Oregon
Tina Kotek, Governor

550 Capitol St. NE
Salem, OR 97301
Phone: 503-378-4040
Toll Free: 1-800-221-8035
FAX: 503-373-7806
www.oregon.gov/energy

Oregon Energy Strategy

Modeling Assumptions and Sources

This document shows changes between the draft Reference Scenario presented in the Reference Scenario assumptions document posted on September 24, 2024 and the Refence Scenario as modeled and presented on January 31, 2025. It also shows changes to the Alternative Scenarios document published on October 2, 2024. Changes were made based on feedback received through the agency's public processes; ODOE engagement with its modeling expert, the CETI-OES Team; and developments in the availability of sources. Data sources that helped inform assumptions also have been added. Scenarios, sensitivities, and assumptions that have been updated since the last publications of Reference and Alternative Scenarios are indicated with struck-out text and revised language written in ***bold teal****.*

March 14, 2025: ODOE has revised this Modeling Assumptions and Sources document to remove a mischaracterization of the Boardman-to-Hemingway line as providing transmission between the Oregon East and West zones; to provide links to EIA and NEEA data supporting Buildings assumptions; and to provide additional detail as to how nuclear electricity generation was priced in the modeling.

Introduction

This document provides inputs for the Reference and Alternative Scenarios of the Oregon Energy Strategy energy pathways model. The modeling phase of the Oregon Energy Strategy involved development of a Reference Scenario, six Alternative Scenarios, and three sensitivities. The modeled scenarios produced different pathways to meeting Oregon's energy and climate objectives and provided information on the effects of different energy policy choices. The energy pathways modeling serves as foundational information for policy discussions in Phase 2 of the Oregon Energy Strategy process, during which ODOE is engaging with stakeholders to develop policy recommendations. The final Oregon Energy Strategy Report will be submitted to the Governor and Legislature by November 1, 2025.

The model must solve to meet Oregon's anchor climate and clean energy goals:

- Executive Order 20-04 (80 percent economy-wide reduction in greenhouse gas emissions by 2050)
- HB 2021 (100 percent reduction in greenhouse gas emissions by 2040 for the state's largest investor-owned electric utilities and Electricity Service Suppliers)
- The Climate Protection Program (90 percent reduction in greenhouse gas emissions from fuels by 2050). This is a requirement of HB 3630, which directs ODOE to develop the energy strategy and identify pathways to achieving the state's energy policy objectives.

These goals are ambitious, and there are many uncertainties surrounding what combination of technologies and measures will allow Oregon to meet its energy and climate goals over time and out to 2050. What is relatively clear based on a range of studies ODOE has evaluated is that:

- Aggressive energy efficiency and electrification are key pillars of cost-effective decarbonization;
- We have a suite of diverse technologies to choose from to decarbonize the electricity sector; and
- Clean fuels will play a key role in decarbonization.[i]

The modeling exercise relied on well-informed, data-driven judgment calls on many of the assumptions, including those relating to energy efficiency and electrification. This is because the transition to economy-wide decarbonization by mid-century requires a pace and scale that is much greater than past trends. And we are still working to understand the combination of consumer behaviors, market forces, and policy supports necessary to accomplish our goals. In order to ensure the Reference Scenario is built on the best available data and aggressive but achievable assumptions that reflect a least-cost path to decarbonization, ODOE has collaborated with industry and community experts to inform the modeling inputs. Using that feedback, ODOE and its technical contractor, the CETI-OES Team, developed a draft Reference Scenario inputs list. ODOE then engaged with experts and interested members of the public to design Alternative Scenarios that, through comparisons against each other and the Reference Scenario, provide insights into the effect of varying key inputs to the model and the elements of Oregon's energy system they reflect. ODOE reviewed all feedback received in designing the Reference and Alternative Scenarios and continued to update the Scenarios to adapt to early indicators from the modeling and new input sources as they became available. The tables below represent key data and assumptions in the Reference Scenario, Alternative Scenarios, and sensitivities.

How the Model Works

At the highest level, the model uses data on the existing state of energy production and consumption and combines this with forecasts on population growth, load growth, technology evolution, and weather patterns to assess future statewide energy demand. The model then provides a least-cost pathway to supply energy resources across the entire energy sector to meet that future demand, subject to reliability constraints.[ii]

For the Oregon Energy Strategy, the Reference Scenario is informed by Oregon's energy consumption across its state-wide economy (residential, commercial, industrial, agricultural, fuel, and transportation

[i] 2022 Biennial Energy Report. Charting a Course for Oregon's Energy Future.
[ii] Evolved Energy's Annual Decarbonization Perspective, 2023.

sectors). To determine energy demand, it looks at energy-consuming technologies across 80 different sub-sectors (space heating, cooking, cars and trucks, and many others), and makes assumptions about how these technologies change over time, including improvements in energy efficiency, when these technologies are expected to turn over, and what they will be replaced with when they reach the end of their useful life.

The Reference Scenario also considers factors like weather, population growth, and industrial load growth (including from industrial data centers and chip manufacturing) to account for how energy demand is likely to change over time. Through this process, the model comes up with a picture of Oregon's energy needs every five years, from now to 2050.

Once we have a picture of how much energy Oregon will need over time, the model searches for the most affordable mix of resources to meet demand across all energy consuming sectors while meeting our key climate and energy goals and maintaining reliability.[iii] It draws on everything from utility-scale resources to smaller-scale and distributed energy resources to do this. The model also considers the availability of energy supply infrastructure (i.e., gas pipes and electricity wires) to deliver that energy to customers.

Using Modeling Results

The modeled Scenarios are not intended to predict the future; rather, they provide insights into pathways that meet our clean energy goals by considering differences in costs, energy efficiency, feasibility, and availability. The Reference Scenario was compared against Alternative Scenarios that produce different energy pathways that are used to explore "What if?" questions. For example: What if transmission development is further delayed? What if we do not achieve as much electrification as in the Reference Scenario and instead rely more on clean fuels? What would these scenarios mean for overall system costs? What would they mean for the mix of resources Oregon would need to meet our clean energy goals? And most importantly: what do we learn from this exercise about the technologies and measures that are most likely to deliver a lowest-cost, highest-benefits energy transition for our state? The information we gather will provide a basis for analysis and discussion around what policies are needed to achieve our energy objectives while maintaining a resilient and affordable energy system — and create a more equitable energy future for Oregon.

ODOE will continue to accept comments on the Energy Strategy throughout Phase 2 policy discussions and expects to publish draft policy recommendations for public input in June**.**

[iii] The model can incorporate some non-energy constraints, such as land use protections. However, much of the analysis on non-energy costs and benefits will happen when we are evaluating the results of the modeling. ODOE and the CETI-OES Team are conducting complementary analyses and a jobs study to help evaluate the effects of different scenarios on affordability, air quality and public health, and employment.

Table of Contents

1. Buildings

1.1. Buildings: Stock and Stock Replacement Data

Residential Space Heating	Northwest Energy Efficiency Alliance (NEEA) Residential Building Stock Assessment & Home Energy Score Data*
Commercial Space Heating	NEEA Commercial Building Stock Assessment
Residential Water Heating	NEEA Residential Building Stock Assessment & Home Energy Score Data*
Commercial Water Heating	NEEA Commercial Building Stock Assessment
Residential Building Shells	NEEA Residential Building Stock Assessment & Home Energy Score Data*
Commercial Building Shells	NEEA Commercial Building Stock Assessment
Residential Technology Stock Replacement	Energy Information Administration (EIA) Updated Buildings Sector Appliance and Equipment Costs and Efficiencies (2023)
Commercial Technology Stock Replacement	EIA Annual Energy Outlook Updated Buildings Sector Appliance and Equipment Costs and Efficiencies (2023)
Residential Cooking & Other Appliances	NEEA Residential Building Stock Assessment

**Oregon's Home Energy Score data comes from Earth Advantage*

1.2. Buildings: Key Assumptions and Sources Informing Assumptions

Residential Space Heating	• Assume existing policies play out for all space heating technologies 65% electric heat pump sales by 2030; 90% by 2040 • **Households with wood stoves: By 2050, 75% air-source heat pump (ASHP) with woodstove hybrid, 20% woodstove only, 5% heat pump only**	**Heat pump sales:** • Multi-agency memorandum of understanding (MOU) • Oregon's Transformational Integrated Greenhouse Gas Emissions Reduction Project Report (TIGHGER) • Langevin, J, et al. (2023). Demand-side solutions in the US building sector could achieve deep emissions reductions and avoid over $100 billion in power sector costs. One Earth, Volume 6, Issue 8, 18 August 2023, Pages 1005-1031. • ODOE review of/work with Oregon local wood stove heating replacement

		assistance programs
Small versus large commercial building split	50/50 split	Portland Salem Medford Building Stock Characterization
Commercial Space Heating	Weighted average of large and small commercial space heating loads, with the following framing: - Small commercial: follow residential - Large commercial: ○ 2030: Electric heat pumps 15% of overall sales; other electric + electric hybrid systems (including hybrid heat pumps) 10% of overall sales ○ 2045: Electric heat pumps 50% of overall sales; other electric + electric hybrid systems (including hybrid heat pumps) 40% of overall sales	Langevin, J, et al. (2023). Demand-side solutions in the US building sector could achieve deep emissions reductions and avoid over $100 billion in power sector costs. One Earth, Volume 6, Issue 8, 18 August 2023, Pages 1005-1031.
Residential Water Heating	• Incorporate Federal Energy Conservation Standards for Consumer Water Heaters (from May 6, 2029) • Electric heat pump sales rising to 95% of overall sales by 2045	USDOE's Energy Conservation Standards for Consumer Water Heaters rule
Commercial Water Heating	Weighted average of large and small commercial water heating loads, with the following framing: - Small commercial: follow residential - Large commercial: ○ 2035: Electric heat pumps for water heaters 15% of overall sales, other electric technologies 10% of overall sales ○ 2045: Electric heat pumps for water heaters 50% of overall sales, other electric technologies 40% of overall sales	USDOE's Energy Conservation Standards for Consumer Water Heaters rule
Cooking	95% sales of new appliances are electric by 2035	TIGHGER
Technology stock replacement	Dual gas/electric heat pump systems, differentiated by climate zone, compete with other electric technologies in line with sales shares above	*N/A*
~~Building shells~~	• ~~Weatherize 80% of existing commercial and residential home envelopes by 2040 and 95% by 2050.~~ ~~Weatherization measures assumed to achieve a~~	2020 OHCS Low Income Weatherization Program Report

Whole-home retrofits	~~10% reduction in overall building energy use on average.~~ • **3,500 homes a year. Whole home retrofits, represented by the Advanced Envelope Efficiency Package in Evolved Energy Research's "Enhancing Building Efficiency Modeling" report**	Evolved Energy Research, Enhancing Building Efficiency Modeling (2024)
Lighting	100% LED sales by 2025	HB 2531

2. Industry

Industrial Processes	1% process efficiency improvements per year in all sectors	*Assumptions based on CETI research, vetted by technical working groups*
Electrification	Fuel switching measures from fuels to electricity as follows: • 100% of machine drives by 2035 • 100% of **low temperature** heat by 2050, including in Oregon's largest industries such as computer and electronics products • **50% of heat in bulk chemicals production, 25% of heat in glass production** • 50% of integrated steam production, including in food manufacturing, by 2045 • 100% of refrigeration by 2040 • 75% of industrial HVAC loads across industrial subsectors by 2050 • 80% of industrial vehicles including in agriculture by 2050 • **50% of construction energy demand by 2050**	*Assumptions based on CETI research and TIGHGER Report, vetted by technical working groups* USDOE, Industrial Decarbonization Roadmap (2022)
Switch to Hydrogen	• 50% of heat in bulk chemicals (not a large industry in OR) • **20% of integrated steam production, including in food manufacturing, by 2050** • 20% of construction energy demand • 20% of industrial vehicles by 2050	*Assumptions based on CETI research, vetted by technical working groups*
Cement	Cement process is optimized in the model, including retrofits and new build rotary kilns to include direct separation, oxy-combustion, biomass fuel, and CCS (not a large sector in Oregon)	*Assumptions based on technology options from Agora Industry Cement Transformation Cost Calculator*
Thermal Energy Storage	Economic adoption modeled in industrial sector	*Assumptions based on costs from IRENA Innovation*

		Outlook: Thermal Energy Storage
Hybrid Boilers	Model can invest in dual fuel electric and gas boilers as well as hydrogen boilers	*N/A*

3. Transportation

3.1. Transportation: Stock and Sales Share Data

Light duty vehicle (LDV) current stocks	Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) model containing data submitted by OR Dept. of Transportation – Driver & Motor Vehicle division (DMV)
Medium- and heavy-duty vehicle (MHDV) current stocks	Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) model containing data submitted by OR Dept. of Transportation – Driver & Motor Vehicle division (DMV)
Transit Buses current stocks	Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) model containing data submitted by OR Dept. of Transportation – Driver & Motor Vehicle division (DMV)
School Buses current stocks	OR Dept. of Transportation – DMV Data
Fuels current	OR Dept. of Environmental Quality Clean Fuels Program Data
Vehicle Miles Traveled (VMT) current	Dept. of Environmental Quality / EPA MOVES (data comes from Highway Performance Monitoring System)
Fuel Economy current	EPA MOVES, Historical average fuel economy by vintage and vehicle type
LDV sales shares MHDV sales shares	Advanced Clean Cars I / Advanced Clean Cars II* International Council on Clean Transportation (ICCT) forecasts based on IRA incentives Advanced Clean Trucks through 2035* ICCT forecasts based on IRA incentives

**These inputs/assumptions are based on existing state or federal policy at the time the model was run.*

3.2. Transportation: Key Assumptions

MDV and HDV sales shares – post 2035	Post 2035: • 100% zero emission vehicle (ZEV) sales by 2040 for Class 2b-8 vehicles (excluding buses) • For long haul: 65% battery electric vehicles (BEVs)/35% hydrogen fuel cell vehicles (FCEVs) • All other classes: 100% electric
Transit Buses future	100% ZEV sales by 2036; 75% BEV / 25% FCEV sales by 2040 TIGHGER 2023 Biennial Zero Emissions Vehicle Report
School Buses future	100% BEV sales by 2036 (100% electric)
Rail future	20% electric, 70% hydrogen by 2050 (logistic growth starting in 2030)
Maritime Shipping future	• Domestic: 10% electric, 20% H2, 50% ammonia by 2050 (logistic growth starting in 2030)

	• International: 20% H2, 60% ammonia by 2050 (logistic growth starting in 2030)
Vehicle Fuels future	Clean Fuels Program*
Vehicle Mean Lifetimes	• Combination trucks: 15 years • Single unit trucks: 18 years • Transit and school buses: 12 years • Passenger cars: 16 years • Passenger trucks: 14 years • Light duty commercial truck: 12 years
Fuel economy: Light duty cars and trucks	Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) model
Fuel economy: Medium duty & heavy-duty vehicles	Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) model
Fuel economy: Buses	Environmental Protection Agency's (EPA's) Motor Vehicle Emission Simulator (MOVES) model
Fuel economy: Aviation	20% efficiency gain through 2050, to reflect International Air Transport Association (IATA) Net Zero Roadmap IATA Net Zero Roadmap
VMT Assumption	20% reduction in LDV VMT per capita by 2050* 2023 Oregon Transportation Plan
Vehicle costs	• Light-Duty Vehicles: Assessment of light-duty electric vehicle costs and consumer benefits in the United States in the 2022 2035 time frame, ICCT, 2022. • Medium- and Heavy-Duty Vehicles: Analyzing the impact of the Inflation Reduction Act on electric vehicle uptake in the United States, ICCT, 2023 • Transit / School Buses: Analyzing the impact of the Inflation Reduction Act on electric vehicle uptake in the United States, ICCT, 2023 • Rail / Aviation / Maritime: Costs assumed to be same as fossil alternatives due to lack of data
Fuel costs	Annual Energy Outlook 2023 Oil and Gas Forecasts
Infrastructure costs	EV Charging: NREL Electrification Futures Study Hydrogen: U.S. Dept. of Energy Technical Targets for H2 Delivery

**These inputs/assumptions are based on existing state or federal policy at the time the model was run.*

4. Direct Use Fuels

Demand Side Assumptions	Modeled residential, commercial, and industrial demand end use using assumptions about sales shares in EnergyPATHWAYS
Supply Side Assumptions	Energy Information Administration Form EIA-860 listing existing and planned generator additions Survey of peer reviewed and government agency sources of capital and operating costs and performance (ADP Technical Documentation 2023, p. 61)

Fuel supply and price forecasting	Energy Information Administration (EIA) Annual Energy Outlook NW Power and Conservation Council's Fuels Advisory Committee natural gas price forecast U.S. Department of Energy Billion Ton Report
Alternative Clean Fuel Investment	DEQ's Climate Protection Program **as regulated under Administrative Order No. DEQ-18-2024: 50% emissions reduction by 2035, 90% by 2050, applied to fossil fuel emissions**
Alternative Clean Fuels	Biomass-derived fuels, hydrogen, and hydrogen-derived fuels qualify as clean (if green hydrogen used). Imported new fuels are counted as zero emission fuels (credit for negative emissions from processes like BECCS are retained by producing state). Clean Fuel Standard incorporated

5. Energy Efficiency and Load Flexibility

Behind the Meter Photovoltaic (BTM PV)	Northwest Power and Conservation Council March 2024 rooftop solar projections	NWPCC 2024 solar rooftop projections https://www.oregonlegislature.gov/bills_laws/ors/ors469a.html
BTM Storage Adoption	Energy Information Administration's (EIA) June 2024 Survey: 10 MW assumed today 42 MW/25 MWh of BTM storage (1% of households install storage systems by 2050; 20% of them participate in offering grid services, 50% of stored energy available	EIA June 2024 Survey Brattle, 2024. California's Virtual Power Potential: How Five Consumer Technologies Could Improve the State's Energy Affordability
Flexible Load Parameters	• Space heating loads can be delayed or advanced by 1 hour • Water heating loads can be delayed or advanced by up to 2 hours • Air conditioning can be delayed or advanced by 1 hour • Residential vehicle charging can be delayed by up to 8 hours and commercial vehicle charging up to 3 hours	
V2G	26% V2G for residential EVs by 2050, assuming utilities can discharge battery down to 40% capacity (so use 60% of EV battery)	National Grid - Distribution Future Energy Scenarios regional information
Tech Load Growth	NWPCC Northwest Power Supply Adequacy Assessment for 2029 mid-higher case, with load differentiated across modeling zones	NWPCC Pacific Northwest Power Supply Adequacy Assessment for 2029
Demand Response –	50% of homes with demand response capability are participating in some form of firm demand response program by 2050	BPA Demand Response Potential Assessment, 2022-2045

Households participation	for heating, water heating, and air conditioning (linear growth from 2025) Residential EVs: Start at 0, ramp up to 2/3 of residential EVs participate in managed charging by 2030	LBNL, The California Demand Response Potential Study (2024) Portland General Electric 2023 Clean Energy Plan and Integrated Resource Plan
Demand Response - Commercial	50% of commercial spaces with demand response capability are participating in some form of firm demand response program by 2050 for heating, water heating, and air conditioning (linear growth from 2025) Commercial EVs: Start at 0, ramp up to 1/3 of commercial EVs participate in managed charging by 2030	BPA Demand Response Potential Assessment, 2022-2045 LBNL, The California Demand Response Potential Study (2024) Portland General Electric 2023 Clean Energy Plan and Integrated Resource Plan
Demand Response - Industrial	Includes dual fuel boilers, thermal energy storage, process flexibility, heating, cooling There is no input assumption. The model will provide insights into the uptake of technologies with flexibility potential over time	*N/A*

6. Electricity Generation Technologies

Energy Demand	• Results from EnergyPATHWAYS model informs Regional Investment and Operations Model (RIO) (both Evolved Energy Research models) • Tech load growth trajectory (see Section 5 above) • Rooftop solar scheduled additions (see Section 5 above)
Electric Supply	Existing supply Siting restrictions apply to new generation, interconnection, transmission (see Section 7 below) Out-of-state generation requires transmission
Generation Options	• Hydropower **(based on simulated hourly hydro data from the NWPCC 2029 Adequacy Assessment Reference Scenario and climate scenarios projected through 2029)** • Solar (photovoltaic and thermal) • Wind (onshore, offshore) • Biomass (woody, manure, biogas) • Natural gas, existing biogas, hydrogen, renewable natural gas, and new biogas supplies eligible to be burned in existing gas turbines. **Option for gas-burning hydrogen or new biogas supplied new hydrogen electricity plants under 25 MW** • **Conventional and enhanced** geothermal

	• Coal, gas, nuclear (siting restrictions – no new natural gas or nuclear sited in Oregon) • Costs for new geothermal generation based on NREL ATB advanced pricing; all other non-nuclear generation pricing based on NREL ATB mid pricing. **Costs associated with nuclear energy generation are described below.**
Nuclear Costs	**Nuclear costs are based on Evolved Energy Research's evaluation of costs, informed by several sources, including US DOE-funded research. Evolved calculated costs by breaking nuclear plants into different components: Reactor, electricity steam turbine, and thermal storage. Thermal energy storage costs were sourced from the International Renewable Energy Agency.**
Transmission Availability	(See Section 8 below) Existing capacity, including PacifiCorp's Gateway South segment F in 2025 Boardman to Hemingway (B2H) project assumed online in 2030 Otherwise no new inter-zonal transmission is built until 2035 New inter-zonal capacity modeled based on The Nature Conservancy Power of Place West
Inflation Reduction Act Incentives	Supply-side incentives include hydrogen production, renewable electricity generation, battery storage, carbon capture, clean fuels, out-of-state nuclear

7. Land Use and Natural Resources

7.1. Land Use Screens

The Reference Scenario restricted the use of legally protected (PoP[iv] Level 1), administratively protected (PoP Level 2), **and high conservation value (PoP Level 3) areas** in Oregon for energy development using The Nature Conservancy's PoP - West study as a framework to select land use screens.

Categories of Exclusion	Definition of Category	Examples	Biomass
PoP Level 1	Legally protected: Areas with existing legal restrictions	National Wildlife Refuges, National Parks, Marine Sanctuaries, Military Training Areas	All feedstocks included, exclude potential supply from conservation reserve program land
PoP Level 2	Administratively protected: Level 1 + areas with existing administrative and legal designations where state or federal law requires	Critical Habitat for Threatened or Endangered Species, Sage Grouse Priority Habitat	No net expansion of land for purpose-grown herbaceous biomass crops. Specifically, land available for herbaceous biomass crops (miscanthus and

[iv] The Nature Conservancy's Power of Place (PoP) report outlined clean energy solutions for energy planners and policymakers to consider for net-zero strategies that benefit climate, conservation, and communities.

	consultation or review and lands owned by non-governmental organizations (NGOs) on which there are conservation restrictions.	Management Areas, vernal pools and wetlands, tribal lands	switchgrass) is limited to the share of land currently cultivated for corn that is eventually consumed as corn ethanol, which is phased out in all net zero scenarios by 2050.
PoP Level 3	High conservation value: Level 1 + Level 2 + areas with high conservation value as determined through multi-state or ecoregional analysis (e.g., state, federal, academic, NGO) and lands with social, economic, or cultural value.	Prime Farmland, Important Bird Areas, big game priority habitat and corridors, TNC Ecologically Core Areas, "Resilient and Connected Network"	Same as Level 2

7.2. Land Use Key Assumptions

Emissions constraint target accounting	Emissions reduction of anthropogenic emissions, using natural climate solutions and sequestration not eligible
Carbon Capture and Storage (CCS)	CCS included as a carbon reduction option in the model
Non-CO2, non-energy	EPA developed supply curves of measures to reduce non-CO2 and non-energy emissions, e.g. reducing methane (CH4) leakage, reducing f-gases in industrial processes and products, reducing nitrous oxide (N2O) from soil management. Optimized by the model against energy emissions reduction measures
Marine Environment	PoP-West Level 3 category of exclusion used for offshore wind potential

8. Transmission and Distribution

Existing Capacity	Existing capacity, including PacifiCorp's Gateway South segment F in 2025
Timing of Electricity Transmission Development	No new transmission until 2035, except for Boardman to Hemingway (B2H) project online in 2030~~; PAC's Gateway project online in 2035; Snow Goose to Longhorn (Boardman) online in 2035~~ ~~Reconductoring/Rebuilding Existing Lines - BPA's Big Eddy to Chemawa project and PGE's Round Butte to Bethel project, both expanding East to West transfer capacity from 230 kV to 500 kV and both online in 2035.~~
Electricity Distribution System Cost Assumption	Proxy value based on historic costs from Energy Information Administration (EIA)

Pipeline Infrastructure Assumptions	No new infrastructure development beyond operations and maintenance for interstate natural gas pipelines
Electricity transfer capacity between East and West Oregon	Publicly available Bonneville Power Administration (BPA) data on historical path flows. ~~Account for transmission expansion project noted above (B2H, Big Eddy to Chemawa, and Round Butte to Bethel~~).

Alternative Scenarios, Sensitivities, and Key Assumptions

The tables below describe the Alternative Scenarios and sensitivities included in the Energy Strategy technical modeling. These alternatives and sensitivities vary the key assumptions included in the Reference Scenario; varying these key assumptions in the modeling produces different cost and energy portfolio results in projected least-cost energy pathways for Oregon. The differences in these results can provide important policy insights for Oregon's energy future. ODOE has, in collaboration with the CETI-OES Team and through stakeholder engagement, designed and selected the Alternative Scenarios and sensitivities below to provide learnings and inform Phase 2 policy discussions.

Updated Alternative Scenarios and sensitivities are named in **bold teal text**. **Bold black text** is used to highlight differences in assumptions between Reference and Alternative Scenario where other, related assumptions are retained.

Sensitivities 0a-0c:

ODOE made a few changes in our approach to modeling sensitivities for the various scenarios. The sensitivity for VMT reductions has been retained, but ODOE decided against including a sensitivity for transmission construction between Eastern and Western Oregon, as early modeling indications showed that that constraint was unlikely to provide valuable learnings. Instead, ODOE decided to model sensitivities to vary tech load growth assumptions and assumptions regarding the implementation of Advanced Clean Trucks regulations. Early modeling indicators demonstrated that tech load growth and vehicle electrification were likely to play a significant role in Oregon decarbonization pathways. Because of the significance of these factors to Oregon energy pathways and policy considerations, as well as robust stakeholder interest in these issues, ODOE decided to investigate them through modeling sensitivities.

Sensitivity 0a*:* *No Change in VMT in Reference Scenario.*

	Reference Scenario	Sensitivity
VMT Assumption	20% reduction in LDV VMT per capita by 2050	No change in VMT per capita from today

Sensitivity 0b: *50% Lower Tech Load Growth in Reference Scenario.*

	Reference Scenario	Sensitivity
Tech Load Growth	NWPCC Northwest Power Supply Adequacy Assessment for 2029 mid-	50% of Reference Scenario tech loads electricity demand

	higher case assumed by 2030, with 1.5% load growth annually 2030-2050	

Sensitivity 0c: *No Advanced Clean Trucks Regulation in Delayed Transportation Electrification Alternative*

	Alternative 2	Sensitivity
MHD Electrification Assumption	• Advanced Clean Trucks targets through 2035 • 100% ZEV sales for transit/school buses by 2036 • 100% ZEV sales for all other MHD vehicle classes by 2050	• 100% ZEV sales for all MHD vehicle classes by 2050 • No interim electrification targets for MHD

Alternative 1. Delayed Energy Efficiency and Building Electrification [*formerly Lower Energy Efficiency and Electrification]*

Key Assumptions

	Reference Scenario	Alternative Scenario
Residential Space Heating	• Assume existing policies play out for all space heating technologies • 65% heat pump sales by 2030; 90% by 2040	• Assume existing policies play out for all space heating technologies • **65% heat pump sales by 2040; 90% by 2050**
Commercial Space Heating	Weighted average of large and small commercial space heating loads, with the following framing: • Small commercial: follow residential • Large commercial: ○ 2030: Electric heat pumps 15% of overall sales; other electric + electric hybrid systems (including hybrid heat pumps) 10% of overall sales ○ 2045: Electric heat pumps 50% of overall sales; other electric + electric hybrid systems (including hybrid heat pumps) 40% of overall sales	Weighted average of large and small commercial space heating loads, with the following framing: • Small commercial: follow residential • Large commercial: ○ **2040: Electric heat pumps 15% of overall sales; other electric + electric hybrid systems (including hybrid heat pumps) 10% of overall sales** ○ **2055: Electric heat pumps 50% of overall sales; other electric + electric hybrid systems (including hybrid heat pumps) 40% of overall sales**

<table>
<tr><td>Residential Water Heating</td><td>Incorporate Federal Energy Conservation Standards for Consumer Water Heaters (from May 6, 2029)
Electric heat pump sales rising to 95% of overall sales by 2045</td><td>Incorporate Federal Energy Conservation Standards for Consumer Water Heaters (from May 6, 2029)
Electric heat pump sales rising to 95% of overall sales by 2055</td></tr>
<tr><td>Commercial Water Heating</td><td>Weighted average of large and small commercial water heating loads, with the following framing:
Small commercial: follow residential
Large commercial:
2035: Electric heat pumps for water heaters 15% of overall sales, other electric technologies 10% of overall sales
2045: Electric heat pumps for water heaters 50% of overall sales, other electric technologies 40% of overall sales</td><td>Weighted average of large and small commercial water heating loads, with the following framing:
Small commercial: follow residential
Large commercial:
2045: Electric heat pumps for water heaters 15% of overall sales, other electric technologies 10% of overall sales
2055: Electric heat pumps for water heaters 50% of overall sales, other electric technologies 40% of overall sales</td></tr>
<tr><td>Industrial Processes</td><td>1% process efficiency improvements per year in all sectors
Fuel switching measures from fuels to electricity</td><td>0.5% process efficiency improvements per year in all sectors
Fuel switching measures from fuels to electricity</td></tr>
<tr><td>Electrification</td><td>100% of machine drives by 2035
100% of low temperature heat by 2050, including in Oregon’s largest industries such as computer and electronics products
50% of heat in bulk chemicals production, 25% of heat in glass production
50% of integrated steam production, including in food manufacturing, by 2045
100% of refrigeration by 2040
75% of industrial HVAC loads across industrial subsectors by 2050
80% of industrial vehicles including in agriculture by 2050
50% of construction energy demand by 2050</td><td>50% of machine drives by 2035
50% of low temperature heat by 2050, including in Oregon’s largest industries such as computer and electronics products
25% of heat in bulk chemicals production, 12.5% of heat in glass production
25% of integrated steam production, including in food manufacturing, by 2045
50% of refrigeration by 2040
37.5% of industrial HVAC loads across industrial subsectors by 2050
40% of industrial vehicles including in agriculture by 2050
25% of construction energy demand by 2050</td></tr>
</table>

Switch to Hydrogen	• 50% of heat in bulk chemicals (not a large industry in OR) • 20% of integrated steam production, including in food manufacturing, by 2050 • 20% of construction energy demand • 20% of industrial vehicles by 2050	• **25% of heat in bulk chemicals (not a large industry in OR)** • **10% of integrated steam production, including in food manufacturing, by 2050** • **10% of construction energy demand** • **10% of industrial vehicles by 2050**

Alternative 2. Delayed Transportation Electrification [*formerly Lower Electrification of Transportation]*

Key Assumptions

	Reference Scenario	Alternative Scenario
MDV and HDV sales shares – post 2035	Transit and School Buses: 100% zero emission vehicle (ZEV) sales by 2036 All other Class 2b-8 vehicles: 100% ZEV sales by 2040 Of the ZEVs: • For transit: 75% of ZEVs are assumed to be battery electric vehicles (BEVs), 25% are assumed to be hydrogen fuel cell electric vehicles (FCEVs) • For long haul: 65% of ZEVs are assumed to be BEVs, 35% are assumed to be hydrogen FCEVs • All other classes are assumed to be 100% BEVs	**For all Class 2b-8 vehicles, including buses: 100% zero emission vehicle (ZEV) sales by 2050** Of the ZEVs: • For transit: 75% of ZEVs are assumed to be battery electric vehicles (BEVs), 25% are assumed to be hydrogen fuel cell electric vehicles (FCEVs) • For long haul: 65% of ZEVs are assumed to be BEVs, 35% are assumed to be hydrogen FCEVs • All other classes are assumed to be 100% BEVs

Alternative 3. Limited Demand Response

Key Assumptions

	Reference Scenario	Alternative Scenario
Demand Response – Households participation	50% of homes with demand response capability are participating in some form of firm demand response program by 2050 (linear growth from 2025) Residential EVs: Start at 0, ramp up to 2/3 of residential EVs participate in managed charging by 2030	**5% of homes with demand response capability are participating in some form of firm demand response program by 2050 (linear growth from 2025)** **Residential EVs: Start at 0, ramp up to 20% of residential EVs participate in managed charging by 2030**
Demand Response - Commercial	50% of commercial spaces with demand response capability are participating in	**5% of commercial spaces with demand response capability are participating in**

	some form of firm demand response program (linear growth from 2025) Commercial EVs: Start at 0, ramp up to 1/3 of commercial EVs participate in managed charging by 2030	**some form of firm demand response program (linear growth from 2025)** **Commercial EVs: No commercial EV participation in managed charging**
Vehicle-to-grid	26% V2G for residential EVs, assuming utilities can discharge battery down to 40% capacity (so use 60% of EV battery)	**No V2G for residential EVs**

Alternative 4. Limited Utility-Scale Electricity Generation in Oregon [*formerly Constrained Transmission*]*

ODOE originally proposed to model an alternative scenario to delay most transmission buildout to 2045 instead of 2035, as assumed in the Reference Scenario. However, early modeling indications showed that it may be economical to construct a large amount of in-state renewables. This construction, along with reconductoring transmission lines, indicated that the proposed constrained transmission alternative was unlikely to produce meaningful learnings to inform Phase 2 policy discussions. Instead, based on conversations with the CETI-OES Team, ODOE decided to model an alternative that would reduce the quantity of in-state, grid-scale renewable construction. Additionally, as described in Alternative 5, below, ODOE designed a new alternative scenario that would include a restriction of transmission development to reconductoring.

Key Assumptions

	Reference Scenario	Alternative Scenario
Resource Availability	Economic selection of grid-scale wind, solar, and geothermal resources based on Oregon energy objective, policy, and reliability constraints.	Limit potential for grid-scale wind, solar, and geothermal generation in Oregon to half of that built in Reference Scenario.

Alternative 5. High Distributed Energy Resources + Limited Transmission [*formerly Constrained Utility-Scale Renewables*]*

ODOE formerly proposed to explore a Constrained Utility-Scale Renewables Alternative Scenario which would explore the impact of restricting infrastructure development in PoP – West Level 3 high conservation value areas. As discussed above, stakeholder feedback and early modeling data indicated that the additional application of Level 3 restrictions would not result in substantial differences of infrastructure construction, and so that limitation was adopted for the Reference Scenario.

As a result, ODOE designed the following High Distributed Energy Resources + Limited Transmission Alternative Scenario and related assumptions to capture some of the learnings intended by the former Constrained Utility-Scale Renewables Alternative Scenario.

Key Assumptions

	Reference Scenario	Alternative Scenario

Transmission Development	TX and pipeline expansion available from 2035 onwards. B2H comes online 2030.	B2H comes online 2030. **Only reconductoring projects allowed.**
Distributed Energy Resources	NWPCC Forecast for rooftop solar. 42 MW/25 MWh of BTM storage (1% of households install storage systems; 20% of them participate in offering grid services, 50% of stored energy available).	**7GW of rooftop solar. 2.1GW/1.3 GWh participating BTM storage capacity (40% of solar customers with storage, 50% participation, 50% of stored energy available).**
Demand Response: V2G	26% V2G for residential vehicles by 2050	**2/3 V2G for residential vehicles by 2050**

Alternative 6. Alternative Flexible Resources [*formerly Higher Hydrogen Availability]***

ODOE considered several alternative scenarios to investigate the role of hydrogen in decarbonization pathways for Oregon in discussions with our technical modeler. Based on these discussions, commenter feedback, and early indicators from the modeling that clean fuels (hydrogen and biogas) might serve an important energy system reliability role, ODOE decided to model an Alternative Scenario to test the impacts of constraining the buildout of clean fuel plants and clean combustion turbines.

Key Assumptions

	Reference Scenario	Alternative Scenario
Resource Availability	Option for 100% hydrogen or new biogas supplied new electricity plants under 25 MW	**No new gas or biogas electricity of any size allowed in Oregon**

~~Alternative 7. More Aggressive Greenhouse Gas Emission Reductions~~

ODOE considered but ultimately decided against modeling an alternative scenario with more aggressive GHG emission reduction objectives. This decision was informed by the mixed feedback ODOE heard on the value of such an alternative scenario and the need to focus on differences shown by the other Alternative Scenarios in Phase 2 policy discussions. ODOE will consider exploring more ambitious GHG reduction objectives for updates to the Energy Strategy.