

# Meeting #2 Agenda

Project: Transportation Electrification Infrastructure Needs Analysis (TEINA)

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Subject: Advisory Group Meeting #2

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Date/Time: Tuesday, January 12, 2021  
8:30 a.m. – 10:30 a.m.

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Location: WebEx Link: [Click here](#)  
Join by Phone: +1-408-418-9388  
Meeting number (access code): 146 850 6487  
Meeting password: FGkivt8R8w7

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Invitees: **AG Members**

Amanda Pietz, ODOT  
Greg Alderson, PGE  
Thomas Ashley, Greenlots  
Philip Barnhart, Emerald Valley EV Assoc.  
Chris Chandler, Central Lincoln PUD  
Marie Dodds, AAA  
Judge Liz Farrar, Gilliam County  
Ingrid Fish, City of Portland  
Stu Green, City of Ashland  
Jamie Hall, General Motors  
Zach Henkin, Cadeo Group  
Joe Hull, Mid-State Electric Cooperative  
Juan Serpa Muñoz, Eugene Water and Electric Board  
Vee Paykar, Climate Solutions  
Cory Scott, PacifiCorp  
Jairaj Singh, Unite Oregon  
Charlie Tracy, Oregon Trail Electric Co-op  
Dexter Turner, OpConnect

**Project Team**

Mary Brazell, ODOT  
Zechariah Heck, ODOT  
Jessica Reichers, ODOE  
Wayne Kittelson, Kittelson and Associates  
Stacy Thomas, HDR  
Alexander Nelson, HDR  
Britta Gross, Rocky Mountain Institute  
Chris Nelder, Rocky Mountain Institute  
Lynn Daniels, Rocky Mountain Institute  
Shenshen Li, Rocky Mountain Institute  
Rhett Lawrence, Forth

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## Meeting Purpose:

- Review and discuss existing ZEV charging infrastructure serving 9 use cases in Oregon
- Review key insights from ZEV charging infrastructure strategies from other leading ZEV states
- Gather input on factors influencing transportation electrification (TE) adoption for unique TE use cases

Time	Topic	Lead
8:30 a.m.	Welcome <ul style="list-style-type: none"> <li>• Welcome and team introductions</li> <li>• Agenda review</li> <li>• AG roll call</li> </ul>	Use
8:40 a.m.	Existing Conditions <ul style="list-style-type: none"> <li>• Review ZEV charging infrastructure serving 9 use cases in Oregon</li> <li>• Highlights from other leading ZEV states (CO, NY, CA)</li> <li>• AG questions/comments (10 minutes)</li> </ul>	Chris Nelder, Shenshen Li
9:20 a.m.	Break Out Session Introduction – Future Scenarios	Chris Nelder, Britta Gross
9:30 a.m.	Future Infrastructure Scenarios Small Group Breakout Sessions Each group will have two use cases to discuss. <ul style="list-style-type: none"> <li>• <i>How quickly will each use case be adopted in Oregon for electrification and why?</i></li> <li>• <i>What are the unique challenges to adding charging infrastructure for each use case?</i></li> <li>• <i>What factors should we be sensitive to that could affect the adoption curve for each use case?</i></li> </ul>	Team
10:00 a.m.	Small Group Report Outs	Team
10:15 a.m.	Public Comment	Amanda Pietz
10:25 a.m.	Next Steps	Amanda Pietz
10:30 a.m.	Adjourn	

## MEMORANDUM

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Date: January 12, 2021 Project #: 23021.027  
To: Mary Brazell (ODOT)  
From: Wayne Kittelson  
Project: Transportation Electrification Infrastructure Needs Analysis (TEINA)  
Subject: January 12 TEINA Advisory Group Meeting #2

### **MEETING SUMMARY**

#### **Meeting Purpose:**

- Review and discuss existing Zero Emission Vehicle (ZEV) charging infrastructure serving nine use cases in Oregon
- Review key insights from ZEV charging infrastructure strategies from other leading ZEV states
- Gather input on factors influencing transportation electrification (TE) infrastructure adoption for unique TE use cases

#### **Welcome and Introductions (Amanda Pietz and Stacy Thomas)**

- Welcome and team introductions
  - Meeting participants should sign in using the chat
  - Members of the public wishing to make a comment should indicate that they would like to do so in the chat now
- Agenda review
  - Discuss identified Electric Vehicle (EV) use cases (different types of vehicles, different users, different places)
  - Review the best practices from other states
  - Discuss the factors that affect EV adoption
- AG membership roll call – see below for details

#### **Existing Conditions (Chris Nelder, Shenshen Li)**

- Reviewed ZEV charging infrastructure serving nine use cases in Oregon
  - Most ZEVs are concentrated in urban areas. Chargers are also concentrated in urban areas.
  - ZEV adoption did not meet the 2020 goal, and is not on pace to meet the 2025, 2030 adoption goals
  - Discussion of identified use cases, including related ongoing and planned efforts in Oregon and best practices from other states. The nine use cases that will be considered include:
    - Urban Electric Light Duty Vehicles (LDVs)
    - Rural Electric LDVs
    - Corridor LDVs
    - Disadvantaged Communities
    - Local and Commercial Industrial Vehicles

- Long-Haul Trucking
- Micro-Mobility
- Transit and School Buses
- Transportation Network Companies (TNC)
- Highlights from other leading ZEV states (CO, NY, CA)
  - ZEV Standard has been adopted by 12 states and has attracted EVs and charging infrastructure to those states
  - Colorado
    - Similar position to Oregon
    - State agency fleets play a major role in the ZEV adoption plan
    - Current focus is on outreach and planning
  - New York
    - Allocated a significant amount of investment to disadvantaged communities
    - Heavy reliance on utility investment in infrastructure
  - California
    - Using a variety of programs to achieve EV adoption, both monetary and non-monetary
    - Clean Transportation Program and utilities are investing in infrastructure
    - California has “EV ready” building codes
- AG questions/comments
  - Charlie Tracy – In rural communities there may be lower population density, but the trip distances are also greater. The use case for EV and cost of ownership is distinct in these contexts. Charging infrastructure provides value to visitors and specialists serving the community.
  - Questions added to the chat were reviewed and briefly answered as follows:
    - Several questions related to funding. This project did not research the funding methods for each state, but funding is expected to be highly variable from state to state.
    - This project did not investigate the reliability or downtime of charging infrastructure.
    - This project did not compare the distribution of gas stations and EV charging infrastructure in rural areas. Since EV charging opportunities face fewer constraints than siting a gasoline station, their locations will probably not be limited to gasoline stations locations.
    - This project did not explore how EVs are being marketed to low-income residents.
    - This project did not reveal any new information on the PGE Mobility Hub in Portland.
- Additional suggestions for edits or additions to the presentation material as well as questions should be sent to Mary Brazell ([mary.brazell@odot.state.or.us](mailto:mary.brazell@odot.state.or.us)) and/or Zechariah Heck ([zechariah.heck@odot.state.or.us](mailto:zechariah.heck@odot.state.or.us))

**Break Out Sessions Introduction and Break Out Sessions** (Chris Nelder, Britta Gross, Team)

- Participants in the Future Infrastructure Scenarios Small Group Breakout Sessions will focus on three scenarios to be used in the modeling process. They will bracket the range of future conditions that might reasonably be expected.
  - Scenario 1: Base case scenario, extend economic trends from before COVID to 2035

- Scenario 2: Rapid recovery from COVID, economy returning to previous level by the end of 2021
- Scenario 3: Slow recovery from COVID, economy returning to previous level by end of 2024
- Scenarios are not designed to define what the future will be. Rather they are intended to bracket the range of the way reality may evolve.
- Each group will have two use cases to discuss. Each group should think through the following three questions.
  - How quickly will each use case be adopted in Oregon for electrification and why? It is most important to identify why you think an adoption rate may be achieved.
  - What are the unique challenges to adding charging infrastructure for each use case? What makes this use case unique?
  - What factors should we be sensitive to that could affect the adoption curve for each use case?

Summaries of the discussions within each breakout were provided by the note takers in each breakout group and included the following:

- Micro-mobility
  - **Adoption Rate:** Perceive increasing adoption in the future. May suffer from seasonality issues. Clean Fuels Program is critical for micro-mobility, not a profitable area.
  - **Unique Challenges:** Public charging is a key issue, especially right-of-way (ROW). However, how much infrastructure is needed?
- Transit and School Buses
  - **Adoption Rate:** Increasing adoption over time.
  - **Unique Challenges:** Funding and cost are key issues. Diesel is several times cheaper than electric. Hydrogen may be a more attractive option in 5-7 years.
- Urban
  - **Adoption Rate:** AAA says 99% of EV owners are happy, so optimistic about urban adoption.
  - **Unique Challenges:** Challenge with MUDs, building codes may not take effect fast enough, so may need to consider community based DCFC charging.
  - **Factors:** Education is needed. Regulatory and incentives are important factors. EV market share has held up through COVID which may indicate strength in adoption after COVID. Apartment buildings without EV charging infrastructure may not be marketable in the future. There could be less commuting occurring in the future. The role of utilities including rate design are very important.
- Local Commercial and Industrial vehicles
  - **Adoption Rate:** Duty cycle (trip length) is known, which may allow adoption to increase
  - **Unique Challenges:** Building codes may not take effect fast enough
  - **Factors:** Free parking, building codes
- Rural
  - **Adoption Rate:** Adoption expected to lag behind denser areas
  - **Unique Challenges:** Smaller utility co-ops may have a challenge building infrastructure that mainly supports tourists and people moving through. Drive longer distances so need charging along a corridor which may have lower utilization. A greater portion of people are living in SU dwellings, which can facilitate Level 2 charging.

- **Factors:** As All Wheel Drive (AWD) and pickup trucks become available, adoption may increase. DCFC will be very important due to corridor based travel.
- Long-Haul Trucking
  - **Adoption Rate:** Much further in the future,
  - **Unique Challenges:** Requires concerted national effort.
  - **Factors:** Price of electricity from DCFC charger compared to diesel.
- Disadvantaged Communities
  - **Adoption Rate:** COVID recovery scenario is a big deal for communities that have been hit harder by COVID
  - **Unique Challenges:** Reliance on shared modes (TNC, micro-mobility, transit). Many different communities included with different challenges. Private investment may not be profitable, requiring greater public investment.
  - **Factors:** Public investment available.
- Transportation Network Companies
  - **Adoption Rate:** Slow rate
  - **Unique Challenges:** Reliance on drivers to purchase their own vehicle, if cost for EV is high it will reduce adoption. Competition between TNC and public at public charging stations, considering the downtime it takes for a vehicle to charge (or wait in line for charging) prevents drivers from making money.
- Corridor
  - **Adoption Rate:** A good adoption strategy was having co-workers pass on adoption strategies around the water cooler.
  - **Unique Challenges:** Range anxiety. Balance corridor charging with charging within communities. Site chargers at locations where you can do something to pass the time.
  - **Factors:** Sign and way find charging infrastructure to educate non-users on the prevalence of charging locations. Decrease cost of public charging to similar to what it would be at home. Must be more DCFC along corridors.

#### Public Comment (Amanda Pietz)

- Notes on all submitted public comments are included in Appendix E.
- There were no public comments made during the meeting

#### Next Steps (Amanda Pietz)

- Submit additional comments or questions to Mary Brazell ([mary.brazell@odot.state.or.us](mailto:mary.brazell@odot.state.or.us)) and Zechariah Heck ([zechariah.heck@odot.state.or.us](mailto:zechariah.heck@odot.state.or.us))
- Slides will be provided on the TEINA webpage
- Next meeting topics
  - Preliminary summary of modeling results
  - Overview of listening session feedback
  - Extend next meeting to 2.5 hours
- Report due to the Governor's office by June 30th

## **MEETING PARTICIPANTS**

### **Project Team Members**

Mary Brazell (ODOT Climate Office and TE Program Manager)  
Zechariah Heck (ODOT Climate Office)  
Jessica Reichers (ODOE and Policy Team Manager)  
Wayne Kittelson (Kittelson & Associates)  
Chris Bame (Kittelson & Associates)  
Stacy Thomas (HDR)  
Alexander Nelson (HDR)  
Chris Nelder (Rocky Mountain Institute)  
Lynn Daniels (Rocky Mountain Institute)  
Britta Gross (Rocky Mountain Institute)  
Shenshen Li (Rocky Mountain Institute)  
Rhett Lawrence (Forth)

### **Advisory Group Members Present**

Amanda Pietz, Director, ODOT Climate Office  
Greg Alderson, PGE, he  
Tom Ashley, Greenlots, he/him  
Phil Barnhart, Emerald Valley EV Assoc.  
Chris Chandler, Central Lincoln PUD (experienced connectivity issues)  
Marie Dodds, AAA Oregon, she/her  
Ingrid Fish, City of Portland, she/her/hers  
Jamie Hall, General Motors, he/him  
Zach Henkin, Cadeo Group, he/him  
Joe Hull, Mid-State Electric Co-op, he/his  
Juan J Serpa Muñoz, Eugene Water and Electric Board, he/him  
Vee Paykar, Climate Solutions  
Cory Scott, Pacific Power, he/him  
Charlie Tracy, Oregon Trail Electric Co-op  
Dexter Turner, OpConnect  
Jairaj Singh, Unite Oregon

### **Advisory Group Members Not Present**

Judge Liz Farrar, Gilliam County, she/her  
Stu Green, City of Ashland

### **Other Attendees**

Allan Branscomb  
Andrew Dick, Electrify America  
Brian Fawcett, Clatskanie PUD  
Charlie Loeb, Emerald Valley Electric Vehicle Association  
Chris Kroeker, NW Natural  
Cory-Ann Wind, Oregon DEQ, Clean Fuels Program  
Dan Frye, OLCF MCAT  
Dan O'Shea

Don Hamilton, ODOT  
Ed Averill, Engineers for a Sustainable Future  
Eric Strid, The Strid Energy Report  
Gil Tal, UC Davis  
Greg Harr, Evergreen Consulting Group  
Jaime Duyck, EV Equity  
Jay Friedland, Plug in America  
Jennifer Joly, OR Municipal Electric Utilities Association  
Jim Avitabile  
Jim Jensen, WA Green Transportation Program  
John Mikulin, US EPA  
Joseph Gale, RS&H  
Knowledge Murphy, Multnomah County  
Meg Rowe, ODOT Office of Innovation  
Michael Reish, Washington Department of Commerce  
Neil Baungard, The Environmental Center  
Nicole Blackwell, Idaho Power  
Peter Thomas, Electrify America  
Rachel Sakata, ODEQ  
Rick Teebay  
Rob Currier, Emerald PUD  
Robert Mullin, RTO Insider  
Ryan Perry, Tillamook PUD  
Sarah Hackett, ODOT Public Transportation Division  
Susan Bladholm, Friends of Frog Ferry  
Tiffany Edwards, Lane Transit District  
Travis Hargitt, City of Eugene  
Wendy Manley, Sunriver Owners Association Dept. Public Works



## **ATTACHMENT A: Notes from AG Breakout Group #1 (Micro-mobility and Transit/School Buses)**

Note Taker: Wayne Kittelson  
Facilitator: Zechariah Heck

Participants: Greg Alderson  
Stu Green  
Zach Henkin  
Juan Serpa Muñoz

### **How quickly will each use case be adopted for micro-mobility in Oregon for electrification and why?**

Juan:

- Adoption rate will definitely increase with more emphasis on less use of vehicles, more convenient access, etc., so the adoption rate can be expected to equal or even exceed that of LDV's
- Micro-mobility use in Oregon may be affected by the seasonal nature of weather (e.g., snow, rain)
- Clean Fuels credits will also help to accelerate the use of micro-mobility. If Clean Fuels credits go away then this will tamp down the use of micro-mobility

Greg:

- Agrees with Juan that micro-mobility will be harder to support with ratepayer funds
- In parts of Oregon where it is colder with more snow in the winter, this will probably slow the adoption of micro-mobility. However, in Western Oregon where rain is frequent, people have gotten used to doing things in the rain and micro-mobility would be no exception
- The loads on the electric system are much lower with micro-mobility so there's not as much focus on it within the utility sector, within electricity rate design considerations, etc.
- E-bikes are still expensive and policies do not provide rebates for e-bikes so this may not be adopted by low-income communities as quickly

Zach:

- Currently the e-bike sales are outpacing regular bike sales. A contributing factor is the degree to which cities are supporting active transportation

### **How quickly will each use case be adopted for transit and school buses in Oregon for electrification and why? (13:20)**

Zach:

- The big factor will be cost – how can the cost be brought down (e.g., leasing the battery)

- Behavioral changes may also be necessary: People are used to having a capital budget and an operations/maintenance budget, whereas for these use cases they will need a much larger capital budget

Juan:

- Any of these technologies will need really strong funding
- Electric buses are expensive. You can get a regular school bus and convert it to cleaner diesel much more cost-effectively than buying an electric bus
- It may be hard for utilities to claim cost rebates in this area are a defensible use of funds outside of Clean Fuels credits
- This use case will increase but the rate will be tamped down by the cost factor

Greg:

- Agrees with Juan – in terms of buying the vehicle, the only way that utilities can help is with Clean Fuels dollars; otherwise, the source of funds for such a purpose would be places like VW Settlement dollars (not as reliable in OR); federal dollars (hopefully more available in the future)
- Electric buses can be several times more expensive than diesel versions
- Some proposed changes to the CFP that hasn't been adopted yet could also help, specifically the idea of advance credits
- Utilities can't and don't spend dollars on rolling stock; school bus charging equipment might be eligible for some of their programs but not the rolling stock

### **What are the unique challenges to adding charging infrastructure to each use case?**

#### **Micro-Mobility:**

Zach:

- There are some docking solutions that are available
- The largest unique challenge for micro-mobility is right-of-way. Having a situation where a 120-V outlet can be plugged in while parked is pretty rare

Juan:

- It's likely that most micro-mobility devices will be charged at home; most users will go only a few miles for commuting, etc.
- Unsure that charging infrastructure will be much of an issue for adoption of micro-mobility

Greg:

- The charging need is much less because the load is much less, which also means the opportunity to realize benefits in terms of flexible loads and demand/response (which create an opportunity for utilities to invest) are not there as much

Juan:

- Considering the flexibility of the load – if you're plugging it into a 120V outlet then that should be enough considering that these are small equipment
- Micro-mobility equipment should not be putting much load demand onto the grid

#### **Transit and School Buses:**

Zach:

- The variety of charging standards that are being used is a problem now and is likely to settle over the next 3-5 years. We're not there yet

Greg:

- The use case of a school bus has value for potential vehicle-to-grid opportunities. It's still kind of early-stage technology but there's an opportunity here
- Managed charging opportunities are much more realistic in the nearer term and this helps manage the loads. But there will be load issues and infrastructure issues to the garages. School District garages currently don't have the infrastructure that they will need in the future

Juan:

- A crossing point may come in the next 5+ years where hydrogen starts taking over for this use case

**What factors should we be sensitive to that could affect the adoption curve for each use case?**

Juan:

- Government incentives that will facilitate much more expensive technologies to be adopted
- Continued availability of Clean Fuels credits
- Municipality policies around walkability, etc. will also affect this

Zach:

- Indicators are all going to be around:
  - Is there return on investment?
  - Is the funding available?
  - Awareness will follow

## **ATTACHMENT B: Notes from AG Breakout Group #2 (Urban and Local Commercial/Industrial Vehicles)**

Note Taker: Shenshen Li  
Facilitator: Britta Gross

Participants: Phil Barnhart  
Marie Dodds  
Jamie Hall  
Dexter Turner

Marie:

### **Urban**

- Urban residents are EV friendly due to their need. Range anxiety is going away as the range is expanding . Customers really like the EV after trying them, so education is important.

### **Commercial/Freight**

- For light duty vehicles, it's easy to make good progress. For larger size vehicles, they are not ready yet.

Phil:

### **Urban**

- Education and public outreach are important
- Key factors: how much work has been done to get the public to touch EV's, test drive them and feel the performance
- Multi-unit dwellings: install chargers, the HOA are supportive. Regulatory effort is needed
- Update the building code. All new construction should be EV-ready, new buildings and new parking lots. And retrofit for existing buildings
- There will be less cars in the future because people no longer travel as much as they did
- Utilities need to develop rate designs that support the infrastructure

### **Commercial/Freight:**

- Demand charges drive the cost high
- Good news: their daily route is fixed. They don't need to go long distance
- Local air pollution is a key driver to promote fleets

Jaime:

**Urban:**

- It's lower hanging fruit
- Multi-unit dwelling: regulatory are probably necessary
- Corridor network is key for an urban family to travel long distance
- There is headwind associated with building code updates and retrofits
- Both public DCFC across the street and multi-unit chargers are critical to promote EV adoption

**Commercial/Freight:**

- GM announced delivery trucks effort this morning
- Putting in a lot of chargers into one facility is a challenge. Some facilities are rented, so the local company cannot do much

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## **ATTACHMENT C: Notes from AG Breakout Group #3 (Rural and Long-haul trucking)**

Note Taker: Lynn Daniels  
Facilitator: Jessica Reichers

Participants: Chris Chandler  
Joe Hull  
Cory Scott  
Charlie Tracy

Charlie: Not a high density of EVs in rural areas yet. Optimistic about new models that will soon be available, especially pickup trucks and vehicles with all-wheel drive. These new models will make EVs more attractive. Charging infrastructure has people nervous about driving, a lot of miles between available public chargers.

Jessica: Availability of models will have a large impact on how quickly adoption will increase in rural areas. Additional infrastructure needs to be installed because of the longer distances rural folks need to drive.

Charlie: The three economic scenarios will be a challenge, depending on what happens with the economy. Rural Oregon is challenged with its economy, a slow recovery could hit us even harder.

Cory: Reasonable to assume that rural areas will lag behind adoption of denser/urban areas. It's not to say they won't adopt once those vehicles are at a lower price. It doesn't bother me that the focus is currently on urban areas because rural areas will lag. I don't know if rural areas will ever catch up to urban. As a rural service provider (PAC), how do we accelerate what's happening in rural areas so that the lag is not too long? It's not about catching up, just accelerating. If there aren't the models available on the market, nothing utilities can do about that. But utilities can work on other programs to help accelerate adoption of models that are available.

Joe: Pickups will be a huge deal in rural areas. We've gotten a lot of comments in my service territory that the new EVs are fine but they won't replace a Ram 2500 e.g. Rural lags on a lot of things economy-wise. When Bend started growing rapidly, the growth didn't hit the rural areas around it for 3 years afterwards. We expect the same kind of lag.

Jessica: What about medium duty vehicles and bucket trucks?

Joe: Some of our foremen will be onboard with electrifying some vehicles, but the larger vehicles will be a ways off.

Cory: High level of interest, but not seeing the technology for the heavier vehicles. We see a lot of advertisements that suggest products are available right now.

Charlie: We're planning electrification of our passenger fleet as well as when models become available for light trucks. We're interested in hybridization of the larger bucket trucks especially for the operation of the hydraulics. Trucks will go to a job site and run the diesel engine to operate the hydraulics, so there's a real opportunity for a hybrid concept. Big bucket trucks, digger derricks are tough, b/c they're used in emergency situations when the power is out and the truck is out in the field for 3 straight days. It's a unique situation to be aware of, that's long-term to electrify.

Jessica: What are the challenges to more infrastructure?

Cory: The anticipated use in rural areas is very low, so not a lot of market actors that look at rural space as a good opportunity to put charging, not a good business case. Rural areas tend to driver further which suggests they need more charging infrastructure than you'd think, but those will still have low utilization.

Jessica: Do you have a feel for whether we need DC fast charger or Level 2?

Cory: My personal feeling is it's fast charging. No one, in urban or rural spaces, want to waste time in waiting to charge. When it's workplace or at-home, Level 2 is fine. But critical need for fast charging along rural corridors because of their driving patterns.

Joe: As a co-op, we have a different issue in that public charging in our territory maybe wouldn't even benefit our members. People that would use it would likely be tourists/visitors to our territory. Our mission is to serve our members, we have board members that have concerns about using funding to support that. We focus on the highway 97 corridor but we've got a lot of other roadways that need support too. We know it's going to happen the question is when do we make that investment?

Charlie: We have ever-increasing tourist economy, so if we continue to be a "blackout zone" for EV fast charging, more tourists won't come here if they can't charge. As a utility, we have an interest in growing load and providing an opportunity for our members to own EVs, that's another reason we want to support it. What's needed locally is a minimum amount of DC fast charging. A ton of value in Level 2. Many hotels don't even have overnight charging. That will be a future focus of our rebates is to target hotels.

Charlie: The biggest challenge we've had with DC charging is finding decent sites, where people want to be, then getting service to those sites (though that's not as hard if we don't have to do a lot of digging).

Cory: Some counties have struggled with the permitting process because it's new, but that's a near-term hurdle and people learn.

Joe: Challenge is having a three-phase source. Some areas we look at, there already is three-phase power, but have identified other areas as destinations to have charging for tourists, but doesn't have three-phase power and it would prohibitively expensive to extend to there. We looked at single-phase power options with backup battery.

Charlie: Would like to see a single-phase power DC fast charger.

Chris Chandler: So many homes are single family dwellings, which makes it easier for many families to install Level 2 charging. Would like to see a stronger rural focus. Very different dynamic than urban areas with multi-family dwellings. So more credits/rebates focused on rural single-family home installations. Likewise to what others said, we have a tourist-based economy but most public charging will be used by tourists and not our members.

Chris: On trucking, we don't have a major interstate going through our territory. If the prices can be kept to a price point that competes with diesel or gasoline, then it's viable.

Charlie: We have I-84 in our territory with decent economics, but I think it will be a national push to get ready for long-haul trucking. There's opportunity here for short-haul trucking, but a bigger effort.

Cory: We see it happening on I-5 in the near future but will require a coordinated effort between all parties like never before.

## **ATTACHMENT D: Notes from AG Breakout Group #4 (Disadvantaged Communities and TNC's)**

Note Taker: Chris Bame  
Facilitator: Amanda Pietz, Chris Nedler

Participants: Thomas Ashley  
Ingrid Fish  
Vee Paykar  
Jiraj Singh  
Knowledge Murphy

### **Disadvantaged Communities**

- Unique Challenges
  - Affordability of the vehicle
  - Access to affordable charging infrastructure
  - Access to shared modes – transit, micro-mobility, TNC
  - Rural vs urban – easier for more urban communities to access EVs via the shared resources than rural communities
  - What communities are being considered 'Disadvantaged Communities'? Typically have been talking about low income, BIPOC, rural communities. Could also include climate vulnerable. We will consider all of the above. 'Disadvantaged Communities' should be more clearly defined.
  - Chicken and the egg problem for rural – need to have infrastructure before people are comfortable enough to buy EVs. Example of need to have private-public partnerships.
  - Education is important. Resistance to adopting new technology. Transparency around acquiring EVs. Providing incentives.
- Would like to direct utilities to spend on public charging, for example at offices, MUDs. If you can get charging at home it is typically cheaper
- City of Portland is developing EV charging infrastructure requirements for MUDs
- Analogous to rural broadband. There are some geographies / use cases that may not work economically for private market. These cases have a clear need for public investment
- Will be more affected by the scenarios, people impacted most by COVID are in disadvantaged communities
- We have an opportunity to accelerate economic recovery through the provision of EV / charging infrastructure. Stimulus spending. Utility regulators are asking utilities to provide stimulus. Good potential for federal stimulus in the Biden administration

### **TNC**

- Unique Challenges
  - Best done through dedicated charging, but very few examples of this
  - TNCs have not showed willingness to install or pay for installation of charging infrastructure
  - Not enough public infrastructure exists to support TNC
  - TNC drivers competing with everyone for a shared public resource, especially during morning/evening rush hour periods



- If we had more DCFC would there be a problem not having dedicated chargers? There are options for making reservation/queueing process more efficient. Problem is that while drivers are charging or waiting to charge, they aren't making income – if they have to wait for charging, there is a greater cost. Nothing we can do about charging time, but something we can do about the waiting time. Try to avoid queueing
- What happens to TNC drivers who don't have an EV? How do we prepare for them to be out of their job?
- Down time for charging is more significant, cost is taken on by the driver, rather than the TNC
- Would like to see TNC purchasing vehicles upfront, instead of drivers being responsible for the vehicles

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## ATTACHMENT E: Notes from AG Breakout Group #5 (Corridors and Urban)

Note Taker: Stacy Thomas  
Facilitator: Mary Brazell and Rhett Lawrence

Participants: Public audience

Eric Strid

- Need fast chargers for remote areas. Hard to drive to Idaho, Eastern Oregon, Northern California
- Automakers scrambling to “productize” EVs – they are going to take off faster than covered in any of the scenarios
- Regarding Greg Harr's comment on small utilities wanting to provide DC fast chargers: OPUC should specify that the big IOUs provide funding for low-use corridors because access to those rural corridors also benefit urban populations

Neil Baunsgard (Central Oregon Environmental Center)

- Charging is challenging in Central Oregon. Mismatch in infrastructure built out compared to need, post electric highway
- Utilities assumed to provide infrastructure but have ended up with large gaps. Need coordinated efforts with all players in the same room
- Charge infrastructure has been built out in Klamath Falls and Bend by Pacific Power, but between areas no DC fast chargers on the US 97 south corridor
- Areas with infrastructure will get more and more based on funding, under all scenarios

Susan Bladholm (Friends of Frog Ferry)

- Talked about Friends of Frog Ferry and planned ferry service in Portland area. Need for shoreline chargers. Anticipating more active commutes post-Covid

James Avitabile

- Could future development be used to help augment the gap in EV Infrastructure? Zoning to be expanded to require new EV charging stations as part of new mixed use, retail, commercial and multifamily development projects
- As you evaluate alternatives for EV sites and means of implementation, take into consideration the maintenance and operational cost of these facilities. The equipment does need to be serviced and kept operational and these costs sometimes get dropped from the discussions.

Rick Teebay

- That's the ideal time to install Get Ready and/or infrastructure. Should anticipate future growth - provided it doesn't require long lead time for substation upgrades
- Renewable diesel is a "drop in" fuel - and can be used with existing fleet with no downside. It is a great bridge fuel
- Agree with Greg on fleet applications. Charging Infrastructure will be key and a trip wire.
- These spots (recharging) could also support local/smaller communities - versus rest stops along the highway

Ed Aveerill / Engineers for a Sustainable Future

- Is there an opportunity to find communities between existing charge points and choose to support community solar with storage as a way to have stored energy for serving

public chargers? I'm imagining that some subsidies allow the solar installation to have the extra capacity to serve the charging

- Hydrogen seems to be enabled by a plan to overproduce wind and solar and use hydrogen as a way to spend surplus electricity. Need truly green grid planning to know when we get there

Jane Stackhouse

- Could Frog Ferries be electric? Would be beneficial if Frog Ferry had public charging at each dock that could help EV users getting to and from the dock and even promote private electric boat use
  - Susan responded yes and discussed best practices the program will follow

Alex

- Building on Neil's comment on utility role. Utilities have critical role and Get Ready. Need to support competitive market moving forward. Not just utilities. Building out market across state

Greg Harr

- Multiple smaller utilities outside of Bend interested in supporting activities but need targeted programs to help with startup costs. Need support to provide infrastructure requested
- Medium and heavy duty EVs. Total cost of ownership nearing breakeven with internal combustion engines (ICE) counterparts, as they are able to meet fleet vehicle requirements. Up front charging is where financing and funding support useful
- Micro-mobility. Impossible to get to Sunset Transit Center early enough to park and get Max. If TriMet had micro-mobility scooters would help with last mile issues
- As I mentioned - upfront costs for DC fast charging for smaller utility territories that cover the needed gaps in corridor charging needs
- Need to focus on demand charge performance. Corridors are great for hotels and restaurants
- Support stations in lower income and disadvantaged areas
- Geographically spaced out across state. Focus where gaps are.

Chris Kroeker

- Availability of hydrogen for medium and heavy trucks has been slow to develop. I feel this will negatively affect how we prioritize hydrogen fueling stations, which will ultimately delay hydrogen truck adoption. How can we ensure hydrogen fueling is in place throughout the corridors to make sure we're not slowing adoption rates?

Andrew Klumpp

- I concur with a previous comment that addressing the few remaining charging deserts in Oregon should be near the top of the 'Corridor' to do list
- A second issue is to focus DC fast chargers for the EV's of tomorrow. The 50kw chargers limit charging speed to around an hour, whereas Tesla chargers provide a user experience of more like 20 minutes. 20 minutes would help unlock travel chargers and this would eliminate the critical barrier of glacial charging speeds of the 50 kw chargers. Consider that an ICE vehicle 'recharges' in a few minutes and EV's infrastructure needs to focus on being as competitive as possible relative to ICE vehicles

Jay Friedland

- From Plug In America's perspective, I'll add that we need urban DC fast chargers and support for MUD charging (low power especially for DACs) to allow the sip and gulp scenarios - commute charging off of Level 1 or low power Level 2 and DC fast charging to augment for additional range

Input from question about how to overcome recharging anxiety to increase adoption:

- Level 2 charging at work or public spaces is important even though will likely to use corridor charging that is less visible. Need better signing and wayfinding, more visible to non-EV charging public not using app
- Follow the Tesla model - build like you know this will happen
- (Daniel Frye) I think a barrier is fear of charging. It's a total unknown outside of the early adopter crowd. I think public service marketing on how easy it is would significantly help adoption beyond natural early adopters
- (Rick Teebay) Pre-Covid, workplace was VERY powerful - seeing your coworker and engaging with your co-worker drove adoption
- (Dan O'shea) – issue in rural areas

DRAFT

## ATTACHMENT F: Public Comments

Eric Strid

- Need fast chargers for remote areas. Hard to drive to Idaho, Eastern Oregon, Northern California
- Automakers scrambling to “productize” EVs – they are going to take off faster than covered in any of the scenarios
- Regarding Greg Harr's comment on small utilities wanting to provide DCFCs: OPUC should specify that the big IOUs provide funding for low-use corridors because access to those rural corridors also benefit urban populations

Neil Baunsgard (Central Oregon Environmental Center)

- Charging is challenging in Central Oregon. Mismatch in infrastructure built out compared to need, post electric highway
- Utilities assumed to provide infrastructure but have ended up with large gaps. Need coordinated efforts with all players in the same room
- Charge infrastructure has been built out in Klamath Falls and Bend by Pacific Power, but between areas no DC fast chargers on US 97 south corridor
- Areas with infrastructure will get more and more based on funding, under all scenarios.

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Chris Kroeker

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- (Dan O'shea) – issue in rural areas

DRAFT

## Public Comments Received Prior to TEINA Advisory Group Meeting #2

### HECK Zechariah

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**From:** Jane Stackhouse <jane@janestackhouse.com>  
**Sent:** Monday, January 11, 2021 11:03 AM  
**To:** HECK Zechariah  
**Cc:** Rich Peppers; John Perona; Bob Robison; Dan Frye; Ed Averill; Elizabeth Lindsey; Joseph Stenger; Mark McLeod; Michael Mitton; Pat Delaquil; Ron Buel; Tracy Farwell; Jonathan Harker  
**Subject:** Public Comment on Transportation Electrification Infrastructure Needs Analysis  
**Attachments:** TEINA Comments 01112021.docx

This message was sent from outside the organization. Treat attachments, links and requests with caution. Be conscious of the information you share if you respond.

Dear Mr. Heck, TEINA Project Managers and Advisory Committee Members:

Thank you for the opportunity to comment on the Transportation Electrification Infrastructure Needs Analysis. I represent members the OLCV Metro Climate Action (MCAT) Transportation Team which includes Portland area residents who are concerned about rampant greenhouse gas emissions and very interested in electrifying light, medium and heavy vehicles to sharply decrease emissions. Our comments are attached.

To summarize: We think the analysis is 'on track' including important considerations and appreciate your work. We urge you to do everything and anything to move transportation electrification forward faster. Let us know how we can help.

--

Jane Stackhouse  
OLCV MCAT Transportation Co-Lead  
503.284.1049  
[jane@janestackhouse.com](mailto:jane@janestackhouse.com)



To: Mary Brazell TEINA Project Manager

From: OLCV MCAT Transportation Team

Date: January 11, 2021

RE: Comments on TEINA

Dear Ms. Brazell, TEINA Project Team Members, and members of the Advisory Group

The OLCV MCAT Transportation Team is a volunteer group of climate activists in the Portland Metro area. OLCV MCAT is a member of the Oregon Climate Action Plan (OCAP) Coalition. The Transportation Team follows all aspects of transportation covered by the Governor's Executive Order 20-04. We have reviewed the notes from the November 17, 2020 meeting and generally support the scope of the study presented in the Project Overview.

The 2019 Senate Bill 1044 setting ZEV targets for light duty vehicles is positive and yet we appear to be far behind the goal of 50 thousand by 2020 (32,000 were registered by August 2020). There is much work to be done promoting electric and clean hydrogen vehicles. We agree that your focus on infrastructure is a necessary component to encourage more EV sales. It seems to be the first question from consumers and the lack of infrastructure has either dissuaded buyers or led to arbitrary restrictions on travel by ZEVs. We also appreciate that you recognize infrastructure is not the only way to create demand.

We support the MOU on Mid and Heavy Duty Vehicles with California and 13 other states. Your inclusion of mid and heavy vehicles in the study, although not mandated, is very important. We also appreciate your efforts to provide equity, especially urban/rural and income based considerations. Related to urban/rural infrastructure, please consider rural charging infrastructure as essential for rural residents and urban travelers to rural areas. State investment in charging stations in recreation areas and State Parks will enhance clean tourism and can be used to promote tourism.

At this time most EV owners are installing charging at home which increases the cost of acquiring an EV. We are pleased you are looking at multi-unit housing charging options and suggest you also consider curb side residential neighborhood charging options in areas zoned residential. The curb side charging stations could be shared and car sharing encouraged to bring down the costs.

We hope to see incentives for purchase of used EVs and would like the restriction on the sale of ICE vehicles to include both new and used vehicles by a specific date. A program to buy old ICE vehicles or tax credits to donate them to be converted to electric could provide additional incentives and employment opportunities.

Overall, we are pleased with the work we see and look forward to a comprehensive and strong final report on June 30, 2021. Please be bold and aggressive in your planning. The faster we can build the infrastructure the quicker we can bring more ZEVs in all weight classes into broad use. Our team would like to help you promote this change.

Sincerely,

Jane Stackhouse, Rich Peppers - OLCV MCAT Transportation Team Co-Leads

[Info.mcat.olcv@gmail.com](mailto:Info.mcat.olcv@gmail.com)

## HECK Zechariah

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**From:** Julie Chapman <bugthewonderdog@gmail.com>  
**Sent:** Monday, January 11, 2021 10:38 AM  
**To:** HECK Zechariah  
**Subject:** TEINA Planning Scenarios and goals for more rapid adoption of ZEVs

This message was sent from outside the organization. Treat attachments, links and requests with caution. Be conscious of the information you share if you respond.

Thank you for this opportunity to comment on the TEINA process.

The adoption of electrification goals enunciated in SB 1044 were, even at that time, less ambitious than our need to transition rapidly off of fossil-fueled transportation.

Arguably, the pathway to rapid reduction of Oregon's transportation emissions is the least complex/most accessible of all sectors of Oregon's economy. The technology exists, the market exists, acceptance is widespread. Yet, we did not meet our 2020 goal of 50,000 registered Zero Emission Vehicles (**ZEVs**), and (until the 2020 Covid economy disruption) yearly transportation emissions have increased since 2013. Much of this delay in transition to ZEVs is caused by limited access to charging and range-anxiety, and I appreciate this RAC's focus on these issues.

The 2021-24 federal administration has enunciated a clear commitment to rapid reduction of greenhouse gas emissions. We can anticipate federal investment in charging infrastructure, subsidies for ZEV purchases and assistance for rapid scale up of ZEV production. States with ambitious programs, centered in equity and access for vulnerable communities, will be in the best position to access federal investments.

Climate science calls for rapid emissions reductions over the next 10 years. This is consistent with a shortened timeline of 100% adoption of ZEV's by 2030. Other Oregon agencies are working toward emissions-free and distributed electricity generation, with storage and smart grid regional interconnections.

Will the TEINA scenarios offer flexibility to adapt to changing goals anticipated in the near future?

Thank you for your consideration,  
Julie Chapman  
League of Women Voters Oregon  
Climate Portfolio

## HECK Zechariah

---

**From:** mail.onlinenw.com <cfox@onlinenw.com>  
**Sent:** Monday, January 11, 2021 9:22 AM  
**To:** HECK Zechariah  
**Subject:** Advisory group comment

This message was sent from outside the organization. Treat attachments, links and requests with caution. Be conscious of the information you share if you respond.

I am a retired ODOT employee. Prior to my retirement, I was the project leader for the rebuild of the I-5 Interchange at Woodburn.

I just wanted to make sure that you knew that I had conduit for 50 EV charging stations installed in the interchange parking lot transfer station in the NE quadrant. The conduit should be shown on the as-built plans on file.

Good luck and best wishes,

Alan Fox

Sent from my iPad

Alan Fox

KF7PPS

Comments for TEINA Advisory Group meeting January 12, 2021

In the “Letter From The Director” in the ODOE 2020 Biennial Energy Report, director Benner makes brief mention of work at OSU, “Oregon State University students and faculty are researching how agriculture and renewable solar can marry for mutual benefit of the farmers, crops, and solar panels.”

Directed by Chad Higgins, OSU’s NEWAg laboratory is leading this work in “dual use” Agri-Voltaic Systems. A study now underway in collaboration with Ecotrust and the American Farmland Trust is mapping the potential for farm and rangelands to provide power to EV charging stations within Oregon. We have submitted a proposal to ODOT’s research program to extend this work.

In contrast to the monolithic solar arrays currently installed in Oregon and those in the application review process, AVS installations do not sacrifice agricultural production to electricity generation. As a result, they offer a pathway out of the land use conflict between the two. In 2019, research findings from our laboratory were used to modify Oregon’s land use laws to recognize dual use AVS in prescribed settings.

In addition to providing power to remote locations, dual use systems can support the decarbonization of transportation by generating Hydrogen for direct use in Fuel Cell Vehicles and as an energy storage “battery” for the charging stations.

We support ODOT and ODOE’s efforts in clean energy and stand ready to assist in Oregon’s urgent response to the climate crisis.

Allan Branscomb  
Faculty Research Assistant  
NEWAg Laboratory  
Dept. of Biological and Ecological Engineering  
116 Gilmore Hall  
Oregon State University  
Corvallis, OR 97331  
(541) 484-1660

## HECK Zechariah

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**From:** Anatta Blackmarr <anatta.blackmarr@icloud.com>  
**Sent:** Sunday, January 10, 2021 9:30 PM  
**To:** HECK Zechariah  
**Subject:** advisory group comment

This message was sent from outside the organization. Treat attachments, links and requests with caution. Be conscious of the information you share if you respond.

Dear Advisory Group members,

An insightful electric charging plan for Oregon will not only prepare for the electrification of public transit on land—it will plan for electric public transportation on water—specifically, the Frog Ferry bike/pedestrian electric ferry system.

A well-rounded plan will include shore-side charging infrastructure to support a ferry service. The Frog Ferry system being developed will be an important element in the reduction of carbon emissions. It's a forward-thinking approach to moving people around the community, as well as being eligible for the Federal Transportation Administration's Passenger Ferry Fund.

Ferries are considered a best practice for a river city because of the low operational cost, modular routing, and flexible scheduling. In addition, they offer a connection with nature, and the opportunity for everyone, not just kayakers and boat owners, to experience the river directly—instead of just from the shore or a bridge.

One of my neighbors says that once we have a ferry system, we'll wonder how we went for so long without one. Please include shore-side charging infrastructure in ODOT's electric transportation plans in preparation for the ferry system on the horizon.

Thank you for considering this idea.

Sincerely,  
Anatta Blackmarr  
14207 SE Fair Oaks Ave., Oak Grove, OR 97267

# TEINA Scenarios

## Contents

Introduction .....	1
Scenario overview.....	2
Scenarios in detail.....	3
Scenario 1: Business as usual—Life as if the pandemic never happened.....	3
Scenario 2: Rapid recovery .....	5
Scenario 3: Slow recovery .....	9

## Introduction

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

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

The purpose of the study is to bracket the likely future TE charging infrastructure needs of all modes of electric transportation (including light duty vehicles, transit, delivery, freight, and micromobility vehicles) measured at three points in time (2025, 2030, and 2035) in order to meet the goals articulated under 2019 OR SB 1044. Those goals include:

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

Logically working back from those goals:

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

## Scenario overview

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

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

The scenarios contemplate a number of factors, such as:

- overall economic vigor and activity
- evolving technologies
- consumer preferences
- future policies
- the changing cost of charging
- potentially changing demographics
- the economic effects of the Covid-19 pandemic
- how utility tariffs and infrastructure investment programs might evolve to accommodate the growing demand for transportation electrification
- how utility tariffs and investments may feed back onto the transportation sector, potentially changing demand levels, costs, and charging behaviors.

A brief summary of each scenario follows.

### **Scenario 1: Life as if the pandemic never happened**

Before the pandemic, EV adoption and charging infrastructure deployment in Oregon were proceeding nicely. In 2018, Oregon was the number three state in the union in EV market share, behind only California and Washington.<sup>1</sup> Therefore, it makes sense to consider what the trajectories of electrification might look like had the pandemic never happened. In this study, we use this scenario as a baseline for comparison to the other two scenarios, and as a proxy for what a “business as usual” outlook might have been.

### **Scenario 2: Rapid recovery**

This “rapid recovery” scenario assumes that one or more vaccines are widely deployed such that the overall U.S. economy quickly returns to its previous vigor by the end of 2021. Considering the current understanding that at least two vaccines offer high (~95%) levels of efficacy, with more vaccines on the way, as well as the current expectation is that enough of the vaccines can be manufactured, delivered,

and administered to enough of the U.S. population to achieve “herd immunity” at some point in 2021, this scenario will serve as a proxy for an “optimistic” outlook.

### **Scenario 3: Slow recovery**

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

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

### Scenarios in detail

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

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

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

#### *Narrative*

A fundamental economic vitality drives Oregon forward through 2035 at the same rates it had from 2009–2019, with a CAGR for real GDP of 3.2% and a per-capita personal income growth rate of 4.1%.<sup>2</sup>

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

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

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

EV sales continue to be strong. In 2018, Oregon ranked third in the country for EV market share, at 3.41%<sup>3</sup> and 2019 sales should have grown beyond 2018 sales.<sup>4</sup>



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

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

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

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

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

As government, private sector providers, and utilities continue to make larger investments in transportation electrification and mode-switching away from personal internal combustion engine (ICE) vehicles, personal transportation based on light duty EVs and electrified micromobility takes ever-growing market share year after year. This steadily drives down the per-mile cost of electrified personal mobility and drives up the cost of ICE-based personal mobility over the forecast period.

#### *By 2025*

EVs have reached sticker-price parity with ICE vehicles, driving a spike in consumer interest. The market share for EVs is 8%, commensurate with the 2025 goal of SB 1044. Charging networks have expanded significantly. Public DCFC are now available within a 50 mile radius of anywhere in the state, and Level 2 chargers increasingly getting installed in public, workplace and MUD parking lots. “Range anxiety” about the availability of charging stations isn’t really something anyone feels anxious about anymore.

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

#### *By 2030*

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

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

#### *By 2035*

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

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

#### Scenario 2: Rapid recovery

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

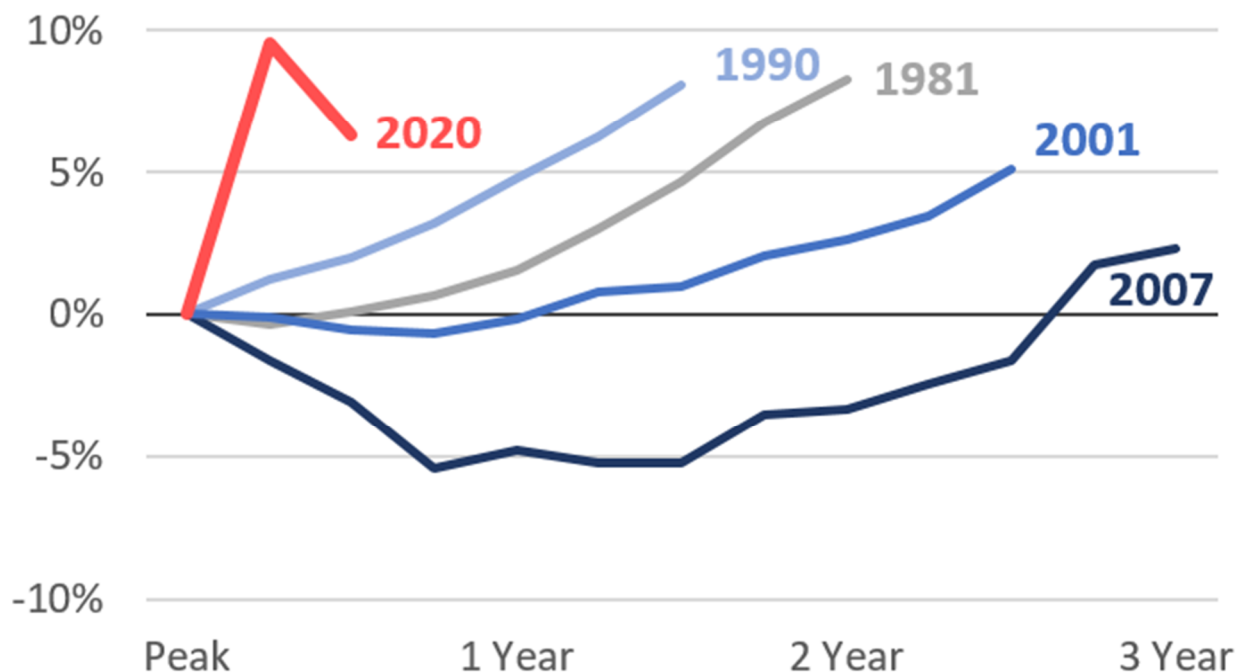
Beginning with Q4 2021, we will apply the same technology adoption S-curve we used in Scenario 1. The difference with Scenario 2 is that the S curve will start at a lower absolute level, after approximately two years of flat EV sales and charger deployment, and the early part of the curve will have a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

#### *Narrative*

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

# Total Oregon Personal Income

Percent Change from Pre-Recession Peak



Quarterly data | Source: BEA, Oregon Office of Economic Analysis

Source: Oregon Office of Economic Analysis<sup>5</sup>

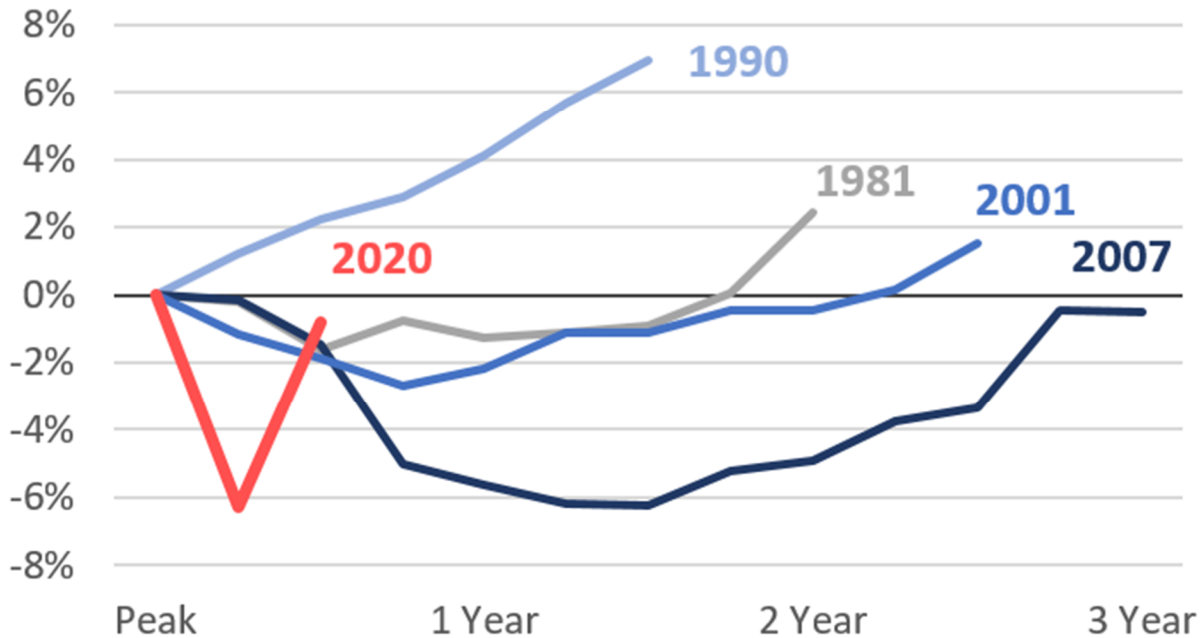
Accordingly, it's reasonable to expect 2019 levels of economic growth or higher to resume in 2021. Since we have entered 2021 with most Oregon counties, including the most populous counties, in a state of "Extreme" COVID-19 risk according to state data,<sup>6</sup> we assume personal income per capita levels will hold at Q4 2020 levels through Q1 and Q2 of 2021, with the likelihood of additional transfer payments offsetting any additional declines in wages and salaries.

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

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

# Oregon Wages and Salaries

Percent Change from Pre-Recession Peak



Quarterly data | Source: BEA, Oregon Office of Economic Analysis

Source: Oregon Office of Economic Analysis<sup>7</sup>

The two largest industries in Oregon—real estate, rental and leasing; and government and government enterprises—reflected this trend. *Inter alia*, the real estate sector saw record levels of business transacted in 2020 nationally, driven by the ultra-low interest rates the Federal Reserve implemented as part of its response to the economic damage of the pandemic. The other largest non-farm industry in Oregon, finance and insurance, posted strong growth in Q2 and modest growth in Q3, which may reflect the effect of transfer payments. By contrast, farm wages and salaries posted modest 0.4 to 2.5% growth in every quarter of 2020, reflecting the fact that it is an essential sector of the economy.<sup>8</sup>

Accordingly, we assume that EV sales trends in rural farming counties will be largely unaffected by the pandemic, whereas they will rebound more vigorously in urban professional counties. For the purposes of this scenario, we might expect the recovery to produce a more pronounced surge in EV adoption and charger deployment in urban areas than in the rural areas.

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

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

Population distribution is expected to shift modestly from urban to rural areas, reflecting national trends seen during the pandemic. Many workers in professional industries who worked from home in 2020 and will be able to continue doing so have opted to move to less-congested, more rural locations. Although this scenario features an economic rebound, we do not expect it to reverse these trends, because many people who chose to move did so for quality of life reasons, and not because of changes in their income. The influx of young urban professionals to major population centers in Oregon that has been seen in recent years may temper somewhat, as those workers are drawn to more rural areas instead. Accordingly, this demographic shift may increase interest in EV adoption in rural counties over the levels seen before the pandemic, and more robust deployment of chargers in rural than in urban areas. However, the chargers deployed in rural areas are more likely to be privately owned than part of EVSP networks.

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

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

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

Investments in infrastructure and rights-of-way for bike- and pedestrian-friendly infrastructure, including micromobility options, could be less robust in urban areas under this scenario than in Scenarios 1 and 3, driven by a perception that everything is quickly going "back to normal" and the in-migration of young urban professionals falls off from the pace of the pre-pandemic era. Major cities may find that the counterbalancing effect of out-migration to other states or to more rural areas has reduced their tax revenues and are no longer able to fund investments into modes of transportation that do not rely on petroleum fuels or personal cars as they had planned prior to the pandemic. In this scenario, the trends away from personal vehicle ownership that had existed before the pandemic could lose momentum or actually reverse, as more people now living in more rural areas now have to drive instead of taking public transit or other non-driving options. Transportation network companies (TNCs) like Uber and Lyft could flounder in this scenario as the growth in ridership they experienced before the pandemic fails to return.

#### *By 2025*

EVs have reached sticker-price parity with ICE vehicles, driving a spike in consumer interest. The market share for EVs is 15%—stronger than in Scenario 1 and well over the 1.15% share in 2020. Charging networks for light duty EVs have expanded significantly. As in Scenario 1, public DCFC are available within a 50 mile radius of anywhere in the state, and Level 2 chargers increasingly getting installed in

public, workplace and MUD parking lots. “Range anxiety” about the availability of charging stations isn’t really something anyone feels anxious about anymore. Proposed upgrades to underpowered chargers and expansion of charging stations along the West Coast Electric Highway have been made, and the 2025 targets in the West Coast Clean Transit Corridor Initiative have been fully met, including eight sites along I-5 in Oregon. Preparations are being made to align with California’s Advanced Clean Trucks (ACT) rule, which will require new Class 7-8 semi truck sales to be 30% zero-emission by 2030, and 40% by 2035.

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

#### *By 2030*

Driven by their superior economics, the market share of light duty EVs is nearing 60% and EVs are quickly gaining share in all other market segments. There is broad support for adopting EVs wherever vehicles are suitable for the use-case, in both urban and rural environments. For specialized applications where EVs have far lower costs of ownership, like refuse trucks and forklifts, electric models enjoy very high (90% or higher) market shares. Electrified pickups and electrified farm equipment are commonplace and no longer regarded as novel in rural communities, but are not yet dominant in the overall rolling stock.

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

#### *By 2035*

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

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

#### *Scenario 3: Slow recovery*

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

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

After four years of economic stasis marked by recurring lockdowns imposed in response to waves of new infection, by the end of 2024 the economy is weak, unemployment rates are high, and the ability of federal and state coffers to cover the shortfalls and support the unemployed is wearing thin. Everyone is looking to the federal government to pull the economy out of its slump, using printed money if necessary.

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

Beginning with 2025, we will apply steeper S-curves than we used in Scenario 1 to model a rapid transition to EVs and the requisite charging infrastructure to support them.

#### *Narrative*

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

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

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

When the virus is finally brought under control by the end of 2024 and normal economic activity can resume, only a major federal stimulus program will have the power to reinvigorate the economy. In 2025, the United States Congress takes aggressive action and embarks on an infrastructure investment program that dwarfs the New Deal, putting tens of millions of people to work. Part of the program is a “cash for clunkers” program designed to replace every light duty ICE vehicle older than 5 years with an EV. It also offers substantial rebates and tax credits aimed at electrifying medium- and heavy-duty vehicles, and creates funding channels that provide federal dollars directly to utilities to support the expansion of charging infrastructure across the country.

Non-farm sector jobs in Oregon have contracted to pre-2019 levels as the pandemic has raged on, and while they do rebound in response to the new stimulus investments, the majority of the federal aid

flows to sectors like construction and engineering that are directly involved in infrastructure projects. Farming and ranching jobs will not have sustained as much contraction or damage as the professional sector, because they are critical jobs sustaining the flow of food and other essentials.

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

As in the other two scenarios, the increasing adoption of EVs steadily drives down the per-mile cost of electrified personal mobility and drives up the cost of ICE-based personal mobility over the forecast period, only these effects start later due to the economic damage of the pandemic through 2024.

Population distribution will shift asymmetrically. During the 2021-2014 recession, wealthier citizens who can afford it will seek refuge from the pandemic in more remote and rural areas where they can continue working from home and enjoy a slower-paced, higher quality of life. Whereas low and middle income citizens and early-career professionals may find it easier to live in cities where they can rely on walking, micromobility, and public transportation instead of owning their own cars. Car-dependent suburbs may experience net outflows of residents as a result, accompanied by declining property values, at least until the stimulus-driven rebound kicks in.

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

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

#### *By 2025*

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

To meet the remaining need for car-based mobility, TNCs gain significant market share. When the economic rebound begins in 2025, many people who switched to micromobility options don't switch back to car ownership, so new vehicle sales to those citizens remain low. Instead, when they need a car, they turn to TNCs and car-sharing and car-rental services, which experience sharp growth starting in 2025. Enabled by federal stimulus and infrastructure spending, autonomous vehicle technology is deployed in Oregon cities by 2026, and over the subsequent five years, scales to full commercial levels.

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



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

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

### *By 2030*

The long-expected conversion of drivers to riders in autonomous vehicles arrives by 2030, but the mix of TNC riders and new EV owners leads to a different topology of charging infrastructure than in the other two scenarios. EV owners largely depend on Level 2 charging at home, and use public DCFC for longer trips. Those who have elected not to own a personal vehicle anymore are now served by autonomous vehicles provided through TNC services. Because those vehicles are autonomous, and the cost of recharging them is trivial, they increasingly use charging depots that are not located on expensive real estate in city centers, as they were when they were driven by professional drivers. Instead, their charging depots are located where provisioning high levels of utility power is cheapest, such as former brownfield industrial sites equipped with high-capacity grid power, or in proximity to utility substations or even power plants. These industrial charging depots may even become fully automated, using wireless charging or some other technology to eliminate the need for charging attendants to connect and disconnect charging cables.

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

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

Adoption of EVs is still slightly below the SB 1044 targets for 2030, with 30% of registered vehicles being ZEVs. However, they are quickly on their way to exceeding the 2030 target thanks to their outsized market share. All new light-duty vehicle purchases or leases by state agencies are ZEVs. The cost of EVs has fallen so sharply that there is no longer an opportunity for hydrogen fuel cell vehicles to catch up, and all of the vehicles purchased by state agencies are EVs.

## By 2035

By 2035, gasoline stations have become virtually non-existent. Charging infrastructure is so ubiquitous that only hobbyists and enthusiasts still own petroleum-burners. Personal vehicle ownership has plummeted to levels not seen in a century. EVs have become utterly dominant, with 95% market share in all vehicle classes. In part owing to the reduced cost of transportation across the board, the economy is roaring. State and federal stimulus spending is no longer needed. Instead of focusing on how to reinvigorate the economy, state agencies are thinking about ways to optimize the new arrangements of vehicles and charging infrastructure, such as novel mobility services dispatched on demand. These new services may begin displacing transit buses and light-duty inner city trains. There are few actual drivers anymore, as autonomous technology has become a feature of all new vehicles.

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<sup>1</sup> EV Market Share by State, EV Adoption. <https://evadoption.com/ev-market-share/ev-market-share-state/>

<sup>2</sup> Economic Profile for Oregon, BEA. <https://apps.bea.gov/regional/bearfacts/statebf.cfm>

<sup>3</sup> EV Sales and Market Share by US State, EV Adoption. <https://evadoption.com/ev-market-share/ev-market-share-state/>

<sup>4</sup> Sales data for EVs in Oregon in 2019 are only available through October 2019 from Auto Alliance. 2020 data has not yet been located. <https://autoalliance.org/energy-environment/advanced-technology-vehicle-sales-dashboard/>

<sup>5</sup> Josh Lehner, "Update on Oregon Personal Income in 2020," December 17, 2020.

<https://oregoneconomicanalysis.com/2020/12/17/update-on-oregon-personal-income-in-2020/>

<sup>6</sup> <https://coronavirus.oregon.gov/Pages/living-with-covid-19.aspx#countystatus> Accessed Jan 5, 2021.

<sup>7</sup> Josh Lehner, "Update on Oregon Personal Income in 2020," December 17, 2020.

<https://oregoneconomicanalysis.com/2020/12/17/update-on-oregon-personal-income-in-2020/>

<sup>8</sup> SQINC7N Wages and Salaries by NAICS Industry, BEA.

<https://apps.bea.gov/iTable/iTable.cfm?acrdn=2&isuri=1&reqid=70&step=1#reqid=70&step=1&isuri=1&acrdn=2>