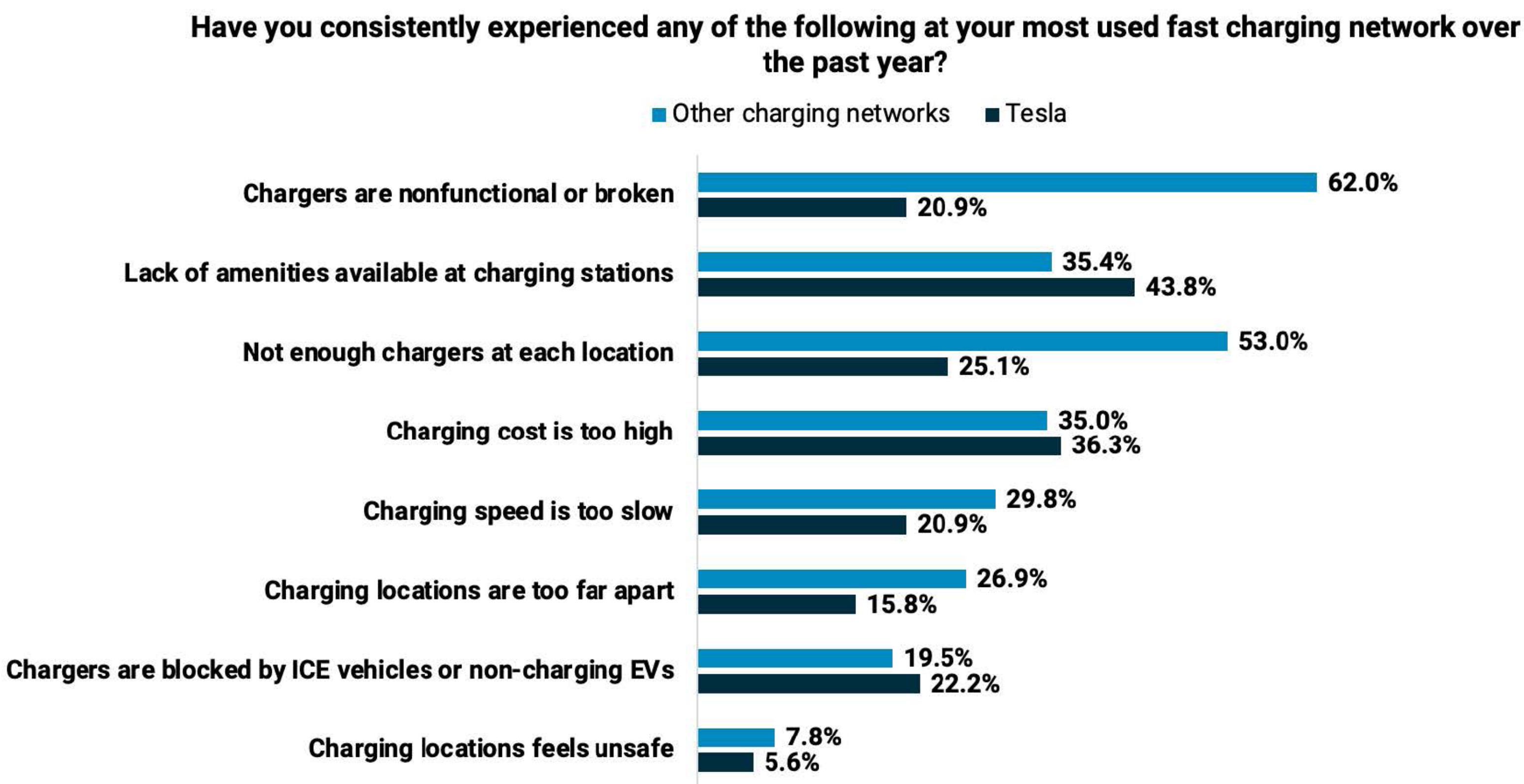


Figure: Plug In America

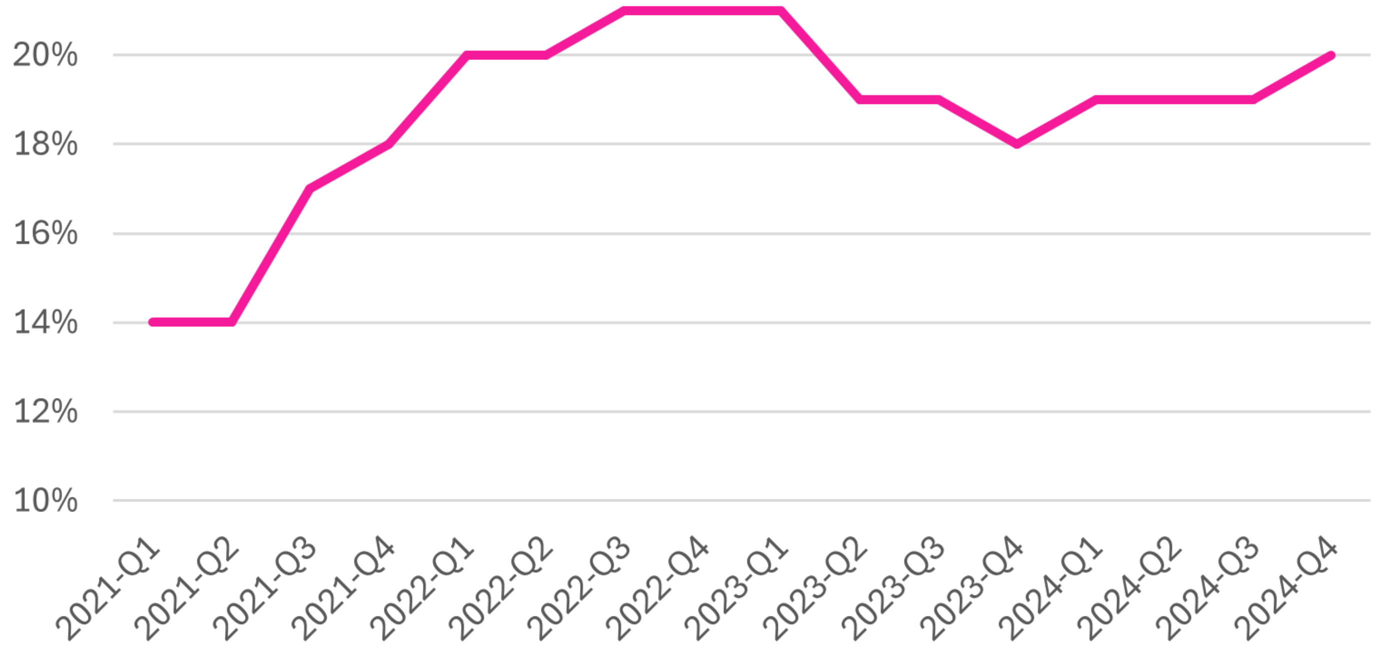
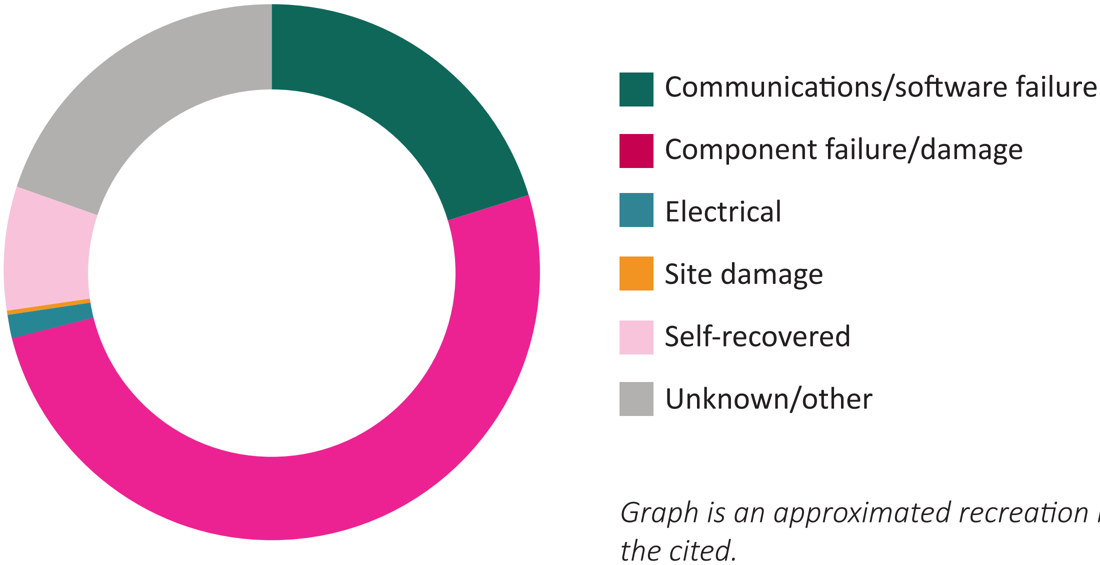


FIGURE 6: Percentage of EV Drivers Unable to Charge (J.D. Power)[12]

To better understand the patterns and causes of charger unreliability, ChargerHelp analyzed over 19 million data points for its 2024 Annual Reliability Report. The findings revealed that while downtime stems from a variety of issues, certain problems are consistently responsible. Physical component failures (particularly involving cables, cable retractors, screens, payment systems, cabinets, and connectors) were the most common, followed by communications or software failures.[56] Together, these accounted for more than two-thirds of problems. Electrical faults or site damage (such as vandalism) combined made up less than 2 percent (see Figure 7). Notably, stations with malfunctioning payment systems showed the strongest correlation with downed stations. As demonstrated in Figure 7, payment system issues were rare among operational chargers, but nearly half of all non-functioning chargers had broken or unresponsive payment systems.

FIGURE 7: Charging Station Symptoms from ChargerHelp's Annual Reliability Report



Graph is an approximated recreation based on the cited.

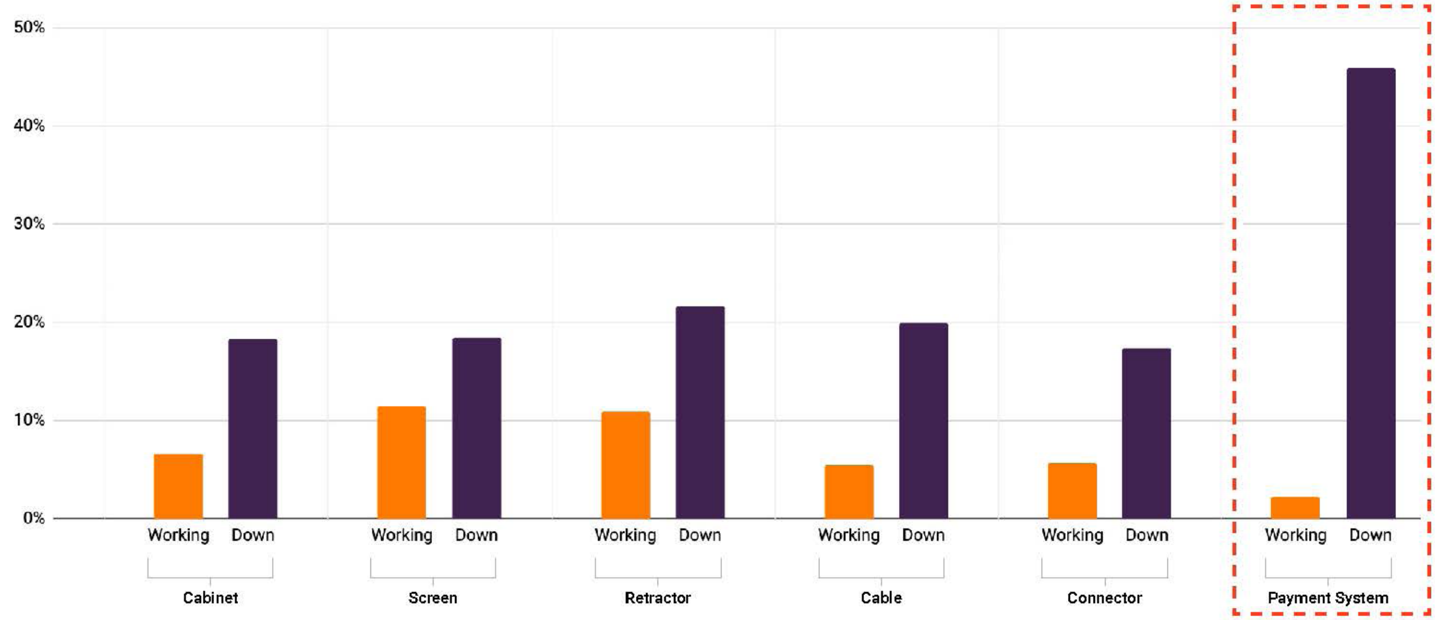


FIGURE 8: Prevalence of Observable Damage at Down Stations (ChargerHelp)
Figure: ChargerHelp

Universal Plug & Charge: EV Charging is About to Get a Whole Lot Easier

Public EV charging in the U.S. has been historically fragmented, with varying plug types, mobile apps, and payment systems required by different automakers and charging providers. However, this is set to change with the introduction of Universal Plug & Charge, a new standard designed to streamline and secure the public charging experience.

Beginning with many 2025 model year vehicles, Plug & Charge capability will allow drivers to start a charging session simply by plugging into a compatible station – without the need for a mobile app, credit card, or RFID tag.[57] Drivers will be able to just plug in and charge.

In December 2024, a coalition of automakers, charging companies, and standards organizations announced a nationwide framework to make this possible, built on the global communications standard ISO 15118.[58] This communications protocol enables secure, automated authentication between the vehicle and charger, facilitating charging and billing through encrypted digital exchanges. This allows EVs and chargers to recognize each other securely, handle payment automatically, and start charging instantly – much like Apple Pay for EVs.

For new and experienced EV drivers alike, Plug & Charge is expected to standardize the public charging experience and support broader EV adoption by making charging more intuitive, seamless, and user-friendly.

EV chargers at a shopping center in The Dalles

POLICIES AND PROGRAMS ADDRESSING CHARGER RELIABILITY

Improving charging station reliability is essential to enhancing the EV driver experience, building trust, and accelerating widespread adoption. While progress in reliability has been limited in recent years, there is growing momentum – and strong reason for optimism – that major improvements are on the horizon.

Federal Policies and Programs

A key turning point was the release of the National Electric Vehicle Infrastructure Program Minimum Standards in February 2023, which set the first nationally enforced benchmarks for EV charging performance. These standards laid a foundation for meaningful progress by:

- **Establishing an uptime requirement:** introduced the first-ever federally enforced uptime standard, requiring National Electric Vehicle Infrastructure Program funded charging stations to maintain at least 97 percent uptime (time available and functional) per charging port. This defined reliability as a compliance issue, giving states and site hosts the power to demand stronger performance.
- **Requiring real-time data sharing:** requires networks to report charger status and availability in real-time through open Application Programming Interfaces, or APIs, increasing transparency and enabling apps, vehicles, and users to know whether a charger is working before arrival at a station.
- **Establishing strong operational expectations:** requires 24/7 customer support, payment via contactless options, and prompt repair timelines. These policies create clear expectations for charger owners and vendors, and mirror what drivers expect from reliable infrastructure.
- **Shifting industry priorities:** drives charging providers to expand maintenance teams, upgrade aging equipment, and adopt proactive monitoring tools by linking federal funding to uptime and operational benchmarks. Previously, many charging providers emphasized fast expansion over long-term performance.

Importantly, the National Electric Vehicle Infrastructure Program's influence extends beyond the program itself. Many states, including Oregon, have adopted the standards as the baseline for their own grant and procurement programs. Hardware manufacturers have scrambled to create charging stations compliant with the program standards. Likewise, automakers like Ford and GM have partnered with public charging networks that adhere to or are moving toward the program standards. In short, it has become a catalyst for transforming EV charging reliability nationwide – pushing both public and private sectors to deliver a more consistent, trustworthy, and user-friendly charging experience.

EV charger in Cascade Locks

State Policies and Programs

Electric Vehicle Charger Reliability and Accessibility Accelerator

The Electric Vehicle Charger Reliability and Accessibility Accelerator is a federally funded program administered by ODOT to improve the reliability, accessibility, and performance of public EV charging infrastructure across the state. Launched in 2024 with a $10 million grant from the Federal Highway Administration, the program is focused on repairing, upgrading, and expanding existing charging stations to better meet modern performance standards and user expectations.

While ODOT manages program oversight and grant administration, private charging companies are responsible for executing the repair and upgrade projects, as well as operating funded chargers. The program addresses a major barrier to EV adoption – charger reliability – by prioritizing investments in three key project categories:

- **Reliability Improvements:** repairing or replacing non-operational or outdated EV charging ports to ensure consistent uptime and functionality.
- **Accessibility Upgrades:** enhancing station capacity by upgrading sites to include at least four charging ports, improving convenience and reducing wait times by adding redundancy.
- **Fast Charging Expansion:** transitioning Level 2 stations to DC fast charging stations, especially along Alternative Fuel Corridors, to support long-distance travel and commercial fleet charging.

In December 2024, ODOT awarded $3.2 million in Round 1 grants to the following EV charging companies[59]:

- EVCS: $1.75 million for projects in Lincoln City and Arlington, each featuring eight DC fast charging ports and battery energy storage systems.
- OpConnect, Inc.: $703,189 for projects in Salem and Portland, including four DC fast charging ports and four Level 2 charging ports, respectively.
- Electrify America: $735,000 for projects in Lake Oswego and Portland, each with four DC fast charging ports.

ODOT is preparing to launch Round 2 of the program in late 2025, with up to $5.8 million available for additional awards. Round 2 will include expanded eligibility criteria and an updated list of qualifying charging equipment.

Additional Efforts to Increase Reliability

While technical standards for charging reliability have been established and will continue to evolve nationwide through collaboration with automakers, charging network providers, and standard-development organizations, states play a vital role in turning those standards into results, especially as they administer state and federal funding and shape local infrastructure policy.

To strengthen EV charger reliability, states can adopt a range of best practices, including:

Adhere to National Electric Vehicle Infrastructure Program standards as a minimum requirement

As detailed above, National Electric Vehicle Infrastructure Program standards establish a consistent, nationwide baseline for uptime, payment systems, customer support, and data sharing. By using these standards as the floor, states ensure chargers are interoperable, reliable, and user-friendly from the outset.

Include enforceable service level agreements in grant or contract terms

Service level agreements define specific performance expectations – such as response times for repairs or minimum uptime – and make them legally binding, holding charging providers accountable for maintaining service quality over time.

Set penalties or "clawback" provisions for failure to meet performance standards

These measures create financial consequences for underperformance, incentivizing providers to prioritize maintenance and avoid extended outages or service lapses.

Require real-time status reporting

Mandating that chargers report availability and functionality through standardized Application Programming Interfaces allows drivers to avoid broken stations and enables state agencies to monitor performance across the network.

Prioritize operations and maintenance

States can include maintenance plans as eligible expenses within grant programs and require grantees to dedicate funding and submit detailed plans for long-term charger upkeep, ensuring public investments deliver value beyond installation.

Standardize procurement and establish qualified product lists
Using vetted equipment lists and clear, consistent specifications reduces confusion and administrative burden on grantees and ensures chargers meet durability and interoperability standards, improving reliability at scale.

Encourage or require networked chargers
Networked chargers, also called smart chargers, are connected to the internet and central management system, and offer a range of benefits compared to non-networked chargers. They support remote diagnostics and over-the-air software updates, allowing operators to detect issues early, perform proactive maintenance, and reduce downtime. They also enable robust data collection on usage and reliability, helping site hosts and program administrators monitor performance, optimize operations, and ensure accountability. This transparency strengthens public trust and supports data-driven improvements to EV infrastructure and funding programs.

Improve transparency and public reporting
Regular reporting of uptime metrics, repair timelines, and user feedback builds public trust and helps agencies identify problem areas early for targeted intervention. Public-facing data also pressures vendors to maintain high performance.

Coordinate across agencies and utilities
Alignment across state agencies, utility, and other charging programs ensures consistent standards, data reporting, and user experience. It can support streamlined deployment, grid interconnection, and long-term planning.

Entities administering EV charging infrastructure funds in Oregon – including state agencies and electric utilities – have incorporated many best practices into their grant and incentive programs. For example, qualified product lists are required under the Community Charging Rebates program as well as utility programs offered by PGE and PAC, ensuring only vetted, reliable equipment is deployed. The ODOT Community Charging Rebates program goes further by requiring service level agreements, maintenance contracts, and five-year equipment warranties to promote long-term performance. Additionally, Oregon's National Electric Vehicle Infrastructure program includes clawback provisions, which allow the state to recover funds or withhold payments if stations fail to meet performance standards.

State agencies involved in transportation electrification – ODOT, ODOE, DEQ, Department of Administrative Services, and the Oregon Public Utility Commission – collaborate regularly through the Zero Emission Vehicle Interagency Working group and other coordination efforts. These forums help align standards, share lessons learned, and ensure that best practices for charger reliability are consistently applied across state-supported programs.

CONCLUSION

A reliable and accessible EV charging network is foundational to Oregon's clean transportation goals and essential to building driver confidence statewide. While challenges remain – including reliability issues and uneven access – strategic investments, strong policy frameworks, and federal standards emphasizing long-term performance are beginning to shift the trajectory. However, recent changes in federal EV policy threaten to stall progress. Oregon is well-positioned to lead in maintaining momentum and building a reliable, connected charging ecosystem, but it must reaffirm its commitment to transportation electrification. State-led support for EV charging programs is critical to ensuring continued growth and infrastructure reliability. Achieving this vision will require strong state leadership and continued collaboration between public agencies, utilities, and private charging providers.

EV chargers in Troutdale

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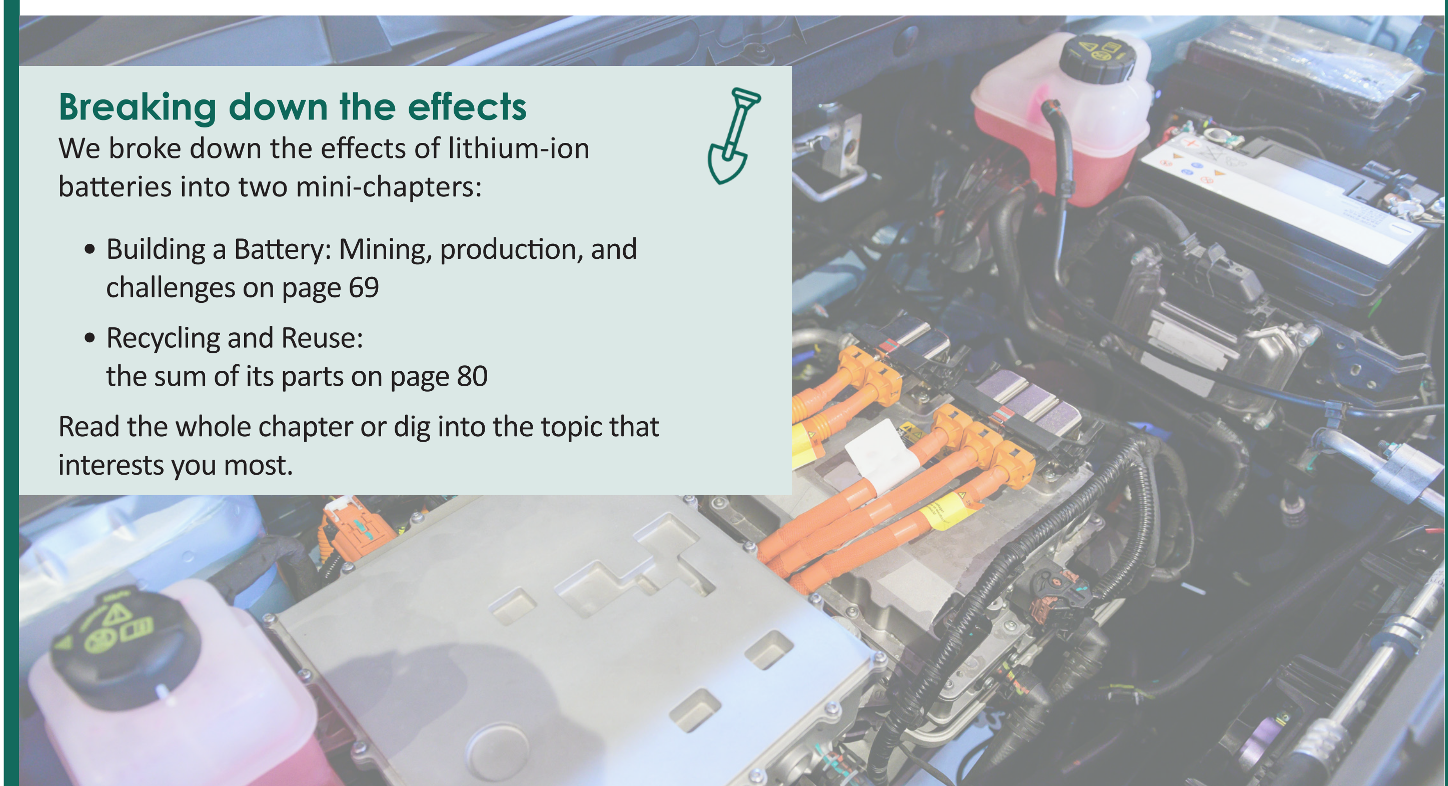
Photo by Kindel Media

THE EFFECTS OF LITHIUM-ION BATTERIES

KEY TAKEAWAYS

1. Lithium-ion batteries currently provide numerous benefits and are an important tool in Oregon's clean energy transition.
2. Producing and disposing of battery materials have some negative effects, including social and environmental costs; however, these challenges are being addressed.
3. Currently most raw materials and battery components are not sourced domestically, and many areas of the globe where these come from have human rights and environmental issues.
4. The battery industry is innovating with design and material substitutions that reduce or eliminate the need for many of the minerals of greatest concern.
5. At the end of their useful life powering an EV, batteries can be repurposed and eventually most of the battery components can be recycled.
6. Working to bring spent equipment into a circular economy where used battery materials return to the economy to be used again will be a priority.



Breaking down the effects

We broke down the effects of lithium-ion batteries into two mini-chapters:

- Building a Battery: Mining, production, and challenges on page 69
- Recycling and Reuse: the sum of its parts on page 80

Read the whole chapter or dig into the topic that interests you most.

INTRODUCTION

Lithium-ion battery manufacturing is increasing around the globe to power everything from rechargeable batteries, computers, and cell phones to electric vehicles and battery storage systems. The growth in manufacturing and use of this technology has spurred interest in the effects of the materials and supply chains required to build them, and what happens to the batteries when they reach the end of their useful life. Lithium-ion batteries power modern life and are an essential technology supporting the clean energy transition.

Oregonians rely on lithium-ion batteries in many ways in the energy system. They can be found in the more than 100,000 electric vehicles registered in Oregon, including passenger vehicles, school buses, garbage trucks, and delivery vans.[1] Batteries are also installed in homes and businesses to provide backup power in the event of outages. Oregon electricity suppliers use batteries to store renewable energy when generation is plentiful and provide that energy back to the grid when demand is high and generation is low. For example, the Wheatridge Renewable Energy Facility owned by NextEra Energy and Portland General Electric includes battery storage co-located with both wind and solar resources.[2]

> Approximately 14 percent of projects funded by the Oregon Department of Energy's Solar + Storage Rebate Program included battery energy storage.[3]

Lithium-ion batteries reduce greenhouse gas emissions when paired with clean energy, improve local air quality by helping to avoid fossil fuel-generated emissions, and provide a resource of stored electricity when grid power is not available.[4] At the same time, there are environmental and societal effects from mining and refining minerals used in the batteries, battery production, and disposal that could be made worse as these activities grow to meet global demand. In the fast-growing lithium-ion battery economy, the United States is at a competitive disadvantage with several other countries, particularly China, who has considerable market share in the production of many key minerals and battery components.[5]

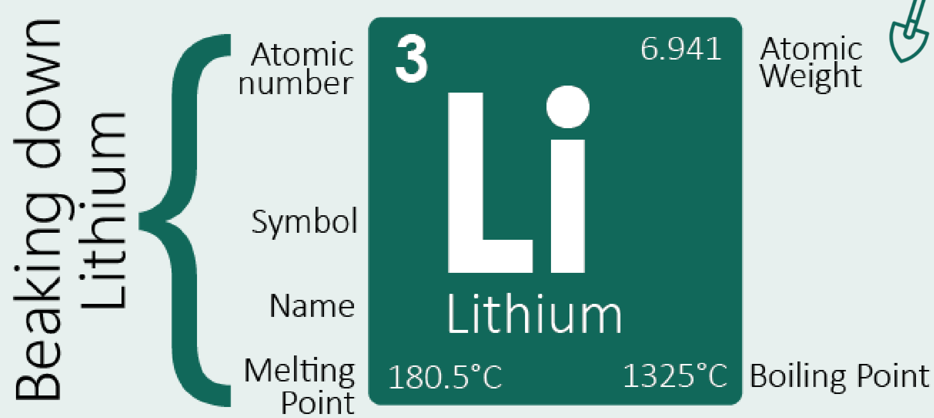
Lithium-ion batteries provide consumers with the opportunity to access electricity to power technologies that have historically depended on gasoline and diesel, such as vehicles and home generators. All energy-consuming technologies have effects on the environment, but batteries have advantages over internal combustion engines that make them a cleaner and more sustainable option from an emissions standpoint. Unlike combusting fuel, there are no direct greenhouse gas or other emissions into the environment when discharging a battery for power. There are indirect emissions from extracting, refining, transporting, and combusting fuels to generate the electricity and bringing fossil fuels to market. In Oregon, driving an EV is 50-95 percent cleaner[6] than using gas or diesel for a comparable vehicle, and as utilities progress toward Oregon's clean electricity goals, charging batteries will incur fewer emissions without requiring any changes in consumer habits or behaviors.[7] Building an EV generates more emissions than building a comparable internal combustion engine vehicle, largely from the production of the battery,[8] but those additional emissions are quickly offset by reduced emissions when operating the vehicle. Further, unlike fossil fuels that power combustion, the minerals used to create batteries are not fully consumed when used. They can be recovered and reused to build new batteries or other products, which can reduce the need for mining and refining in the future.[9]

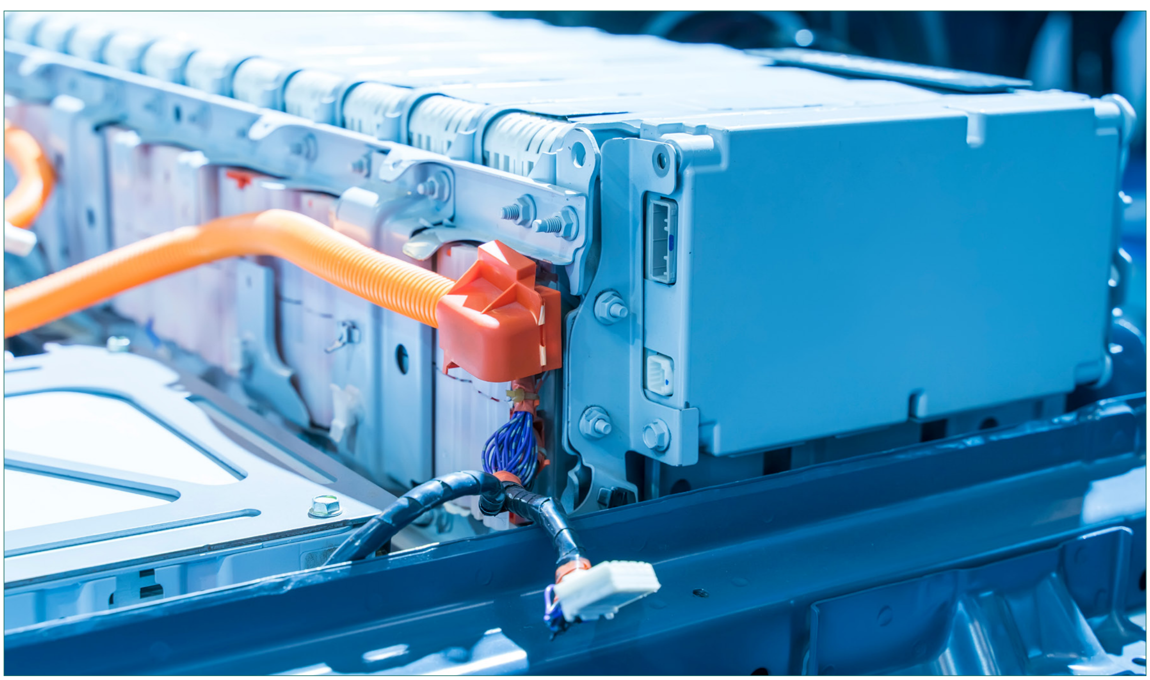
Strategies encouraging electrification of end uses are a powerful tool to address climate change and the negative health impacts of fossil fuel use, but there are societal and environmental effects from battery production that need to be addressed. This section will provide insight into the lithium-ion battery supply chain, the effects of mining minerals and producing the batteries, and where they end up at the end of their useful lives. It will also describe actions being taken to address some of the issues in battery supply chain practices and outcomes, and how the U.S. and Oregon are contributing to developing a more sustainable battery economy.

In 2019, John B. Goodenough, M. Stanley Whittingham, and Akira Yoshino received the Nobel Prize in Chemistry for their contributions to the development of the modern lithium-ion battery.[12]

Why lithium?

Lithium is the lightest, smallest, non-gaseous element on the periodic table. Because its chemical structure is highly reactive, it is an optimal choice for fast charging and discharging.[13] Compared to many other battery types, lithium-ion batteries perform well because they have high energy density[i], longevity, versatility, and require little maintenance.[15]





i Energy density is the amount of energy a battery can store relative to its size. This is often reported as watt-hours/kilogram, and can be thought of similarly to how much gasoline can be stored in the tank of an internal combustion engine vehicle.[14]

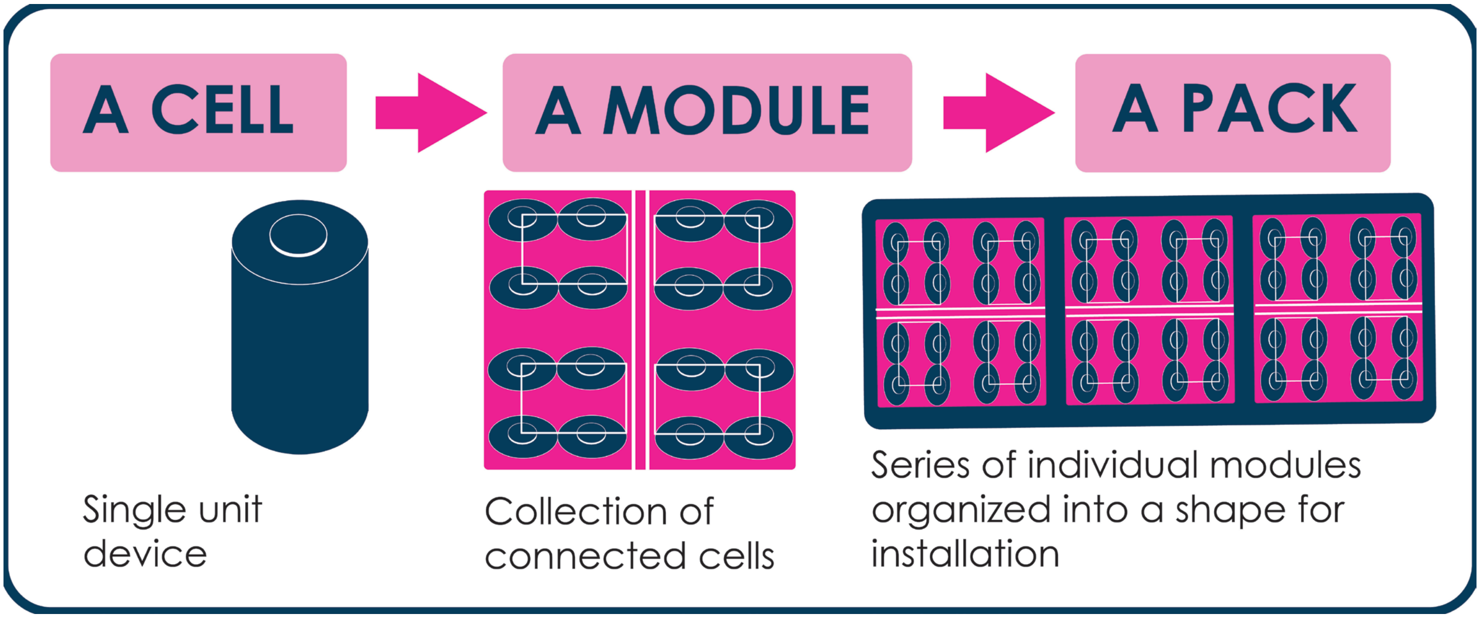
Lithium battery pack

BATTERY DESIGN

Most of the batteries used in daily activities work through electrochemical reactions that allow them to charge and discharge electrical energy. The most common type of rechargeable battery is lithium-ion.[10] Larger batteries, like those used for electric vehicles and the grid, are generally produced as a pack consisting of packaging and mounting structures, a battery management or control system, and modules of battery cells.[11]

Lithium-ion battery cells contain two electrodes (a cathode and an anode), an electrolyte (a chemical solution that allows electricity to flow between the electrodes), and a separator (a physical barrier between the cathode and anode that only allows for the flow of charged particles called ions). Anodes have a negative charge and cathodes a positive charge, which in the presence of the electrolyte allows the flow of electricity. The anodes and cathodes are made of different materials to facilitate this reaction. Anodes are made with graphite[ii], while cathodes are generally comprised of lithium (which evokes the name), nickel, manganese, cobalt, iron, and phosphorous.

FIGURE 1: Large lithium-ion battery components



[ii] *Recently, manufacturers have been replacing some of the graphite with silicon. For more information, see the* Different Battery Chemistries section *of this chapter.*

Global Clean Transportation Transition

In 2024, China purchased about two-thirds of EVs around the globe and saw the number of EV sales compared to internal combustion engine vehicles rise to nearly 50 percent, up from 35 the previous year.[17,18] Europe is the second largest market for EV sales, at about 20 percent of new vehicles, with Norway leading at 88 percent of those sales. Emerging economies in Asia, Latin America, and Africa saw their share of new EV sales nearly double, from 2.5 percent in 2023 to 4 percent in 2024. The U.S. saw modest increases in the share of EV sales for the new vehicle market over that same period, and EV sales outperformed internal combustion engine vehicles, which were largely stagnant. It remains to be seen how the loss of federal incentives for EVs and charging will affect U.S. EV market share, but globally the transition remains strong.

BUILDING A BATTERY: MINING, PRODUCTION, AND CHALLENGES

Demand for lithium-ion batteries is increasing. Supply chains for these batteries originated about 30 years ago to support the growing use of rechargeable batteries that power computers, cell phones, and other mobile electronic equipment.[16] Today the demand for lithium-ion batteries is being driven (pun intended) by a growing electric vehicle market.[17] In 2024, EVs were about 20 percent of car sales globally, with China leading in sales growth, followed by Europe and the U.S.[18]

> Gasoline-powered vehicles also use some of the minerals that comprise an EV battery, although in smaller quantities. Graphite is used for brake linings and lubricants, nickel-based alloys are used in turbochargers and engine components, and cobalt is used in vehicle airbags.[25–27]

Critical mineral demand is also growing to accommodate an increasing preference for larger EV battery sizes, meaning more critical minerals are needed per vehicle. Batteries for EVs sold in the U.S. are on average 30 percent larger than the rest of the globe to accommodate the longer driving ranges that Americans prefer. Sales of larger battery capacity vehicles in China – the largest EV market – have quadrupled in the last four years.[20,21]

Growth in EV sales is expected to greatly increase demand for lithium-ion batteries.[18] Although a much smaller share of sales than EVs, demand for batteries to store electricity for utilities, homes, businesses, and other places is also contributing to increasing critical mineral demand.[22] As demand increases, mining and manufacturing to produce batteries is also increasing. The following sections will cover the different steps of lithium-ion battery production, provide a basic overview of production pathways, identify the biggest issues associated with these pathways, and share insights into how concerns are being addressed.

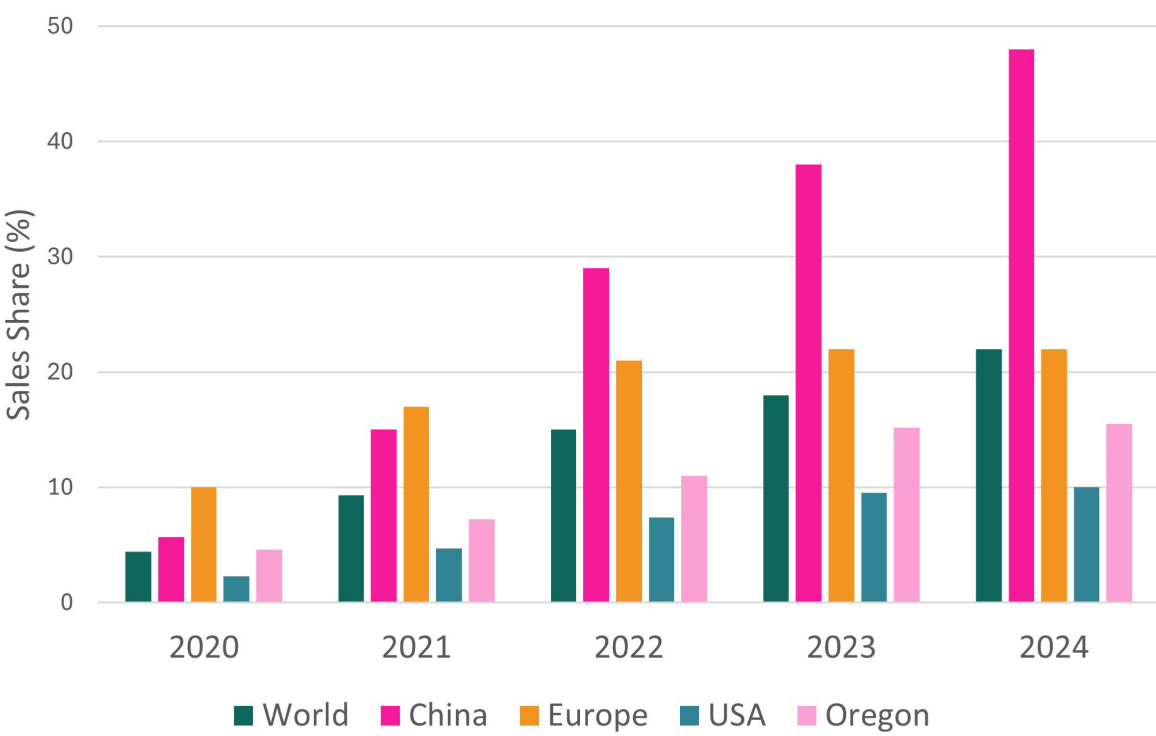
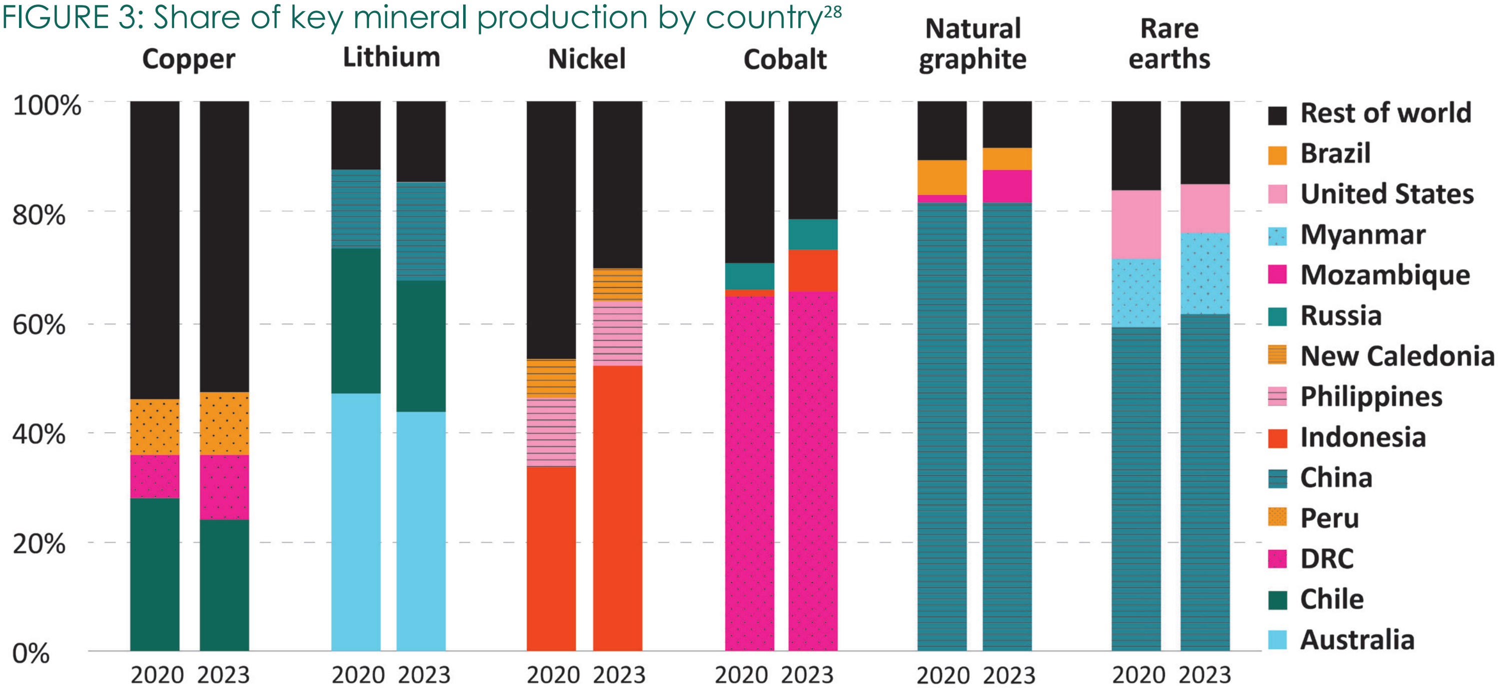


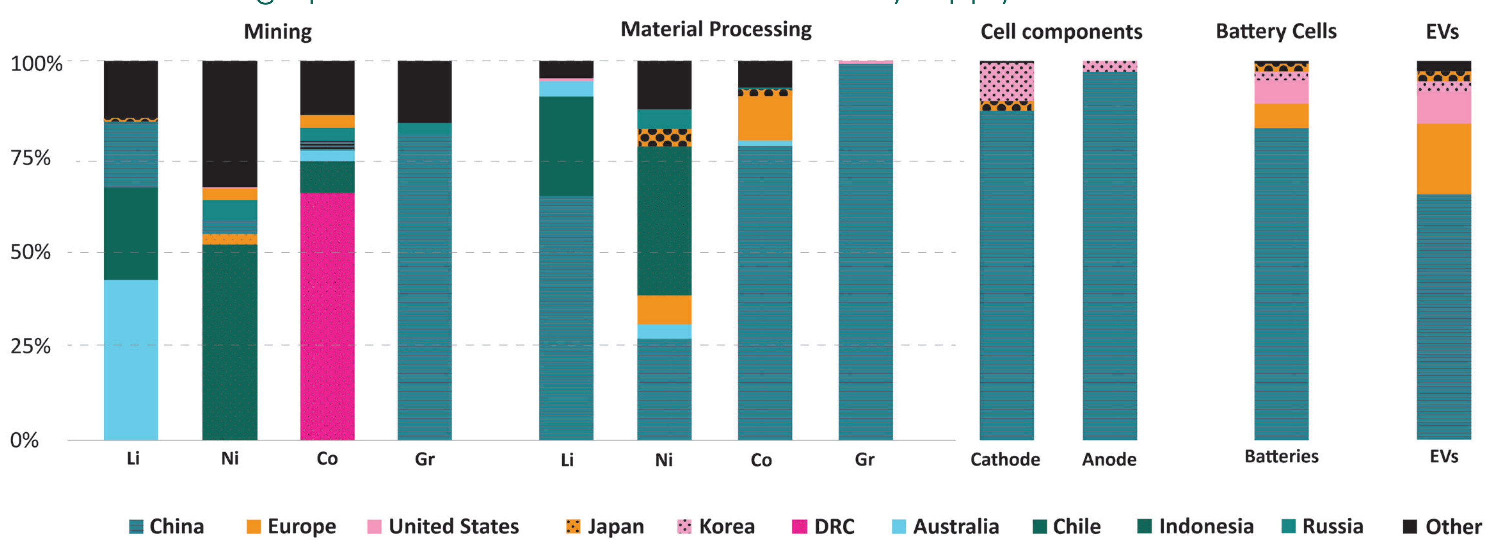
FIGURE 2: Electric vehicle sales as a percentage of total light-duty vehicle sales globally and by region/country (2020-2024)[19]

FIGURE 3: Share of key mineral production by country[28]



Graph is an is an approximated recreation based on the cited chart.

FIGURE 4: Geographical distribution of lithium-ion battery supply chains[29,30]



Graph is an approximated recreation based on the cited chart.

LITHIUM-ION BATTERY MANUFACTURING

Battery production begins with extraction and refining of the raw materials, assembly of the components, and finally the assembly of the battery itself. This supply chain pathway occurs in multiple places, passing through many hands, and several regulatory and permitting jurisdictions. The supply chain is very complex and often difficult to track backward from any specific battery produced.

The first step in the process is mining key minerals used in battery production. Minerals are mined around the globe for use in many applications, but demand for some minerals is increasing sharply as countries are encouraging or requiring the development of clean energy technologies and resources.[23] The International Energy Administration, an independent intergovernmental organization that tracks and forecasts global energy information, found that mineral demand for clean energy technologies, including batteries, could double or triple by 2030 and nearly quadruple by 2050. Most of the growth is driven by battery demand for electric vehicles and energy storage. Many of these minerals are defined as critical minerals because they are essential to the economic and national security of the United States.[24]

Mining for critical minerals largely occurs outside the United States, and in some cases, specific minerals are mined in only one or two countries.[28] Figure 3 shows sources of different key minerals used in electric vehicle production. The Democratic Republic of Congo, shown as DRC, mines nearly two-thirds of the world's cobalt, shown as the largest portion of the bars for this mineral, and China produces the majority of the rare earth minerals[iii] and graphite, shown as the largest portion of those bars. Australia is the largest producer of lithium followed by Indonesia and China.

After raw materials are extracted from mines, they are sent to facilities to be concentrated, purified, and refined, and then manufactured into the anodes and cathodes that make up individual lithium-ion battery cells.[29] Cells are in turn assembled into a battery. Figure 4 shows where different parts of this supply chain process occur. China holds significant market share in many pieces of the lithium-ion battery material processing and production supply chain, especially manufacturing battery cathodes and anodes.

Environmental and Societal Effects of Mining and Manufacturing

Minerals are the basis for the infrastructure and non-food goods produced around the globe, but there are downsides associated with exploiting these resources. This is true of mineral extraction for lithium-ion batteries and for myriad other uses of minerals. Mining, processing, and refining minerals come with negative societal and environmental effects, especially where regulations may be lacking.[31] These include poor health outcomes for workers and local communities as well as air, soil, and water pollution, and loss of local biodiversity. Operations in some countries have also been associated with human rights abuses, including child and forced labor practices.[31] Indonesia, China, and the Democratic Republic of Congo — which are collectively responsible for the majority of EV battery mineral mining, processing, and manufacturing — rank in the bottom third in Yale University's Environmental Performance index.[iv] Over 50 percent of today's lithium and copper production – both water-intensive processes – is concentrated in areas where water demand exceeds water supply, mostly in Australia and Chile.[33] In the Democratic Republic of Congo, where most of the world's cobalt is mined, there have been documented human rights' abuses, including health and safety risks for miners, child labor practices, and gender discrimination.[22,34] All of these affect public safety, health, and the economic well-being of local communities.[31]

Aligning mining practices

Some mining companies are taking steps to align and improve their practices.[35,36] The Consolidated Mining Standard Initiative aims to consolidate the best practices of four separate mining standards to produce a single, global standard.[37] Member companies agreed to adopt these standards at their operations. Beyond this, about 20 companies have pledged to achieve net-zero greenhouse gas emissions by or before 2050.[35] A few companies have committed to causing no net loss of biodiversity in the locations of their mines, and some are limiting the amount of fresh water they can use in their operations.

In the *2024 Global Critical Mineral Outlook*, the IEA reported that there is indication of some improvements in overall environmental and social outcomes in mining practices.[35] In an assessment of sustainability reports and pledges of 25 major mining companies, they found that there have been improvements in worker safety, percentage of workers who are women, and local community investments since 2019. The transparency of the information is lacking, with companies often aggregating data so it is not clear where issues at specific mining operations or for particular minerals are occurring. There are few companies that report on other areas of concern, including detailing risks of child labor practices, displacement of residents, water consumption, wastewater issues, or providing transparent information about supply chains and contracting.

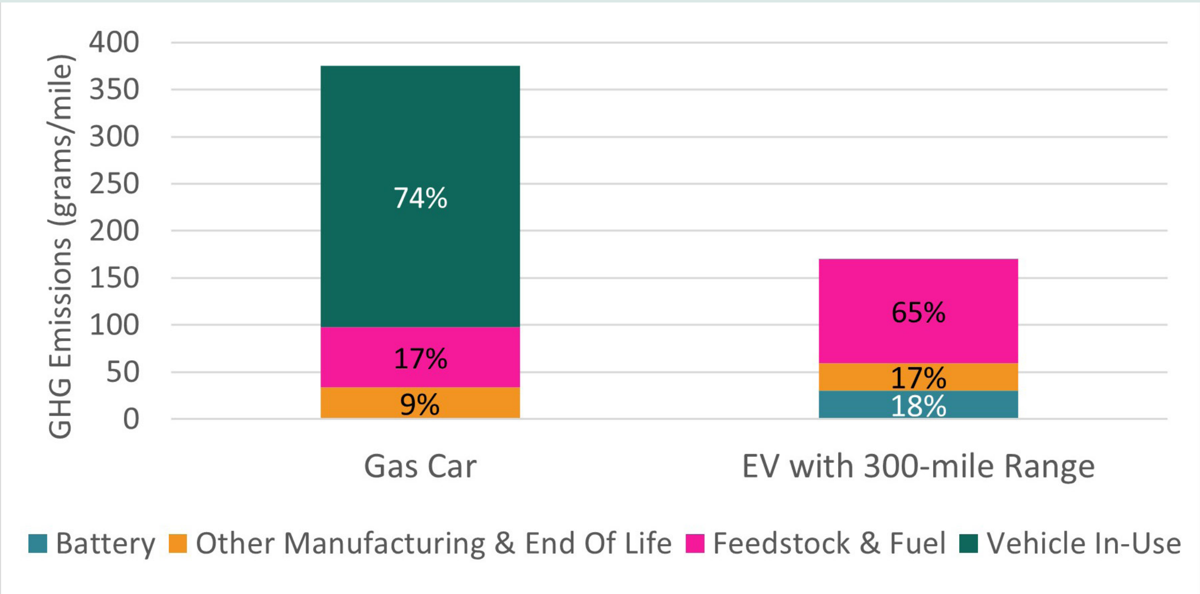
[iii] *Rare earth minerals are a group of metallic elements with unique properties that make them valuable in various technologies. Despite the name, they are fairly commonly found.*

[iv] *The EPI ranks environmental performance using indicators across categories ranging from climate change mitigation and air pollution to waste management, sustainability of fisheries and agriculture, deforestation, and biodiversity protection.*[32]

Are electric vehicles climate friendly?

Over the lifetime of the vehicle, an EV produces less than half the greenhouse gas emissions of a comparable gasoline vehicle.[8] Emissions to *build* the EV are higher, largely due to the high energy requirements of producing the battery, but the zero tailpipe emissions from an EV quickly make up for this once the vehicle is in use. Figure 5 shows emissions for similar gas and electric vehicles as estimated by Argonne National Laboratory; the emissions from the production of the battery for EVs is far less than the emissions accrued over the lifetime of the average gasoline car. In Oregon, EV emissions are even less than what is reflected in the figure, because Oregon's average electricity emissions are about 20 percent lower than national emissions.[42]

FIGURE 5: Lifetime greenhouse gas emissions for comparable electric and gasoline powered vehicles in the United States[8]



Effects of Mining and Manufacturing on Energy Use and Implications for Climate Change

The mining and minerals production industry produces greenhouse gases that contribute to climate change, primarily due to energy consumption. It is estimated that the minerals supply chain constitutes about 4-7[v] percent of global energy use, with about a third from electricity, a third from diesel, and the remaining third from coal, natural gas, and gasoline.[38]

The specific percentage of global energy use for extraction of minerals for lithium-ion batteries is unknown. Extracting and refining alone, which involves ore removal, crushing, heating, transporting, and refining processes, account for 3-4 percent of global energy consumption.[39,40] As an example of the large amounts of energy needed, over 60 percent of global lithium production is hard rock extraction, which requires crushing the rock, separating out the ore, roasting it at nearly 2,000°F, cooling, mixing with sulfuric acid, and then re-roasting at nearly 400°F.[41] Energy consumption is expected to rise over time, not only to meet demand but also because ore quality at mines degrades over time. Lower quality ores require more effort to extract, process, and refine, all of which means more energy is needed to produce the same amount of refined material.

Effects of Mining and Manufacturing on Economic Security

China's dominance in lithium-ion battery supply chain markets is a major concern for many companies and governments.[43] This market dominance is the result of early Chinese policies supporting domestic investments and developments of critical mineral extraction and refining.[22] From 2000-2010, Chinese companies were the sole source

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[v] *A study published in the journal Global Environmental Change in 2023 finds there are few studies on global energy consumption from mining and/or the entire metals production supply chain. The amount provided here represents the most recent study available on this, which was from 2017. With critical minerals mining increasing, this value may be biased low.*[38]

TABLE 1: Recent mineral and component export restriction announcements[47]

Category	Element	Country	Market Share	Type of Control
Material	Lithium	Zimbabwe	9%	Imposed a ban on raw lithium ore exports in Dec 2022, followed by export licensing requirements for all unprocessed base minerals in Jan. 2023
Material	Gallium	China	99%	Export licensing in July 2023, followed by an export ban to the U.S. in Dec. 2024
Material	Germanium	China	74%	Export licensing in July 2023, followed by an export ban to the U.S. in Dec. 2024
Material	Antimony	China	74%	Export licensing in Sept. 2024, followed by an export ban to the U.S. in Dec. 2024
Material	Rare earths	China	92%	Export reporting requirements from Nov. 2023 (effective until Oct. 2025), followed by export licensing on seven medium and heavy rare earths in April 2025
Material	Graphite	China	98%	Export licensing in Dec. 2023
Material	Cobalt	DRC	68%	4-month half to exports announced in Feb. 2025
Material	Tungsten	China	44%	Export licensing in Feb. 2025
Material	Bismuth	China	80%	Export licensing in Feb. 2026
Material	Indium	China	70%	Export licensing in Feb. 2027
Material	Tellurium	China	77%	Export licensing in Feb. 2028
Material	Molybdenum	China	81%	Export licensing in Feb. 2029
Material	Nickel	Philippines	9%	Proposed ban on raw mineral exports in Feb. 2025
Technology	Rare earths	China	92%	Export ban of rare earth extraction and separation technologies in Dec. 2023
Technology	LFP cathode	China	98%	Proposed technology export control in Jan. 2025
Technology	Lithium Refining	China	72%	Proposed technology export control in Jan. 2025

for many components in the supply chain because of patent agreements on the processes used to build them.[44] Those agreements ended in 2022, at the same time the effects of COVID had reduced demand for EVs and critical minerals, and battery component supply outpaced demand, driving prices lower. With demand on the rise again, it is not certain when or if market constraints might drive up costs for these minerals, nor is it clear how China might influence the market.

International supply chains are open to disruption by natural or political events, which can create market instability that leads to changes in manufacturer and consumer costs, adds risk to business planning, and affects the implementation of government clean energy and climate goals. Table 1 shows export restrictions enacted in 2023 and 2024, with a large majority coming from China. Companies in the U.S. and the rest of the globe are reliant upon China for most minerals, refined materials, and components that comprise a lithium-ion battery. When a single country or business owns a large market share of a step along the supply chain pathway, that entity can choose to manipulate the market in their favor. For example, in Table 1, the Democratic Republic of Congo (listed as DRC), while facing decreasing prices on raw cobalt ore, effected a 4-month halt on exports in February 2025 which led to an 84 percent surge in prices for the raw ore. In June, the DRC extended the ban for an additional three months through September 2025. Although analysts expect prices to drop once the ban is lifted, this demonstrates the power over the market that a single government can have on commodity prices when competition is lacking.[45,46]

One way to address these monopolies is to diversify where products are sourced, but the challenges to this are considerable. For other businesses to enter the market they have to be competitive with Chinese manufacturers, who have benefited from national subsidies that make their production costs very low.[51] Prospective manufacturing businesses would need to overcome the high market entry cost from the capital expenditures needed to buy or build a facility and purchase all of the equipment. However, China is the sole producer of technologies used to produce battery cathodes and process lithium, and in 2025, China established export restrictions on these technologies.[52]

Oregon and Nevada could play a role in U.S. efforts to reduce dependence on foreign lithium resources. The McDermitt Caldera located in southeastern Oregon potentially has some of the highest concentrations of lithium in the U.S., and Hi-Tech Minerals, a subsidiary of Australian mining company Jindalee Lithium Limited, was recently greenlighted to begin drilling exploratory holes.[53–56] To develop a lithium mine in Oregon, a developer needs a permit from DOGAMI, which must be updated annually while the mine is in operation.[57] If the mine is located on federal lands, additional permitting and environmental assessments are also needed. In March 2025, the project received the approvals needed to begin operations.[54,55] Hi-Tech plans to build on findings from exploratory sites they assessed in 2018, drilling as many as 261 new sites and constructing

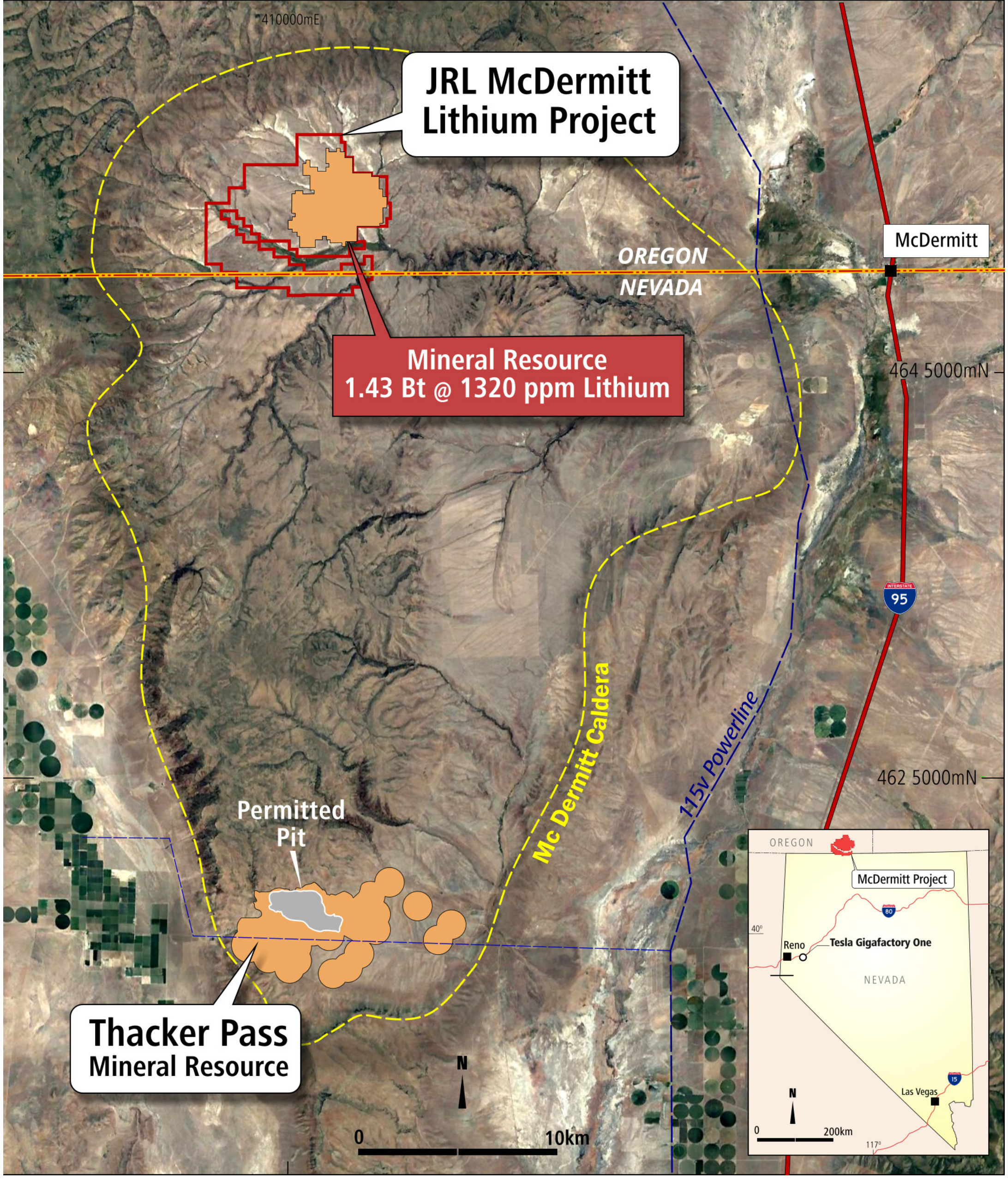


FIGURE 6: Location of McDermitt Lithium Project[59]
Image Courtesy of Jindalee Lithium

U.S. tariffs and electric vehicle production

Since April 2025, the U.S. has been setting and resetting tariffs with other countries, with some of the highest tariffs targeting China.[48] Many key critical minerals for battery production were exempt from these, including lithium, nickel, cobalt, graphite, and rare earth elements, but the tariffs apply to batteries and battery components. China produces most battery anodes and cathodes, and over 75 percent of lithium-ion battery cells. Although the U.S. manufactures some lithium-ion batteries and EVs, producers are reliant on Chinese components. In response to the initial tariffs, China placed export restrictions on rare earth elements to the U.S.[49] On May 12, President Trump issued a pause on the increased tariffs.[50] It is uncertain if tariffs will hold, if more critical minerals export restrictions might be leveraged by China, and what costs would be passed on to U.S. EV manufacturers.

up to 30 miles of roads to better understand the full potential of lithium deposits at the site.[58]

The McDermitt Lithium Project is receiving federal government support that may lead to faster development timelines.[60] The project benefited from President Trump's Executive Order 14241, which directed federal mining permitting agencies to identify priority projects and take all necessary and appropriate actions to expedite approvals.[61] As a result, it was determined to be a project of national strategic importance and designated one of ten Transparency FAST-41 projects that aim to streamline permitting timelines.[62,63] Trump's order also makes available more opportunities for federal funds that support domestic critical minerals development which the project may be able to leverage.

There are many societal and environmental considerations for a full-scale lithium mining operation in the area. There are likely to be positive local economic benefits. For example, Jindalee estimates that the McDermitt Lithium Project would provide about 1,000 construction jobs at peak development, 600 long-term local operational jobs, and up to 1,200 additional indirect jobs in a highly rural part of the state.[64] However, a large-scale mining operation will affect local fauna and flora, water resources, cultural resources and artifacts, and air quality. Mining companies in cooperation with local, state, and federal regulators, will need to plan for and operationalize mitigation efforts to address negative outcomes.

Just across the border in Nevada, the process to permit the Thacker Pass lithium mine took years and met considerable resistance, particularly from environmental organizations and west coast Paiute Tribes, who sued the federal government citing violations of federal environmental laws.[65] The lawsuit was not successful but illustrates that any permitting requests for a mine in Oregon would likely face high levels of scrutiny and longer timelines to develop while cases are heard in the court system.

Jindalee is collaborating with the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy to research ways to reduce water consumption and negative environmental effects from mining lithium at the Oregon site.[60] The Cooperative Research and Development Agreement provides funding along with in-kind support from Jindalee to research innovative lithium extraction technologies.

The McDermitt Lithium Project is still exploratory in nature, but if sufficient lithium deposits are discovered, it is likely that the company would move forward with permitting and approvals for a full-scale mining operation. As recently as November 2024, an assessment for Jindalee Lithium estimated that full-scale mining operations could begin as early as 2032 for the site, provided feasibility assessments are in line with projections.[66]

Critical mineral security and the Inflation Reduction Act

Provisions in the Inflation Reduction Act, along with strategic decisions from automakers to secure EV battery supply chains during COVID, were intended to reduce reliance on Chinese imports and create more certainty for investors.

- In order to be eligible for the federal EV tax credit, vehicles were required to use an increasing percentage of domestic EV battery assembly and components.
- The section 45X tax credit provided subsidies to battery production and component assembly companies.[76] From July 2022 (before the IRA passed) through Nov. 1, 2024, the number of battery assembly plants increased from 22 to 37.

Since then, amid shifting EV policies at the national level, the U.S. saw 11 battery projects canceled in the first half of 2025, representing investments totaling approximately $10.6 million dollars. This is in comparison to 13 battery projects canceled in all of 2023 and 2024 combined, totaling roughly $7 million dollars of investments.[77,78] It is uncertain how the rolling back of these pieces of the IRA will affect overall domestic battery production and assembly, but this and rapidly changing U.S. trade policies have dampened investor confidence.[79]

ADDRESSING BATTERY SUPPLY CHAIN CONCERNS

This section covers policies that address human rights and environmental issues, protect people and communities, enable the clean energy transition, and support a more secure and reliable critical mineral supply.[67]

These policies generally focus on four key areas:

- Improving human rights and environmental outcomes
- Diversifying supply chains
- Increasing supply chain transparency
- Supporting efforts that repurpose and recycle used batteries

Improving Human Rights and Environmental Outcomes

Countries often have existing policies setting environmental and social standards for mining and refining practices.[68] Influencing standards in other countries is complex and usually involves international trade policies or cooperative agreements.[69] For example, U.S. trade policies are designed to require or encourage certain human rights standards, labor practices, and environmental standards.[70–72]

There are dozens of policies supporting more stable critical minerals markets, mostly enacted by countries and/or the European Union.[68] The most common policies require the enacting country to create a list of key minerals and develop strategic plans that serve to strengthen critical mineral security, but some countries have also instituted polices that include trade mechanisms, international coordination, investing public dollars to secure access to minerals, or even stockpiling some minerals. Strategic plans can include recommendations on policies to reduce dependencies on sole source actors, develop trade relationships with key allies, and support domestic supply chain economies.[73] For example, the Biden Administration released "America's Strategy to Secure the Supply Chain for a Robust Clean Energy Transition" in 2022, which included recommendations to increase domestic mining and supply chain manufacturing and form trade alliances with diverse and reliable partners.[74] Executive orders from both the Biden and Trump administrations have encouraged domestic critical mineral development.[61,75]

Governments and businesses also play a role in reducing the effects of mining on greenhouse gas emissions, through reductions in energy consumption and using cleaner energy resources. While the challenge of reducing emissions in the critical mineral supply chain is great, there are policies in place, in both the public and private sectors, to encourage lower emissions. Most countries and many states in the U.S. have committed to achieving the emissions reduction goals of the Paris Agreement to prevent climate warming from exceeding 2°C.[vi,81,82] Some mining companies are indicating they will make efforts to reduce their emissions[81] and will likely continue to make investments in more energy efficient technologies and operations for their cost reduction benefits, which also reduce energy use and emissions.[40]

Increasing Supply Chain Transparency

All the opportunities listed here can be furthered with more transparency into the lithium-ion battery supply chain. Today, it is difficult to know where all materials and components in a battery were mined and manufactured, but many existing multinational policies aim to create more transparency in mining and refining supply chains.[68,83] Europe is leading in this space by establishing mandatory requirements for large companies to track and report on specific human rights and environmental metrics and requiring them to identify, prevent, and mitigate adverse impacts at their operations and along the supply chains they use.[84] Policies and programs that support more transparency at the different steps of the supply chains inform buying decisions, create more effective policies, and give consumers the ability to influence the choices of manufacturers.[85]

There is interest in this type of program in Oregon. In 2025, Oregon legislators considered a bill (HB 2425) that would have required certifications for EVs or solar panels procured by the state to indicate that no forced or child

[vi] *The 2023 IPCC reports that the 2 degree goal is still technically feasible, but the window is rapidly closing and the 2023 UNEP Emissions Gap Report put us on track for 2.5-2.9 degrees warming by 2100 with current national policies, including climate commitments.*[80]

labor was used in the production of the technology.[86] The bill was amended to create a task force to study how to develop these certifications, which passed out of committee on both sides of the Legislature, but ultimately did not receive a floor vote in either the House or Senate.[87]

Oak Ridge National Laboratory has been working on a methodology to track steps along the supply chain and encode the information into the goods that are produced: a Battery Identity Global Passport. The battery passport would provide consumers with supply chain information about the product, such as certifications that mining operations meet certain human rights or environmental standards, in the form of a scannable QR code or computer chip applied to each battery, similar to how plastics have numbers printed on them that identify their makeup.[88] This standard is being developed globally, and the European Union has made a battery passport mandatory beginning in early 2027.[89]

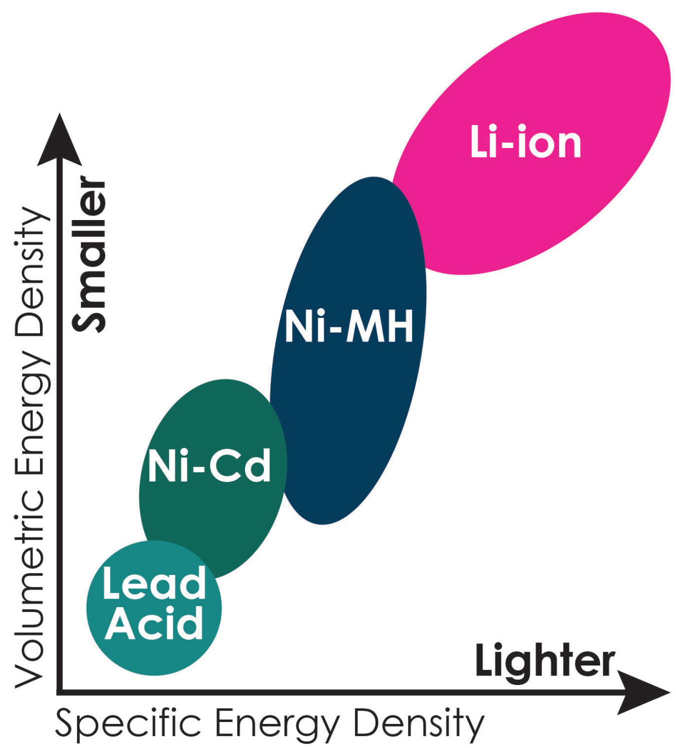
House Bill 2425 (2025) would have required certifications for EVs or solar panels procured by the state to indicate that no forced or child labor was used in the production of the technology.[86] While several legislators raised concerns about only addressing renewable energy products when there are exploitation issues economy-wide, proponents said that EVs and solar panels were singled out because the state has mandates that require the use of these technologies.[90] The House Labor and Workplace Standards Committee passed the bill after adopting amendments that would have created a task force to explore certifications and expanded the program to cover other technologies that use the same minerals.[91] HB 2425 moved to the Joint Committee on Ways and Means for budget consideration, but did not see further action before session adjourned.

Different Battery Chemistries to Address Supply Chain Concerns

One way to address supply chain issues is to develop batteries that use different minerals, especially minerals that are widely available in the U.S. or trade-friendly countries. Using different minerals means changing the battery chemistry, which will affect many factors, including: overall cost, battery pack monitoring and cooling systems, battery energy and power densities, safety, environmental and social concerns, and battery lifespan.[92] Optimizing for one or more of these factors often affects the other properties. The most common lithium-ion batteries in use today are each optimized for the needs of different end uses. For example, batteries in EVs are optimized to be very energy dense but also able to be charged and discharged quickly. The trade-off for this is that they are relatively costly to build and have more safety concerns than some other chemistries.

Lithium-ion batteries were the fourth commercially successful rechargeable battery type after lead-acid, nickel-cadmium (Ni-Cd), and nickel-metal hydride (Ni-MH), which are still available for some applications. One of the reasons lithium-ion has become so prolific is that it provides a lot of energy with very little weight. Figure 7 shows the relative energy to weight of different battery formats, and the position of lithium-ion batteries shown in the upper right indicates they hold more energy per size (volumetric energy density) and more energy per kilogram (specific energy density) compared to lead-acid, Ni-Cd, and Ni-MH batteries.[93]

FIGURE 7: Comparison of energy densities and weights of different battery types



Lithium iron phosphate (LFP) batteries were invented at the University of Texas at Austin in the 1990s.[97]

> The U.S. Departments of Energy and Defense approved a grant for an Australian mining company to produce battery-grade manganese in southern Arizona. Production is expected to begin in 2027.[103]

Lithium-ion does not indicate a specific chemistry but rather batteries that comprise a family of chemistries using lithium as part of the battery cathode material. Lithium nickel manganese cobalt oxides (Li-NMC) and lithium iron phosphates (LFP) are the two main chemistries used within the Li-ion family, with 60 percent and 30 percent of the market respectively.[94] These battery types are named after the elements used in the cathode.

Lithium iron phosphate batteries are safer, charge faster, and cost less to produce than Li-NMC batteries.[15] The LFP chemistry has a lower energy density comparatively, but adding manganese to LFP (making them LMFP) increases the energy density.[95] It is anticipated that continued development of LMFP will reduce the nickel-based battery market share in the future, and thus the demand for nickel and cobalt.[96]

Different chemistries are being researched today and could be commercially viable options for different end uses in the future. Table 2 shows a few chemistries that are currently in use or are being studied and their comparative attributes.

Using iron and phosphorous reduces dependence on nickel and cobalt, which in turn reduces the negative environmental and societal effects and improves economic benefits for the U.S. and several other countries. The U.S. actively mines iron for steel production and is the third largest producer of phosphate (the source ore for phosphorous), largely for use in fertilizers.[99–101] Manganese is a widely available mineral, most of which is produced in South Africa, Gabon, and Australia. The U.S. has several inactive manganese mines but because of the rise in LFMP demand, some investors have signaled interest in re-opening them.[102]

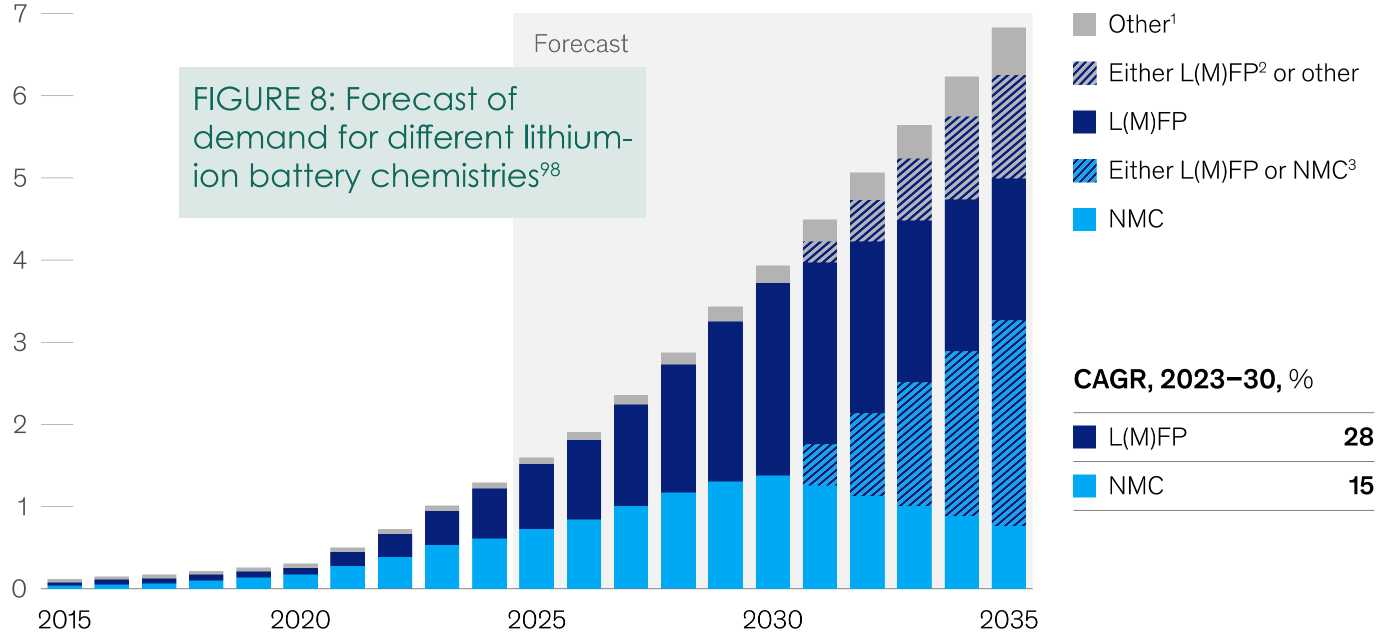
A great deal of research is being done develop non-lithium-based batteries. This is being driven by the U.S. DOE and other federal entities in an effort to reduce dependence on foreign supply lines, as well as by companies and entrepreneurs looking at ways to improve the cost, sustainability, and/or performance of batteries.[104,105] The rest of this section covers some of the most prominent research happening today.

TABLE 2: Features of batteries by chemistry[15]

Battery Chemistry	Energy Density	Charging Rates	Safety	Cost
Nickel Lithium Manganese Cobalt Oxide (NMC)	⚡⚡⚡⚡⚡⚡	🚗🚗🚗🚗🚗	♥♥♥♥	$$$$
Lithium Iron Phosphate (LFP)	⚡⚡	🚗🚗🚗🚗🚗🚗	♥♥♥♥♥♥	$$$$
Lithium Nickel Cobalt Aluminum Oxide (NCA)	⚡⚡⚡⚡⚡⚡	🚗🚗🚗	♥♥♥	$
Lithium Titanate (LTO)	⚡	🚗🚗🚗🚗🚗🚗	♥♥♥♥♥♥	$
Lithium Cobalt Oxide (LCO)	⚡⚡⚡⚡	🚗🚗🚗	♥♥	$
Lithium Manganese Oxide (LMO)	⚡⚡⚡	🚗🚗🚗	♥♥♥♥♥	$

**Energy Density is the amount of energy a battery can store relative to its size or weight*
***Cycle Life is the number of times a battery can be charged and discharged over its expected lifetime*

FIGURE 8: Forecast of demand for different lithium-ion battery chemistries[98]



[1]Including sodium-ion and other lithium-ion chemistries.
[2]Lithium manganese iron phosphate, or L(M)FP, is a type of lithium-ion battery with a manganese and iron phosphate-based cathode active material.
[3]Nickel manganese cobalt, or NMC, is a type of lithium-ion battery with a nickel, cobalt, manganese mix oxide-based cathode active material.
Source: McKinsey Battery Insights

Figure: McKinsey and Company

Solid-state batteries

Solid-state batteries are one of the most anticipated advancements in battery technology. As the name suggests, solid-state batteries have a solid electrolyte rather than liquid, which makes them lighter, safer, able to charge faster, and have a longer lifespan than current Li-ion batteries. A drawback to solid-state batteries is that their electrolyte degrades during normal battery use. A recent paper published by MIT researchers points to a possible source for the degradation, and this would need to be overcome before solid-state batteries could be scaled up and commercialized.[106–108]

Sodium

Sodium is the primary candidate for a new cathode chemistry, because it is chemically similar to lithium but is naturally abundant, easily mined, and costs less. Research shows batteries using sodium perform better in low temperatures. The U.S. DOE's Argonne National Laboratory invented and patented a new cathode material using sodium, and the lab is currently testing its performance.[109] Sodium is about three times heavier than lithium, and this reduces vehicle range. However, these batteries could be a cost-effective option for vehicles that don't need to travel far.

Silicon

Silicon is being studied as a replacement for graphite in the anode. Like sodium, it is readily available and improves performance.[110] In fact, these batteries have remarkably high energy density. Much like solid state electrolyte materials, batteries using silicon in the anode are damaged from expansion and contraction during charging that creates cracks, resulting in a relatively short life. Nanotechnologies – molecule-sized structures or devices – are being studied as a means to address this issue in silicon anode-based batteries.[111]

There are many other promising alternative chemistries, each with different benefits and challenges. It is foreseeable that alternative chemistries will be beneficial in different applications. For example, sodium-based batteries might be better suited to local delivery vehicles, port equipment, and some transit or school buses, and solid-state batteries might support longer-range-vehicles such as trucking. In addition, because many of these alternative chemistries rely on more domestic minerals, they could provide economic benefits for local communities from jobs to local tax revenues from businesses supporting the different supply lines. With domestic materials, the U.S. would see economic and trade benefits of the growing global clean energy economy, reducing reliance on foreign resources.

RECYCLING AND REUSE: THE SUM OF ITS PARTS

Over their lifetime, batteries will lose their charging capacity, slowly reducing the amount of power they can provide on a single charge. While EV batteries are lasting longer than expected, and longevity has improved about 22 percent in the last five years, at some point, they and other lithium-ion batteries, will no longer be able to perform the function for which they were built.[112,113] The ultimate demise of batteries is of concern, because in some cases, there are limited options for disposal, and when improperly disposed of, pose a fire risk and other safety hazards. However, batteries may be more valuable to repurpose and eventually recycle than to simply throw away. For example, nearly all lead-acid batteries used in vehicles are recycled today.[114] Programs are already ramping up to collect used lithium-ion batteries, and the basis of work like this would be a precursor to more sustainable circular battery economy.

MAKING BATTERIES LAST LONGER

Making batteries last longer not only reduces the need to build as many new batteries but also helps consumers get the most out of their battery powered goods, saving them time and reducing waste over time. Battery longevity can be improved during manufacturing but also in the way consumers use their battery-powered technologies.

Manufacturers include Battery Management Systems in larger rechargeable batteries, like those in EVs and energy storage systems, to ensure the battery operates efficiently, safely, and reliably. These systems monitor and make small adjustments to voltage, current, temperature, and other critical parameters that extend battery lifespans by preventing overcharging, over-discharging, overheating, and other dangerous, damaging, or faulty conditions.[115,116] The narrow area in which lithium-ion batteries operate with safety and reliability necessitates the effective control and management of battery management systems. There is active research on options to improve the performance of Battery Management Systems, including using artificial intelligence to step up the technology's performance to provide more protective actions that further lengthens the battery lifetime.[115–118]

Lithium-ion batteries can last from 300 to 15,000 full charging and discharging cycles, depending on how the battery is used.[119] Consumers can get more cycles out of their battery by protecting it from physical damage and extreme temperatures, but also by optimizing charging practices that minimize degradation. For example, fully charging and discharging puts more stress on a battery, so studies indicate maintaining the battery charge between 20 and 80 percent is preferred.[120] Following the EV manufacturer's best practices not only extends the battery life and enhances performance but also saves consumers money by delaying the need to replace the battery and getting the most efficient use of the critical minerals used to build it.

Supporting Efforts that Repurpose and Recycle Used Batteries

Beyond policies addressing supply chain concerns, there is increased focus on establishing a battery recycling economy, so that the minerals that exist in today's batteries can be recovered and reused. The U.S. and Europe are developing policies to encourage more robust recycling and repurposing of batteries and other products made with these minerals.[84]

Redwood Materials is a lithium-ion battery recycling company with two facilities in the U.S. that processes the equivalent of 250,000 EV batteries a year. Redwood Materials' business model has an environmental focus, dismantling batteries without sending anything to landfills or creating any wastewater from the recycling process. The operations are 100 percent electrically powered, relying solely on clean energy without using natural gas or other fossil fuels.[122] The company operates facilities in Nevada and South Carolina, with production scaling rapidly and a goal to recover enough materials annually to produce more than a million EV batteries. It is also in the process of building a research and development center in San Francisco.[123–125]

Photo courtesy of Redwood Materials

When performance no longer meets user needs, an assessment of all the components will determine if the battery is repairable or needs to be replaced. Most larger batteries are built from cells, which are packaged together into modules, which are then further packaged into packs. Problems in a few cells will negatively affect the whole assembly's performance. Assessing the condition of the batteries' sub-assemblies is critical and must be done without compromising the battery itself, usually using electrical test equipment and even x-rays.[121] If a particular failure is identified and can readily be replaced, it can be repaired. Otherwise, the whole battery must be replaced.

There are three options for a used lithium-ion battery: repurpose, recycle, or disposal. While Oregon does not have laws requiring lithium-ion battery recycling, most EV manufacturers have committed to programs that will repurpose or recycle old batteries.[126] Volkswagen, Toyota, Ford, and the ridesharing company Lyft partner with the lithium-ion battery recycling company Redwood Materials to recycle their used lithium-ion batteries.[127] Tesla and General Motors have their own battery recycling commitments, with GM also providing guidance to mechanics on how to properly recycle used EV batteries.[128,129]

Second Life Applications

When batteries no longer suit their original purpose (especially in vehicles), reuse can provide additional value where there is demand for other energy storage applications that do not need as much charge. As markets mature, second-life batteries are estimated to be 30 to 70 percent less expensive than new ones for similar applications, tying up significantly less capital per cycle.[130] Lithium-ion battery repurposing is in the early stages of development, with recycled batteries currently limited to only a few applications. However, the potential market is very large, with a forecast from IDTechEx showing the market growing to about $4.2 billion by 2035.[131]

The modular design of lithium-ion batteries creates different options to dismantle and repurpose the different components, depending on where failures are located. Each component can be tested for performance, which will inform how and for what applications the battery can be used. The more the battery must be disassembled, the higher the cost to repurpose, which means repurposing companies have the potential for multiple value streams even if some components are not reusable.

Today, lithium-ion batteries are largely repurposed as mobile uninterrupted power supplies, like for mobile EV chargers, large outdoor events with limited nearby power sources, and for telecommunications towers.[132] However, this mobile power supply function is also needed for other applications such as backup power for data centers, homes, businesses, and industry. Grid operators can use them to reduce peak electricity demand, store renewable energy, and provide other grid stability functions like frequency regulation and voltage support. These batteries could also be repurposed for low-speed vehicles like golf carts and forklifts.[133]

Despite the broad potential market for repurposed batteries, there are challenges to a profitable business model. Lithium-ion batteries are classified as hazardous materials because of their corrosive and flammable electrolyte, and are therefore more expensive to transport. Although fires are rare, they can be difficult to deal with and may trigger a chain reaction if stored en masse.[133] Battery modules vary vehicle-to-vehicle, and these differences (form factor, chemistry, etc.) require skilled labor to sort, disassemble, test, and rebuild. The Battery Management System used in its automotive application is likely not appropriate for second-life use and would need to be recycled or disposed and a new system installed.[133] These re-configured units will also likely be subject to recertification of safety standards such as UL listing. These repurposed batteries will also be competing with new batteries, the cost of which has steadily declined.[134]

End of Life and Recycling

Once a lithium-ion battery can no longer be repaired or repurposed, it can be recycled to recover the minerals. There are different methods of recycling batteries; each comes with different costs and environmental considerations. Recycling requires energy, which has associated greenhouse gas emissions, and it often uses processes that can have associated air and/or water pollutants. Research to address these environmental effects is happening in multiple venues.[135] Argonne National Lab, in collaboration with Toyota, is studying ways to reduce costs and the environmental footprint of the entire lithium-ion battery recycling process.[136] Researchers at Rice University are using microwave radiation to improve lithium recovery.[137] There are even companies focused on designing batteries that are easier to recycle and can take better advantage of recycled materials.[138]

The two most common practices for battery recycling in the U.S. are:

Smelting

Smelting (pyrometallurgical) starts with shredding or crushing the battery then heating to 1,200–1,800°F, which enables separation of different materials. This method is energy intensive and because it has been adapted for lithium-ion battery recycling, it does not recover much of the lithium or non-metal components. It is expensive, has associated greenhouse gas emissions, and has the most negative environmental impacts of recycling options.[139]

Leaching

Leaching (hydrometallurgical) also starts with some sort of sorting or crushing but uses chemical solutions to separate the cathode metals. It is less energy intensive, cheaper, and has fewer air pollutant emissions, but the effluent produced requires wastewater treatment.[123] Leaching is currently the only potentially economically viable method and is therefore used in most commercial recycling operations.

A new option in the research and development phase is direct recycling, which does not try to recover individual minerals but only disassembles the components for refurbishment and reuse. A collaboration of universities and several U.S. DOE National Laboratories are working on multiple projects to address the challenges to direct recycling.[140] The focus of these efforts is to identify pathways for recovery and refurbishment with fewer emissions and pollution compared to other recycling methods. These projects could provide cleaner and more economical ways to refurbish different components of lithium-ion batteries.

Recycling battery components has significant environmental benefits. A 2025 Stanford University study found that current recycling practices to recover battery minerals emit less than half the greenhouse gases of mining and refining new minerals and use about one-fourth of the water and energy.[141] Recovering scrap materials from the batteries for reuse has emissions savings of nearly 80 percent, and uses nearly 90 percent less water and energy use.

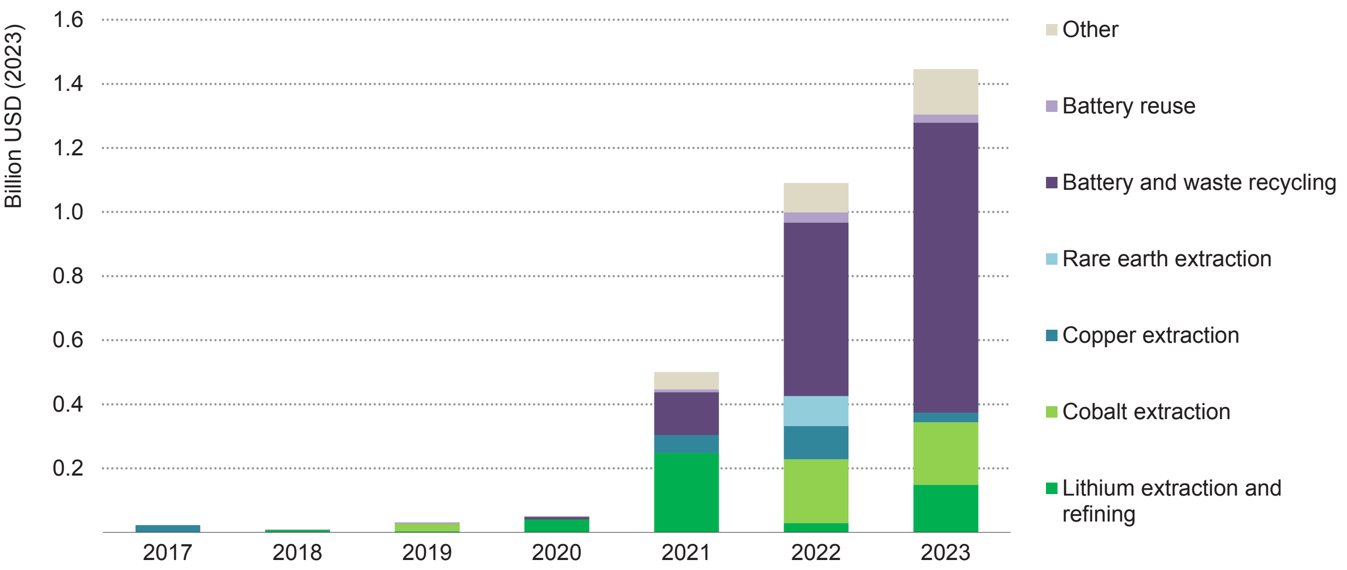


FIGURE 9: Early- and growth-stage venture capital investments in critical mineral start-ups[142]
Figure: IEA

The recovery of critical minerals from used batteries is attracting significant financial investments. Critical mineral sector venture capital investments in the past several years are shifting from mining and refining toward recycling and reuse of batteries.[142] Figure 9 shows that prior to 2022, most venture capital investments in this area were for the extraction of critical minerals. Battery reuse and recycling start-ups now comprise a much greater share.

Recycling and refurbishing economies are an important step in driving toward a circular economy, where a closed loop system of resources and materials can be self-sustaining. Several companies in the U.S. are working toward developing these systems. As mentioned above, Redwood Materials, a battery recycling business started by Tesla co-founder JB Straubel, is partnering with Toyota to develop a closed loop battery manufacturing process.[123,127] California-based SVX is creating a new way to produce the materials in battery cathodes, which contain many of the most expensive critical minerals.[143] Its process produces cathodes from less energy- and resource-intensive critical mineral resources, and can also be recycled but allows other feedstocks (raw materials for production) to be used in cathode manufacturing. Onto Technology based in Bend, Oregon has developed a "Cathode Healing" process that would refurbish used cathodes for reuse rather than the more energy-intensive recycling process.[144]

Oregon Innovation: OnTo Technology

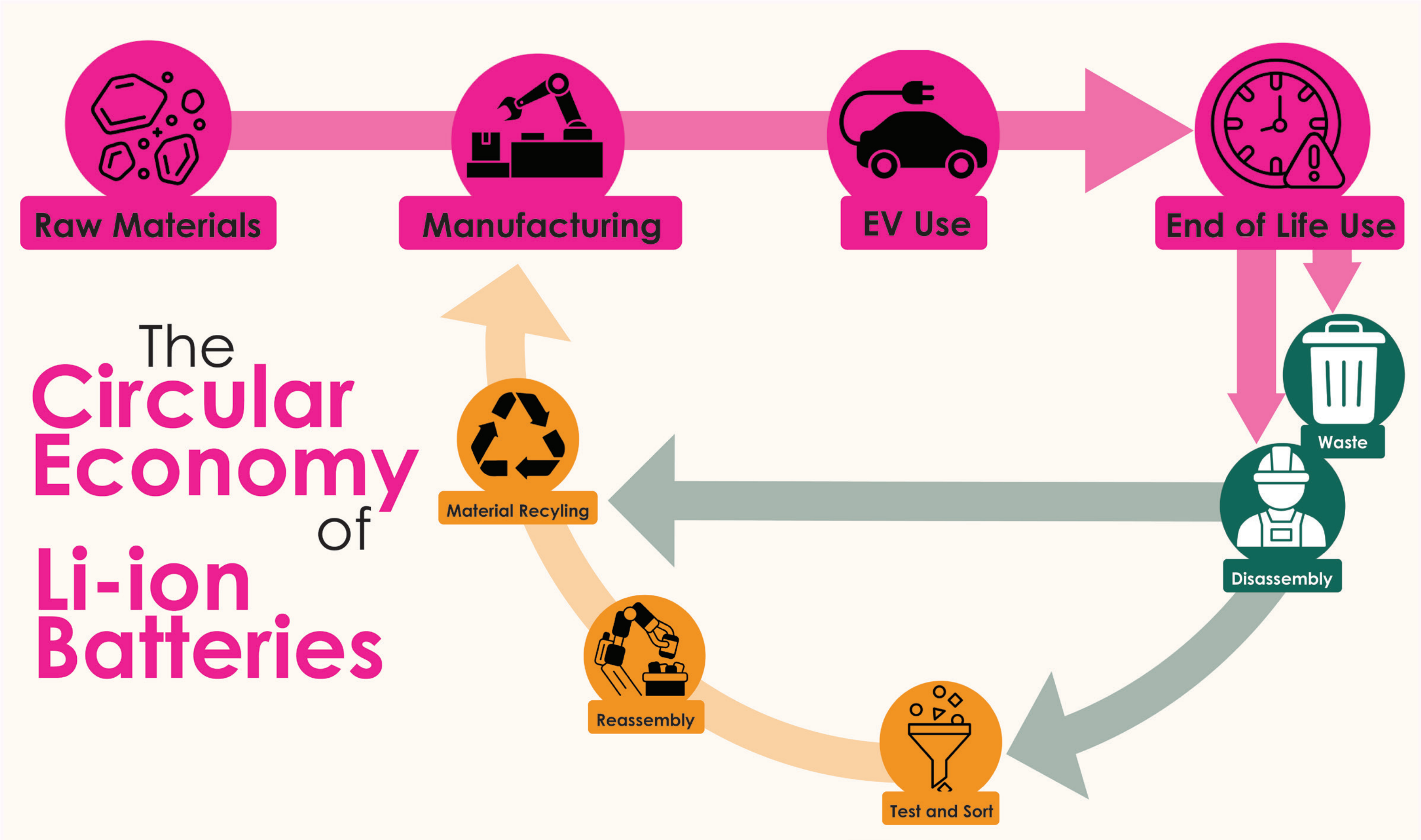
Founded in 2004, OnTo Technology is a Bend-based company developing battery rejuvenation techniques for batteries with different cell shapes and intelligent recycling technologies, including:

- Lithium Iron Phosphate Recycling for industrial approaches
- Battery deactivation to remove hazardous characteristics of batteries allowing for cost effective collection, transportation, and processing while recovering materials
- Electrolyte Recovery to remove the lithium-rich electrolyte from whole cells, maximizing value
- Cathode Healing to refurbish the cathode for use in new batteries
- On-site cathode healing to improve efficiency in manufacturing.

Direct recycling allows recovery of the valuable materials within a battery for reuse, without destroying the original chemical structure.

Steve Sloop, the founder and president of OnTo Technology, was a lead inventor of direct recycling of lithium-ion battery cathode materials

FIGURE 10: Circular economy for lithium-ion batteries



A Circular Economy for Batteries

Lithium-ion batteries can readily be incorporated into a circular economy; the materials and resources used in the batteries can be recycled back into the economy because they retain value even when the battery itself is no longer functional. This stands in contrast to most economic pathways for goods or energy today, where resources are extracted, manufactured into products or fuel, used, and then discarded — or in the case of fuels, utterly consumed. The benefits of a circular economy are numerous, from reduced dependence on resources, fewer negative effects from resource extraction and processing, and retaining more money in local communities. Efficient and cost-effective recovery and reuse of battery components, materials, and critical minerals is ideal. It reduces reliance on foreign-mined resources and supply chains; supports the use of zero-emission technologies like EVs that improve air quality; and the repurposing, refurbishing, and recycling activities needed can provide jobs and support local economies.

Developing circular economies can greatly reduce the amount of raw materials mined and processed. A study by the International Council on Clean Transportation estimated that over one million EV batteries would reach end of life each year by 2030, and about 14 million per year by 2040.[9] With this supply of batteries, the The council found that by 2050, mineral recovery from batteries could reduce total mineral demand 28 percent.[145] A study by the Institute of Circular Economy at the Beijing University of Technology found that if the European Union's battery regulation – a rule to create a circular economy for batteries in Europe – were implemented globally, mined lithium consumption could be reduced more than half by 2050.[146,147]

Repurposing and recycling businesses must currently contend with a small supply while simultaneously preparing for significantly more used battery feedstocks in the next 5-10 years. The limited amount of used EV batteries limits revenue, and investment is needed to ramp up production in the coming years and reduce operational costs. Joint ventures between recyclers and battery manufacturers provide businesses with more certainty in future feedstock supply. When these also include agreements from manufacturers to purchase the recycled or refurbished materials, it provides additional certainty in future revenue sources.[148]

More policies are needed to ensure that the value of used batteries is not wasted. A 2025 Stanford University study in found that Europe and China have policies and clear guidelines on managing batteries at the end of their functional lives, but the U.S. has no national policies requiring battery repurposing or recycling.[145] Nineteen states have some form of battery recycling requirements, and 19 others require producers to offer or fund battery recycling. There are no state laws that require lithium-ion battery recycling in Oregon.

Federal governments, states, private companies, and coalitions are taking on challenges throughout this industry. Improvements in production, performance optimization, second life uses, and recycling are helping to build the foundation of a circular economy for lithium-ion batteries.

The industry can become more sustainable, circular, and resilient along the entire value chain through a combination of collaborative actions, standardized processes and regulations, and greater data transparency. The Global Battery Alliance is one such collaboration of international organizations, including NGOs, industry companies, academics, and multiple governments whose goal is to drive systemic change along the entire value chain. Some actions taken by this group are establishing the global criteria for Battery Passports, working to ensure critical materials are sourced, processed, manufactured and recycled in a manner that protects human rights, minimizes environmental impacts, and creates benefits along the value chain, and to promote circularity in the industry.[150]

The conundrum of battery manufacturing standardization

Batteries from different manufacturers and for different purposes often have very different designs, which makes disassembly, refurbishing, and recycling a complex task. Safety is paramount to the process, since the components of batteries are toxic and highly flammable. Recycling businesses use a highly skilled workforce, but it would be easier if all the batteries were built the same way. Standardization of assemblies would reduce costs for recycling, but this might also stifle innovation. The battery industry is changing so fast that standardization requirements could unintentionally limit advancements in battery design. In the near term, recyclers will need to decide whether to invest in processes to incorporate new battery technologies or specialize in specific battery formats.[148,149]

CONCLUSION

The use of lithium-ion batteries is evolving to address many of the challenges that exist today, from improving transparency in battery mineral and component supply chains and establishing policies that encourage mining and manufacturing practices with better outcomes for people and the environment. Where negative effects cannot easily be addressed, institutions and businesses are looking at alternative battery designs that rely on resources that are more widely available, less costly, and have fewer negative side-effects. New battery chemistries along with repurposing and recycling used batteries can create economic benefits in the U.S. while also reducing reliance on foreign commodities and the risk that the goods consumers rely on come with negative human rights and environmental consequences. Today, many businesses, governments, institutions, and organizations are actively supporting the development of a more sustainable circular battery economy that gets the most value out of the minerals that have already been produced while also reducing the overall need for more mining and refining. Additional support and focus on these activities are important to ensuring the technologies that Oregonians rely on to communicate, conduct business, be more resilient, and enable the clean energy transition are more beneficial for all.

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Charging at The Fruit Company in the Hood River Valley

OPPORTUNITIES TO MANAGE GROWING ELECTRIC VEHICLE LOADS ON THE GRID

KEY TAKEAWAYS:

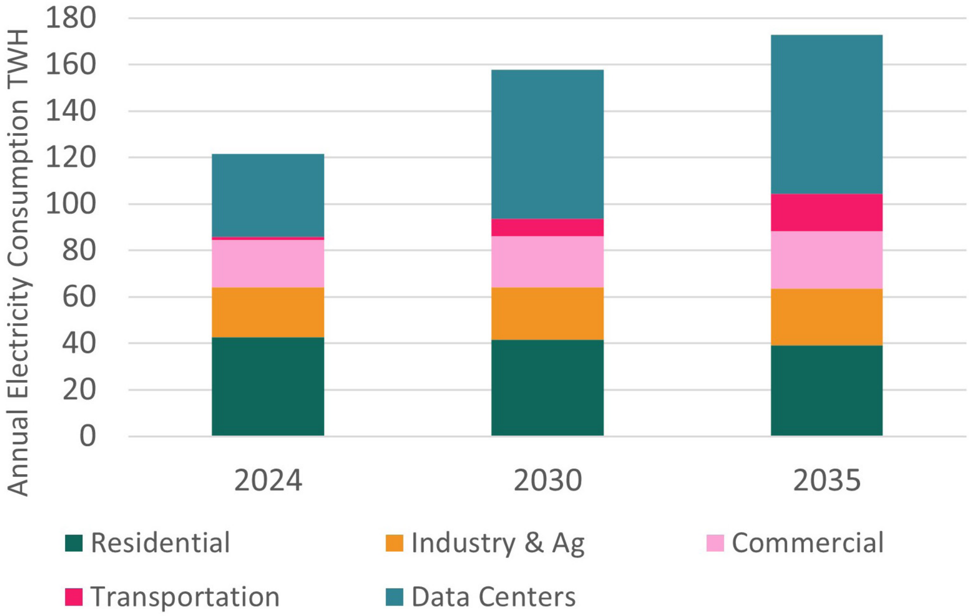
- Demand for electricity is growing, driven primarily by data centers and electric vehicles.
- Electric vehicle charging can be a flexible load, meaning many EV owners can shift charging from periods of high demand on the electric grid to periods of low demand, which enables utilities to better balance supply and demand.
- Many utilities have created programs to encourage charging at times that minimize negative effects on the grid while also helping get more out of other resources – like solar and wind.
- In the future, electric vehicles may play a role in supporting grid operations, improving energy resilience, discharging energy back to the grid during periods of peak demand, and reducing costs associated with adding new generation and transmission resources.
- Planning and policies are needed to ensure that utilities, ratepayers, and all Oregonians benefit from EV load management outcomes.

INTRODUCTION

Demand for electricity is growing rapidly, driven mostly by new industrial developments like data centers and electric vehicles.[1] This increase in demand is seen in electric utility integrated resource plans and the regional forecast developed by the Northwest Power and Conservation Council, which is then reflected in Oregon Energy Strategy modeling. The modeling is an assessment of future energy needs for Oregon, taking into consideration existing forecasts for population growth and economic development, and technology adoption trends such as assumptions about electric vehicles, building electrification, and data centers.[2] Like other long-range energy models, the Oregon Energy Strategy must grapple with uncertainties, such as future trends in vehicle miles traveled, the scale of data center loads from AI computing, and many others. However, models are a valuable tool to consider existing conditions and understand possible trajectories of future loads. Model results shown in Figure 1 point to significant load growth from data centers and electric vehicles through 2035.[1] Data centers represent the largest component of electricity load growth (about 32 TWh load growth from 2024 to 2035), while electric vehicle loads also grow but represent a much smaller share of total energy (about 15 TWh load growth from 2024 to 2035). In a decade, electricity consumption is forecasted to grow from 80 TWh to about 125 TWh, an increase of over 50 percent.

A terawatt-hour (TWh) is equivalent to 1,000 gigawatt-hours, 1,000,000 megawatt-hours, or 1,000,000,000 kilowatt-hours. One kilowatt hour can run a 300-watt refrigerator for one hour.

FIGURE 1: Oregon Projected Electricity Consumption Through 2035 by Sector[1]



DEMAND RESPONSE

Utility programs that coordinate customer actions to reduce electricity consumption during periods of grid constraints are referred to as demand response. For example, some EV charging loads can be voluntarily delayed by utility customers to better match grid conditions. When the utility announces a demand response event, program participants may delay charging to another time or may opt out of the event and charge their EV anyway.

Utility generation, transmission, and distribution infrastructure has historically been sized to accommodate the largest, or peak, loads on the system. When new loads are added that occur during periods of peak electricity demand, such as hot summer evenings, it may prompt a need for more generation, transmission, or distribution infrastructure. In Oregon, utility demand response programs tend to call events in summer evenings to help address these high-cost, high-risk hours.

MANAGED CHARGING

In addition to demand response, Oregon electric companies have been developing managed charging, which shifts EV charging nearly every day to times when electricity demand is lower. This enables utilities to get more use out of existing grid infrastructure and reduce the need for new investments that increase ratepayer costs. In the future, EVs may be able to help supply electricity to the grid – known as vehicle-to-grid, or V2G – providing a supply resource during periods of peak electricity demand.

Find out More! You can read about topics in this chapter in the [2024 Biennial Energy Report](), including:

- Peak Electricity Demand
- Electricity Rate Increase Drivers
- Clean & Efficient Vehicle Technologies

Both demand response and managed charging programs serve as a partnership between utilities and customers to manage grid resources and share financial benefits. Portland General Electric had more than 188,000 residential customers in its demand response programs in 2023 and forecasts more than 250,000 participants by 2026.[3] In total, all of PGE's demand response programs are expected to deliver 162 megawatts of summer peak capacity by 2030.[3] For reference, 248 MW is about the same power output as the River Road natural gas power plant in Vancouver, WA[4], or the same as the annual average amount of electricity supplied by Eugene Water and Electric Board.[5]

Existing EV Managed Charging Programs

Managed charging and demand response can take many forms, from programs offering cost savings that encourage customer actions to direct utility control of devices like EV chargers or appliances like electric water heaters. Today, several Oregon utilities offer programs that encourage customers to change their charging habits, such as offering discounted rates for charging during off-peak hours (passive measures). Many utilities also run pilot programs that allow grid operators to directly manage EV charging (active measures) as a means to better balance grid supply and demand. These customer opt-in programs help utilities learn more about how EV batteries can be used for grid management and still meet customer charging needs. The following section will explain two such programs, how they work, and the relative benefits for utilities and customers.

Time-of-Use Rates

Time-of-use rates, or TOU rates, are a common type of EV load shifting program offered by utilities. While many residential rate plans in Oregon charge the same rate for electricity regardless of the when it is used, time-of-use rates have electricity prices that vary depending on the time of day. They provide a financial incentive for customers to shift consumption from periods of high demand, when utility costs are higher, to periods of less demand, when costs are lower. This gives customers the opportunity to save money on their energy bills by charging their EV – or any electrically powered items – during off-peak hours. Most new EVs and smart chargers[i] have a feature that allows the user to program a start time for charging, providing a set-it-and-forget-it option to take advantage of low electricity rate times.[7]

Time-of-use rates are available from several electric utilities in Oregon and may differ to help each utility meet its specific electricity demand needs. For example, Idaho Power's time-of-use rates vary by season as well as by day of the week and time of day. The seasonal variation in rates enables Idaho Power to better manage their peak electricity periods which occur in the summertime.[8,9] PGE and Pacific Power have consistent rate schedules all year, reflecting Oregon's two seasonal electricity peaks, one in summer and another in winter. Pacific Power's rate plan has a single peak period from 5-9 p.m. every day of the week, as shown in Figure 2.[10]

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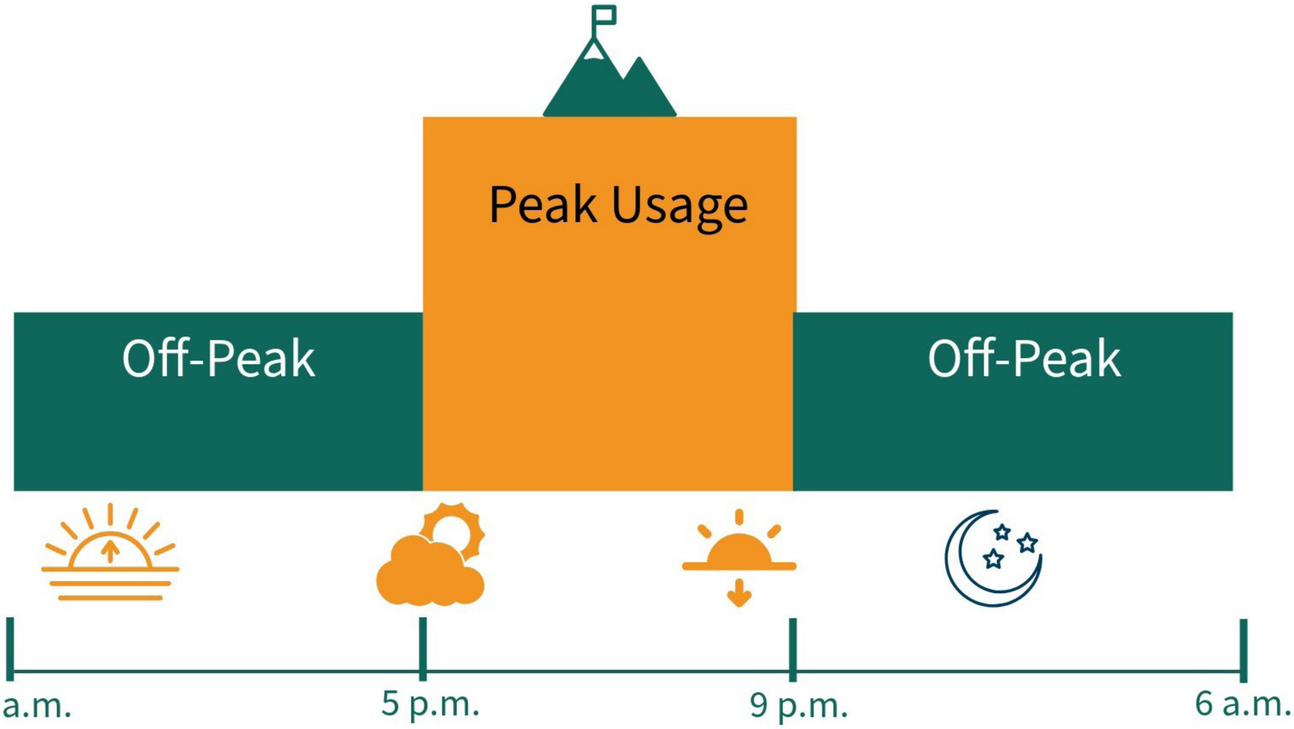
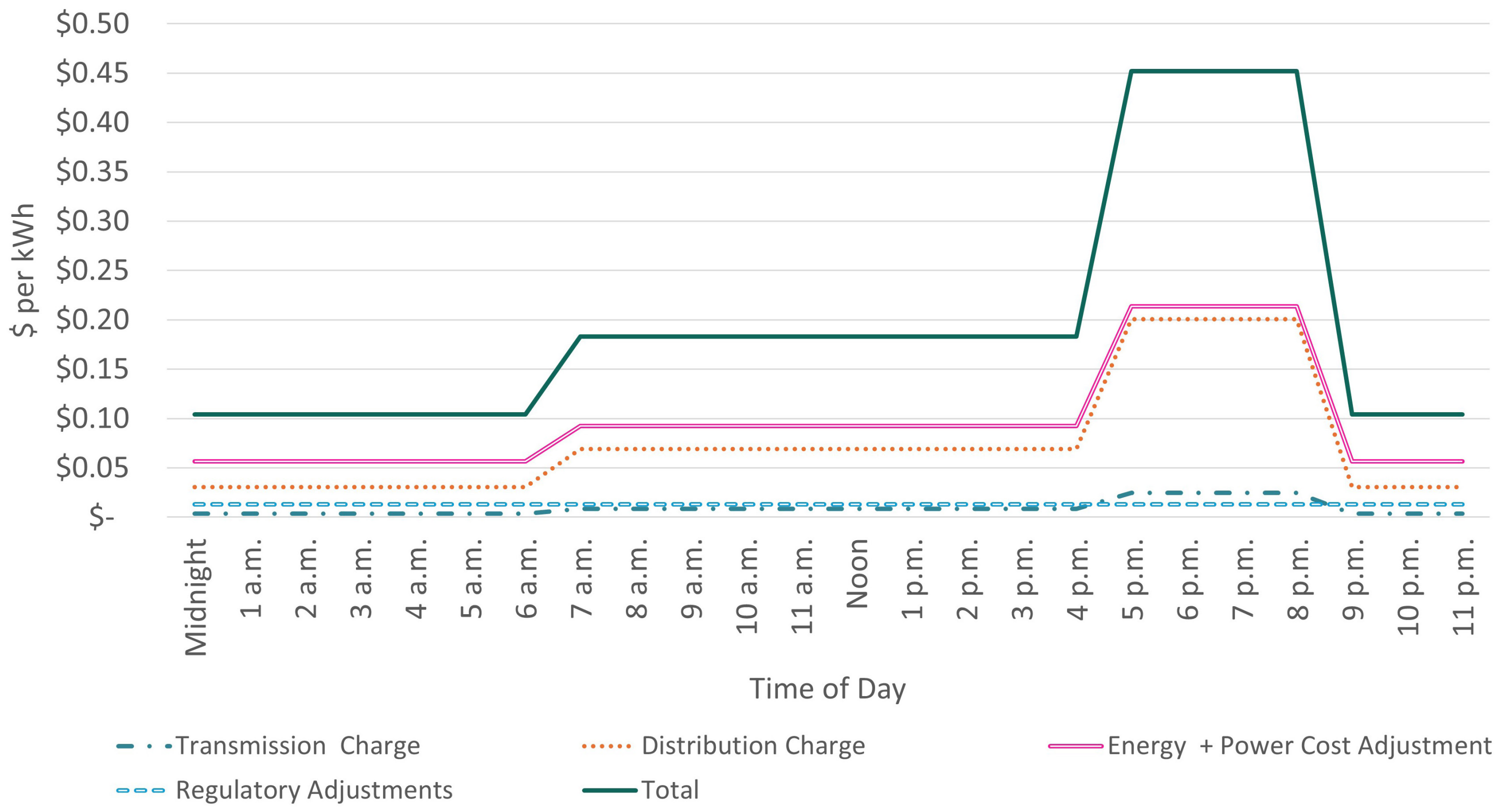
i Smart chargers are Wi-Fi enabled EV chargers that allow the customer to schedule charging times, offer remote access and monitoring, and may interact with other home management systems. Some smart chargers also allow periodic utility access and control for active managed charging programs.[6]

FIGURE 2: Pacific Power Time-of-Use Rate Schedule[11]



Portland General Electric also has a tiered time-of-use rate plan, offering three rates at different times of the day during the week, with the lowest rates in the overnight hours.[12] Weekends and holidays are also considered off-peak. Figure 3 shows PGE's residential rate schedule broken out into the different components that make up the costs. The top line represents the total cost, which is largely driven by the costs for energy and distribution while transmission costs make up a small proportion of the overall costs. This breakdown could look different for other utilities, and they can structure rates to address their unique costs, considering how many of the resources they own or contract for compared to how much they rely on market purchases.

FIGURE 3: Portland General Electric Time-of-Use Rate Schedule[13]



How much can you save by enrolling in a time-of-use rate for EV charging?

Customers with flexible EV charging schedules can save money with time-of-use rates. ODOE found that customers would pay about $703 per year on PGE's standard residential rate plan to charge their EV, compared to $395 (about 44 percent less) per year for off-peak charging on the *Time of Day* rate.[i] To save this money, customers need to charge between 9 p.m. and 6 a.m.[12] EV drivers using the Time-of-Day rate benefit from lower energy costs on their bill. Utilities benefit from additional revenue being generated while minimizing the investment costs for additional infrastructure, which keeps rates low for all customers regardless of whether they charge EVs at home.

TABLE 1: ODOE Assessment of Electricity Cost Savings Using PGE's Time of Day Plan Compared to Standard Residential Rate[13]

Scenario 1: Start Charging at 9 p.m.	Cost	Default Residential Plan	Cost
Energy Charge	$265	Energy Charge	$404
Transmission and Distribution Charges	$130	Transmission and Distribution Charges	$299
Total Annual Cost	**$395**	**Total Annual Cost**	**$703**

i Costs are based on PGE's residential Tariff 007[12] and include rate adjustments as of June 1, 2025.[14] The analysis assumes an annual EV electricity consumption of 3,800 kWh[15] and a 7 kW charging rate, which is typical for a level 2 charger.[16] Under this scenario an electric vehicle will consume 10.4 kWh on an average day and take a little over two hours to recharge.

Active Managed Charging

Utilities can play an active role in managed charging programs to maximize benefits from flexible EV charging loads. Unlike time-of-use rates, which rely on customer actions to change charging times, active managed charging allows the utility to directly operate a customer's EV charger. Because utilities continuously monitor grid conditions, grid operators are uniquely positioned to determine when it is most effective to shift EV charging loads. Customers voluntarily opt-in to active managed charging programs and can opt-out at any time if desired.

Portland General Electric and Pacific Power have developed managed charging pilot programs.[17,18] Pacific Power's Transportation Electrification Managed Charging pilot provides customers up to $100 for their first year of enrollment to temporarily pause their vehicle charging for up to 5 minutes at a time. Participants can choose to opt out of any managed charging event if it interferes with their transportation needs. The annual incentive may be reduced depending on the number of events a customer opts out of during the year. The pilot is expected to launch September 2025. PGE's program, which began in 2021, operates similarly, providing a $25 bill credit twice a year if participants meet certain criteria.

PGE's program also offers one-time rebates for the purchase of qualifying materials including:

- Up to $300 for a qualified level two charger (up to $1,000 if a customer is income qualified)
- Up to $1,000 if the customer requires an upgrade to their electric service panel (up to $5,000 if a customer is income qualified)
- $50 for customers who enroll with a previously purchased eligible charger
- $50 for vehicle telematics required to enroll a Tesla.

Time-of-use rates and active managed charging programs have different considerations for customers and utilities. Time-of-use rates encourage customers to shift their electricity use to off-peak times every day, which may provide benefits even if there is not a system peak. Customers who choose time-of-use rates can realize financial benefits on every electric bill by charging their EV(s) and running other loads, such as laundry and dishwashers, during off-peak periods.

On the other hand, managed charging allows utilities more direct control over impacts to the electric grid, creating a more surgical option to balance peak supply and demand. Managed charging reduces the need for customer actions except when they choose to opt out if a charging pause is initiated by the utility at an inopportune time. Managed charging also requires a customer to use a charger that is capable of direct communication and control by the utility. Utilities can design programs that best support grid management, and customers can choose the best available programs to meet their needs and lifestyle.

EMERGING OPPORTUNITIES

Electric vehicle batteries offer an increasingly large amount of stored energy that could be used by utilities to manage their systems.[19] Vehicle-to-grid, or V2G, programs leverage electric vehicle batteries, using designated amounts of EV battery power to supply energy back to the grid. EV owners who participate in these programs allow their local utility access to a share of the battery's power in exchange for financial incentives. Utility access is made possible through V2G-capable chargers that are networked together and operated by the local utility.

Fully integrating electric vehicle charging infrastructure with the grid can provide additional benefits beyond other demand response programs. V2G capabilities offer a new tool for managing the grid by providing utilities an option to use the collective energy stored in EVs to provide power. Like load shifting demand response programs, V2G can reduce the need for expensive upgrades and get more out of existing wind and solar resources, potentially reducing utility costs.[20] Leveraging EVs as a power supply can help utilities maintain affordable energy prices for all ratepayers and improve grid reliability and resilience by supporting grid operations during periods of peak demand.[19]

Virtual Power Plants

Utilities can use electric vehicles and other customer-owned resources to provide grid services such as voltage and frequency control, demand response and distributed generation during periods of electricity supply constraints.

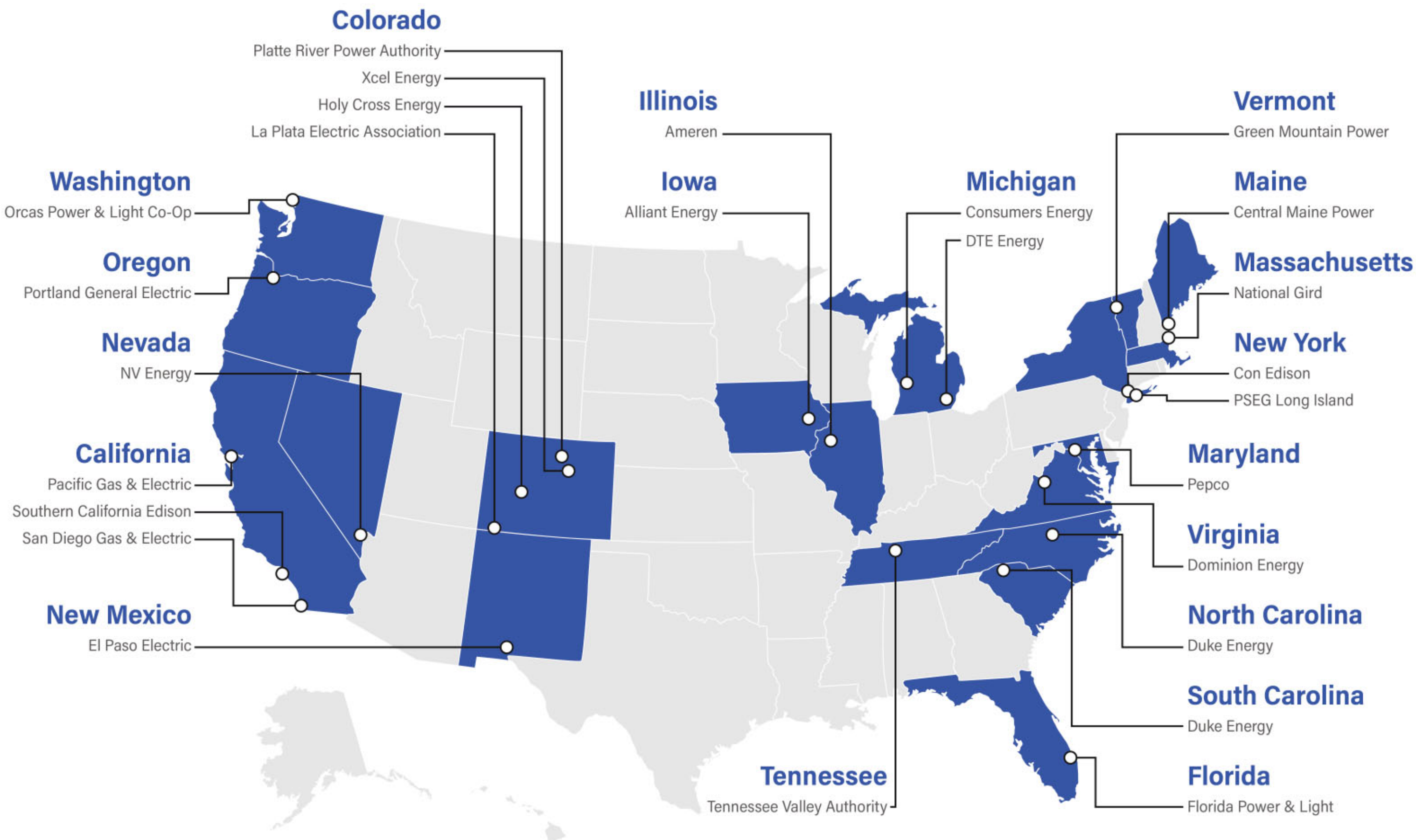
Interconnected and utility-controlled customer-owned resources are collectively referred to as virtual power plants, or VPPs. In addition to electric vehicles, virtual power plants include devices like rooftop solar photovoltaics, water heaters, thermostats, and consumer batteries. Each of these devices can be operated to change when and how much energy they draw from the electric grid. Some devices, such as solar, EVs, and standalone batteries can also discharge power back to the grid. Collectively, the changes add up to larger shifts in overall electricity load, reducing the need for new power plants and transmission and distribution system upgrades.

There are many V2G programs already underway across the country with more than 300 V2G-enabled school buses operating in 19 states.[21] In Virginia, Dominion Energy established the largest electric school bus V2G initiative in the country with 50 buses capable of providing 3 megawatts of capacity during periods of peak demand. In 2024, Maryland and Colorado both enacted state mandates for utility support of V2G programs.[21] Beyond school buses, utilities are also testing V2G with other types of vehicles.

V2G virtual power plants have the potential to provide significant grid capacity in Oregon. In a 2021 V2G pilot, PGE was able to discharge 7.2 kW of electrical power from a Nissan LEAF's battery to the grid using a V2G-enabled bidirectional charger.[22] While that may seem like a small amount individually, collectively EVs have the potential to provide meaningful power to the grid. The Klamath Generation Peakers facility in Klamath Falls is a gas fired power plant used to provide peak power with an output of up to 95 MW.[23] Using the 7.2 kW V2G example, it would take about 13,200 V2G-enabled EVs to equal the output of the Klamath Falls power plant.

There are more than 119,000 electric vehicles in Oregon today with many more expected in the future. As V2G technologies improve, Oregon utilities will be able to leverage EV virtual power plants as a valuable grid resource.[24]

School bus fleets represent a great opportunity to pilot V2G programs with minimal operational disruptions. In the Pacific Northwest, utilities experience peak electricity loads in the evening when most school buses are parked. The buses can support grid operations during the evening peak when not in use and then recharge overnight when



Source: Authors.
25.04.17

Electric School Bus INITIATIVE

WORLD RESOURCES INSTITUTE

FIGURE 4: Map of Utility Vehicle-to-Grid Electric School Bus Pilot Programs[25]
Figure: Electric School Bus Initiative, World Resources Institute

customer electricity demand is lower. School buses also create a potential V2G opportunity in the summer when many school buses sit idle and can be tapped into when large air conditioning loads are straining the grid.

Even if an EV is not configured to provide grid services, it can still provide additional value to the customer as an onsite backup power source. Many of the EVs available today offer vehicle-to-home (V2H) or vehicle-to-load (V2L) options to improve the energy resilience of a home or business.[26] Like V2G systems, vehicle-to-home systems require a bidirectional charger which is integrated into the home's electric service panel. In the event of a power outage, a vehicle-to-home enabled EV will disconnect from the grid and provide emergency backup power that can be used throughout the home to power medical devices, refrigeration, or other critical items.

Vehicle-to-load systems provide power from the EV battery to one or more electrical outlets on or in the vehicle, providing a mobile source of power. It does not require a bidirectional charger, but includes an inverter that converts the DC power from the battery to AC. The Ford F-150, Hyundai Ioniq 5, and Kia EV6 come equipped with Vehicle-to-load systems, and some emergency vehicle fleets use them to support field operations and disaster recovery power needs.[27]

More work is needed before utilities can take advantage of a fully integrated grid that includes virtual power plants:

- Utilities and regulators will need to conduct more pilots and analyses to understand the benefits and risks of using V2G, identify opportunities and benefits, and develop broader customer programs.
- Utility rates will need to be designed for V2G resources that are equitably assessed for the utility and ratepayers, and that promote appropriate price signals to encourage or discourage charging under different grid conditions.[20]
- Utility and government EV charging activities will need to incorporate grid benefits when considering program design.[28]
- Charger manufacturers need to work toward lowering prices for equipment and software and standardizing V2G equipment, operating conditions, and software.[28]
- Finally, governments will need to assess V2G security and safety issues, workforce development needs, and equity concerns to ensure broad access to safe and reliable V2G charging.[28]

CONCLUSION

Electric vehicles represent a large new demand for electricity that Oregon utilities need to plan for, but they also provide an opportunity to help manage loads with more efficiency. EV charging is a flexible load, and that flexibility makes it a valuable tool for utility operators as they optimize grid conditions. Time-of-use rates and managed charging programs shift loads away from periods of peak demand, potentially reducing strain on the grid and providing a valuable revenue stream for utilities and ratepayers. Vehicle-to-grid programs offer an opportunity to go even further and use EV batteries as grid resource, providing more ratepayer and utility benefits, including increased grid reliability, and local energy resilience. Planning and policies are needed to address the risks that EV load growth presents to the grid and to fully realize the potential benefits for all Oregonians.

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