Modeling Study on Program Options to Reduce Greenhouse Gas Emissions

Assumptions, Data Sources, and Methods

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DEQ
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Department of
Environmental
Quality

ICF

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1 Introduction

Oregon DEQ seeks to establish the Climate Protection Program to set declining and enforceable limits on greenhouse gas emissions from some of the most significant sources in Oregon, including transportation fuels, such as diesel and gasoline, and other liquid and gaseous fuels, such as natural gas and propane. The Climate Protection Program aims to not only significantly reduce greenhouse gas emissions in Oregon, but to do so in a manner that contains costs for businesses and consumers and achieves co-benefits for the citizens of Oregon, in particular for those communities disproportionately impacted by air pollution, climate change, and energy costs.

To support those objectives, DEQ contracted with ICF and their subcontractor, Cascadia Consulting Group, to complete the following:

- Estimate a Reference Case of greenhouse gas emissions for Oregon that would occur in absence of the program;
- Estimate reductions in greenhouse gas emissions under different policy scenarios; and
- Determine potential health, economic, co-benefits, and equity impacts under those policy scenarios.

The results of these analyses will help inform the design of the Climate Protection Program (“the program”) during DEQ's Greenhouse Gas Emissions Program 2021 Rulemaking.

This document details the methods used in conducting these analyses and key results. More information is included in the materials posted on DEQ’s modeling study website. Results from these analyses are also summarized in the report titled *Modeling Study on Program Options to Reduce Greenhouse Gas Emissions: Summary Report*.

2 Overview of Approach

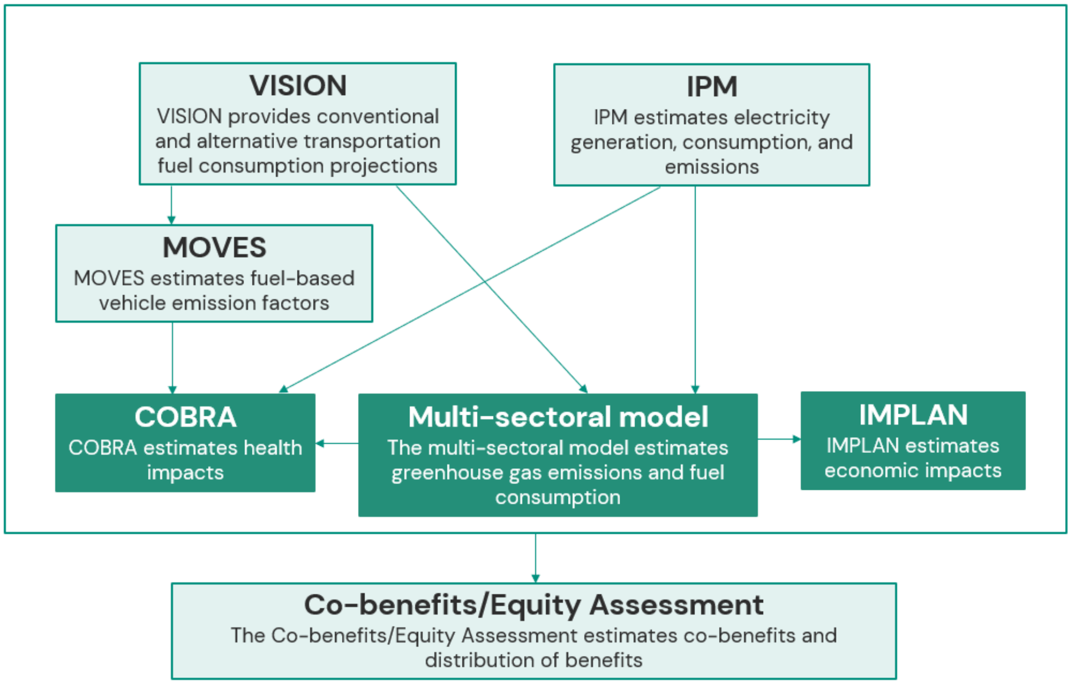
2.1 Types of Analyses Conducted

This involved estimating the impacts of different policy design scenarios with respect to:

- Reductions in greenhouse gas emissions;
- Impacts on Oregon public health due to associated reductions in air pollution;
- Macroeconomic impacts to Oregon’s overall economy; and
- Whether the program might result in other co-benefits in the state, and the extent to which benefits or negative impacts may differentially affect different populations in Oregon.

As shown in Figure 1, ICF used various models for these components. These models are discussed in more detail in later sections. However, it is important to note that outputs from some analyses became inputs into the next analysis, demonstrating the interrelatedness of different sectors, policy assumptions, and environmental and social outcomes.

Figure 1: ICF's Modeling Approach



2.2 Policy Scenarios Evaluated

ICF conducted modeling for the following future scenarios:

- A **Reference Case scenario**, for which ICF estimated projected future greenhouse gas emissions in Oregon in the absence of the program.
- **Three initial policy scenarios**, for which ICF modeled the impact of theoretical program designs in terms of greenhouse gas emission reductions, health impacts, and economic impacts at the state-level. ICF subcontractor, Cascadia, completed a qualitative assessment of co-benefit and equity impacts for these scenarios as well.
- **A final, fourth scenario**, whose assumptions were informed by the findings of the first three scenarios. The same analyses were conducted for this final scenario, and more detailed, county-level impacts were evaluated for health, co-benefits, and equity.

Design elements associated with each policy scenario are described in Table 1 below. Each policy scenario is analyzed using the Reference Case scenario as the starting point, and then is compared to the Reference Case within the analysis. The Reference Case scenario assumes a continuation of current trends and existing policies across emission sources in Oregon. Emission levels and trends in the Reference Case scenario are informed by Oregon's Sector-Based Greenhouse Gas Inventory and standard projection methodologies using various data sources such as the Energy Information Administration's Annual Energy Outlook, Oregon's Clean Fuels Program data, utility Integrated Resource Plans (IRPs), and the U.S. Environmental Protection Agency's State Inventory Tool; these resources are discussed more below. The Reference Case scenario also includes a number of existing policies and programs, outlined in Table 2.

It is important to note that none of these policy scenarios are meant to represent the actual program that will be put in place. Rather, these scenarios were intended to help provide insights into possible program design decisions, and how those decisions might affect the outcomes of the program and the impacts on Oregon.

Table 1: Policy Scenario Parameters, as defined by DEQ

Key Topic	Policy Scenario 1	Policy Scenario 2	Policy Scenario 3	Policy Scenario 4
Modeled Program Length	2022 through 2050	2022 through 2050	2022 through 2050	2022 through 2050
Baseline Year for Initial Program Cap	2010	2010	2010	2010
Cap and Trajectory	Straight line to 80% by 2050	45% by 2035 80% by 2050	50% by 2035 90% by 2050	45% by 2035 80% by 2050
Banking Allowed?	Yes; unlimited through time	Yes; unlimited through time	Yes; unlimited through time	Yes; unlimited through time
Trading Allowed?	Yes	Yes, excluding stationary sources	Yes	Yes
Regulated Sectors under the Greenhouse Gas Emissions Caps	Natural gas utilities Non-natural gas fossil fuel suppliers Large stationary sources with process emissions ≥ 25,000	Natural gas utilities Non-natural gas fossil fuel suppliers Large stationary sources with process emissions plus natural gas emissions ≥ 25,000	Natural gas utilities Non-natural gas fuel suppliers with emissions ≥ 300,000 Large stationary sources with process emissions ≥ 25,000	Natural gas utilities Non-natural gas fuel suppliers
Sector not Included under the Greenhouse Gas Emissions Cap	All natural gas supplied by interstate pipeline companies Fuels used for aviation Landfills; Electric Generators; stationary source process emissions below threshold	Natural gas supplied by interstate pipeline companies that is not regulated at stationary sources Fuels used for aviation Landfills; Electric Generators; stationary source process emissions below threshold	All natural gas supplied by interstate pipeline companies Fuels used for aviation; emissions from fuel suppliers below threshold Landfills; Electric Generators; stationary source process emissions below threshold	Landfills Electric generators Fuels used for aviation Stationary sources
Natural Gas Point of Regulation	All natural gas regulated at utility, not at stationary source. Stationary sources are only regulated directly for process emissions above threshold.	Regulated at stationary sources if emissions are above threshold. Natural gas used at smaller stationary sources is regulated at utility supplier. Emissions from other uses such as at homes and commercial buildings is regulated at utility supplier.	All natural gas regulated at utility, not at stationary source. Stationary sources are only regulated directly for process emissions above threshold.	All natural gas regulated at utility (and covered by the cap), not at stationary source.
Allowable Use of Alternative Compliance (CCIs: Community Climate Investments)	Up to 25% of compliance obligation per year	Up to 5% of compliance obligation per year	Up to 25% of compliance obligation per year	Up to 20% of compliance obligation per year

Key Topic	Policy Scenario 1	Policy Scenario 2	Policy Scenario 3	Policy Scenario 4
CCI Price	EPA Social Cost of Carbon using a 2.5% discount rate (starts at $76 and increases to $116 in 2020$)	EPA Social Cost of Carbon using a 2.5% discount rate (starts at $76 and increases to $116 in 2020$)	EPA Social Cost of Carbon using a 2.5% discount rate (starts at $76 and increases to $116 in 2020$)	EPA Social Cost of Carbon using a 2.5% discount rate (starts at $76 and increases to $116 in 2020$)
Expanded Complementary Policies	Clean Fuels Program assumed to expand from current 10% by 2025 target to 25% by 2035	Clean Fuels Program assumed to expand from current 10% by 2025 target to 25% by 2035	Clean Fuels Program assumed to expand from current 10% by 2025 target to 25% by 2035	Clean Fuels Program assumed to expand from current 10% by 2025 target to 25% by 2035

3 Key Assumptions and Limitations

There are a number of assumptions that underlie the analyses and that are common across the Reference Case and all policy scenarios.

First, the Reference Case and policy scenarios assume that the various policies, programs, and regulations that are currently in effect will continue. In the four policy scenarios the Clean Fuels Program is assumed to expand from the current 10% by 2025 target to 25% by 2035 based on the understanding that DEQ intends to open a rulemaking in 2021 to develop expanded Clean Fuels Program targets. These assumptions are outlined in Table 2.

Table 2: Summary of Existing Policy Assumptions

Emission Source(s)	Policies, Programs, and Regulations Assumed to Continue in Future
Transportation and mobile sources	• Oregon Clean Fuels Program: 10% reduction in transportation fuel carbon intensity by 2025, expanded to 25% by 2035 in policy scenarios • CAFE Standards: federal corporate average fuel economy standards from 2016 rulemaking • Senate Bill 1044: Electric vehicle load impacts from light-duty zero emission vehicle regulations and vehicle sales by 2035
High-GWP pollutants	• U.S. AIM Act: 85% consumption/production reduction by 2035 relative to annual average 2011-2013 baseline
Electricity generation and consumption	• Senate Bill 1547: renewable portfolio standard (RPS) of 50% by 2040 and no coal generation attributed to Oregon past 2030 • Adjacent state policies impacting Oregon power mix: California's Senate Bill 100 goal of 100% renewable electricity by 2045, Washington's Clean Energy Transformation Act (CETA), and others • Energy efficiency programs: included in utility Integrated Resource Plan (IRP) data and used as IPM input assumptions
Natural gas supply and consumption	• Senate Bill 98: large utilities (NW Natural) transition to 30% zero-emitting renewable natural gas (RNG) by 2050 • Energy efficiency programs: included in utility IRP data and used as model input assumptions

Policy scenario assumptions were developed by DEQ to limit emissions from natural gas, non-natural gas fossil fuels, and large stationary sources. While the electricity sector was modeled to inform the overall analysis, DEQ developed assumptions did not propose to regulate emissions from this sector under the Climate Protection Program.

3.1 Limitations

DEQ provided ICF with assumptions for policy scenarios which ICF used in its modeling to provide insights for potential program design elements. The modeling process uses existing public data and resources, as well as simplified assumptions about how the program would work. Emissions reductions are estimated using a technical potential approach[1]; there may be other more or less cost-effective approaches to reducing emissions based on specific circumstances. The information in this analysis does not represent any specific facility or entity that may be subject to the DEQ climate program. The policy scenarios do not represent DEQ program proposals nor complete program designs.

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[1] A technical potential approach analyzes the maximum achievable emission reductions given the current state of available technologies.

ICF estimated high-level costs for greenhouse gas reductions to help determine the use of CCIs and to inform the macroeconomic analysis. ICF acknowledges that there were limitations in how these estimated costs for reducing emissions were calculated and how they can be understood, and these are discussed below. ICF did not design this analysis to be a regulatory impact analysis, and therefore the full costs and benefits of program compliance are not a result or insight that can be derived from this effort.

4 Calculating Greenhouse Gas Emissions and Policy Scenario Costs

To estimate future greenhouse gas emissions for the Reference Case and policy scenarios, ICF used its in-house Multi-Sectoral Model. The Multi-Sectoral Model is an Excel-based planning model that captures emissions trajectories, costs, and benefits from multiple sectors. ICF customized the Multi-Sectoral model for this analysis in-house using a variety of sources including data from DEQ's sector-based inventory, EPA's State Inventory and Projections Tool (SIT),[2] the U.S. EPA Greenhouse Gas Reporting Program (EPA GHGRP), Oregon's Greenhouse Gas Reporting Program (Oregon GHGRP), Argonne National Labs' VISION model, the Energy Information Administration's (EIA) State Energy Data System (SEDS), the Annual Energy Outlook (AEO), ICF's Integrated Planning Model (IPM), and utility IRP data. ICF also used cost data from several additional sources to inform cost and benefit analyses, such as data from the Cal ETC Comparison of Medium- and Heavy-duty Technologies in California, the U.S. DOE Alternative Fuels Data Center, the U.S. EPA Global Non-CO_2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050, and the U.S. DOE State Energy Database and Annual Energy Outlook. Additional information on sources and assumption are provided below.

In the Reference Case, historic greenhouse gas emissions estimates align with Oregon's sector-based Greenhouse Gas Inventory (1990-2018), including transportation, electricity, natural gas, industrial, residential & commercial, and agriculture sectors. Emissions occur at end-uses (e.g., point of fuel combustion or industrial processes), and the same sectors are modeled into the future (2019-2050). The same sectors are used in policy scenario modeling. With the cap's baseline year in 2010, ICF modeled years 2010 through 2050 for policy scenarios.

ICF first developed estimates for the Reference Case, and then calculated emissions for each of the policy scenarios. For each policy scenario, ICF then calculated the difference in greenhouse gas emissions for each year compared to the Reference Case to determine the greenhouse gas reductions achieved by the program policy scenarios.

For each policy scenario, ICF also estimated the cost of greenhouse gas reductions as incremental costs to the Reference Case.

Sector-specific methodology, data sources, and assumptions are described below for:

- Transportation sector
- Electricity sector
- Industrial sector
- Natural gas sector
- Residential and commercial sectors
- Agriculture sector
- Regulated source greenhouse gas reductions from banking, trading, and CCIs

4.1 Transportation

ICF used DEQ's estimates from Oregon's Greenhouse Gas Sector-Based Inventory: 1990 through 2018[3] (Oregon's Sector-Based Inventory) for transportation greenhouse gas emissions from 2010 to 2018. For future projections, ICF used an Oregon-modified version of the Argonne's VISION model to estimate and quantify future annual vehicle

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[2] U.S. EPA. EPA State Inventory and Projection Tool (2021). Available at: https://www.epa.gov/statelocalenergy/state-inventory-and-projection-tool.

[3] State of Oregon (2021). Oregon Greenhouse Gas Sector-Based Inventory Data. Available at: https://www.oregon.gov/deq/aq/programs/Pages/GHG-Inventory.aspx.

sales, future vehicle fleet characterization and fuel consumption. The VISION model is used to model conventional and alternative fuel consumption scenarios by varying fleet and technology sales rates by vehicle type. The Oregon-modified VISION model can run scenarios taking into account different vehicle sales policies and requirements and future fuel consumption by type and feedstock, and can quantify annual fuel consumption by vehicle category (light-duty, medium-duty and heavy-duty) based on vehicle miles traveled (VMT) and fuel economy for the future vehicle makeup of the fleet.

To quantify the statewide and fuel-specific annual vehicle sales for light-duty, medium-duty, and heavy-duty vehicles, ICF used vehicle registration data provided directly by the Oregon Department of Transportation (ODOT). Oregon's historical portion of U.S. annual vehicle sales[4] was used to forecast future total sales based on the national level sales in VISION[5] based on the 2020 EIA Annual Energy Outlook.[6]

Where necessary, ICF supplemented data for historic and projected emission estimates in a few instances to maintain a consistent methodology across the time series. For example, ICF adjusted estimated projections of natural gas to include off-road vehicles and equipment in addition to on-road vehicle use supplied by VISION. ICF used projections from the SIT Projection Tool to determine off-road natural gas use by taking the total SIT projection for natural gas minus the on-road estimates. Additionally, ICF developed historic estimates for some alternative fuels not captured in Oregon's Sector-Based Inventory, including biodiesel and renewable diesel, using fuel consumption projections for these fuels from VISION, historic and projected SIT data, and information on Clean Fuels Program mandates for the use of biodiesel and renewable diesel. VISION data also included estimates for hydrogen, which was not captured in Oregon's Sector-Based Inventory. ICF analyzed historic data and assumed no hydrogen use in historic years. Table 3 below outlines key inputs and assumptions for transportation sector modeling.

Table 3: Transportation Sector Inputs and Assumptions

Input/Assumption	Source or Justification
Oregon Registration Data	ODOT
Reference Case includes extension of LD ZEV	Based on the Governor's executive order of 90% LD vehicles sales being ZEV by 2035
Reference Case includes no expansion of the Oregon Clean Fuels Program (CFP)	The CFP remained at 10% in the Reference Case
Scenarios include electric trucks policies	Oregon is a 177 State[7] and is discussing implementing a version of California's Advanced Clean Trucks
Scenarios include expanded clean fuels	Clean fuels achieve an 80% reduction of petroleum fuel consumption by 2050
Capital costs	Capital costs from medium and heavy-duty vehicles were estimated based on the Cal ETC Comparison of Medium- and Heavy-duty Technologies in California report.[8] Other types of medium and heavy-duty vehicles (e.g.,

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[4] Powell, James. "Multiple emails between 12/17/2020 and 01/21/2021." Messages to Jeffrey Rosenfeld (ICF).

[5] Argonne National Laboratory (ANL) (2020). Argonne National Laboratory VISION Model. Available at: https://www.anl.gov/es/vision-model.

[6] U.S. Energy Information Administration (2021). Annual Energy Outlook. Available at https://www.eia.gov/outlooks/aeo/.

[7] A 177 State refers to States that have chosen to adopt California′s standards in lieu of federal requirements for vehicle emission standards, authorized by Section 177 of the Clean Air Act.

[8] Cal ETC (2020. Cal ETC Comparison of Medium- and Heavy-duty Technologies in California . Available at: https://www.caletc.com/research.html.

Input/Assumption	Source or Justification
	diesel, biodiesel) were assumed to have cost parity with existing vehicles on the road today.
Fuel costs/savings	Fuel costs were estimated based on Oregon-specific fuel prices from the U.S. DOE State Energy Database[9] and projected using national trends from the U.S. DOE Annual Energy Outlook.[10] Alternative fuels cost data (e.g., diesel and biodiesel) were sourced from the DOE Alternative Fuels Data Center.[11]
Labor, maintenance, and other non-capital costs	Not included

4.2 Electricity

ICF's historic emissions for the electric sector are consistent with DEQ's *"Oregon Greenhouse Gas Sector-Based Inventory"*.[12] ICF forecasted electricity emissions utilizing its Integrated Planning Model (IPM). IPM is an ICF-proprietary electricity market model projecting generation, capacity and emissions based on market assumptions such as electric load. IPM takes into account policy considerations such as Renewable Portfolio Standards (RPS) and other electricity market policies.

4.2.1 Oregon Emission Projections

Electric sector emissions are outputs of ICF's IPM modeling. IPM's representation of the electricity system captures power generation facilities and associated counties. IPM calculates emissions from generating stations based on IPM projected fuel consumption and emission rates assumptions derived from EPA emission datasets such as the Clean Air Markets Division (CAMD) Air Markets Program Data (AMPD)[13] and Emissions & Generation (RID)[14,15] dataset, as well as the National Emissions Inventory (NEI).Forecasted emissions include CO_2, SO_2, NOx, $PM_{2.5}$, and volatile organic compounds (VOCs).

ICF forecasted emissions associated with electric generation through two methodologies, each capturing different geographies and with different applications in the modeling framework:

1. **Electricity emissions for health impacts modeling.** ICF's electricity modeling in IPM produced emission projections on the county level, which were aggregated to the state level. The health impacts assessment described further below in this report utilized the county-level emission projections out of IPM to estimate health benefits..

2. **Electricity emissions to serve load.** DEQ's Oregon Greenhouse Gas Sector-Based Inventory reports electricity emissions by end-use sector, including residential, commercial, and industrial. The sectoral emissions reported by DEQ are consumption-based emissions from electricity generated to serve Oregon's electricity demand. These emissions are generated from facilities located within Oregon but also beyond the state as the load serving entities in the state are serving their customers with electric supply from a range of supply sources, some of which are located outside of the state. To estimate the emissions to serve Oregon's load throughout the forecast, ICF reviewed data on the sources of generation and associated

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[9] U.S. DOE (2021). State Energy Database. Available at: https://www.eia.gov/state/seds/seds-data-fuel.php?sid=US#DataFiles.

[10] U.S. Energy Information Administration (2021). Available at https://www.eia.gov/outlooks/aeo/.

[11] U.S. DOE Alternative Fuels Data Center (2021). Alternative Fuel Price Report. Available at: https://afdc.energy.gov/fuels/prices.html.

[12] Oregon DEQ (2021). Oregon GHG Sector-Based Inventory Data. Available at: https://www.oregon.gov/deq/aq/programs/Pages/GHG-Inventory.aspx.

[13] U.S. EPA (2021). Air Markets Program Data. Available at: https://ampd.epa.gov/ampd/.

[14] U.S. EPA (2021). eGRID. Available at: https://www.epa.gov/egrid.

[15] U.S. EPA (2021). Inventory of U.S. Greenhouse Gas Emissions and Sinks. Available at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks.

emissions to serve current electric load based on data provided by DEQ. ICF's approach to estimating consumption-based emissions incorporates ICF's emission projections out of IPM for Oregon, the broader Western Electricity Coordination Council region, and assumes the Oregon policy of not sourcing electricity from coal starting in 2030.

4.2.2 Electric Load Assumptions

ICF's electricity sector modeling in IPM incorporated demand projections from the most recent releases of the IRPs filed by investor-owned utilities (IOU) in the state. The load projections for Oregon are based on the latest published IRP forecasts for the three main IOUs in the state: PacifiCorp, Portland General Electric, and Idaho Power Company, shown in Table 4 below. ICF extrapolated utility IRP forecasts out to 2050 utilizing the average growth rate of the last three years of the available IRP forecast and maintaining that growth rate through 2050.

Table 4: Utility IRP sources for Oregon load forecasts for the Reference Case

Utility	IRP Vintage	Last Year of Load Forecast
Portland General Electric (PGE)[16]	2019	2050
PacifiCorp[17]	2019	2028
Idaho Power Corporation[18]	2019	2038

ICF estimated electric load assumptions for non-IOUs based on the Oregon Public Utility Commission (PUC) Oregon Utility Statistics 2019 documentation.[19] Based on 2019 retails sales data, IOUs make up 62% of the sales in the state. ICF utilized the combined IOU forecast derived from IRP projections and maintained the 62% ratio to estimate the total load from non-IOU load-serving entities. ICF then created individual load forecasts for non-IOU load serving entities based on the PUC Oregon Utility Statistics 2019 materials, breaking the remaining 32% of the forecast out between the non-IOU load serving entities based on their respective sales share in 2019.

Any load-serving entity that provided electric demand in the form of sales rather than electric load had sales projections trued up to electric load utilizing a ratio of EIA retail sales to electric load projections.

For the policy scenarios, load forecasts were based on future projections of potential electrification of end uses. Additional details on this approach are provided below in the discussion on approach for natural gas emissions methods.

4.2.3 Accounting of electric vehicle load forecast

ICF's modeling of the transportation sector in Oregon resulted in electric vehicle projections, along with associated electric load impacts. To avoid double-counting of electric vehicle loads, utility forecasts that included projections

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[16] Portland General Electric (2019). Integrated Resources Plan. Available at: https://downloads.ctfassets.net/416ywc1laqmd/6KTPcOKFlLvXpf18xKNseh/271b9b966c913703a5126b2e7bbbc37a/2019-Integrated-Resource-Plan.pdf, Table D3, p. 264 – 265.

[17] PacifiCorp (2019). Integrated Resources Plan. Available at: https://www.pacificorp.com/content/dam/pcorp/documents/en/pacificorp/energy/integrated-resource-plan/2019_IRP_Volume_II_Appendices_A-L.pdf, Table A9, p. 16.

[18] Idaho Power (2019). Integrated Resources Plan. Available at: https://docs.idahopower.com/pdfs/AboutUs/PlanningForFuture/irp/2019/2019_IRP_AppendixA.pdf, Appendix A1, p.42.

[19] Oregon Public Utilities Commission (2019). Oregon Utility Statistics. Available at: https://www.oregon.gov/puc/forms/Forms%20and%20Reports/2019-Oregon-Utility-Statistics-Book.pdf.

of electric vehicle load growth were adjusted to instead incorporate the electric vehicle load forecast that ICF's transportation team developed for the Reference Case and the scenarios.

4.2.4 Oregon Renewable Portfolio Standard Implementation

ICF's modeling of the electricity system in Oregon captures the demand for renewable energy created through Oregon's renewable portfolio standard. The RPS target increases to 50% by 2040 for large investor-owned utilities, with lower targets for smaller utilities and non-IOUs. ICF determined the renewable energy requirement for the state based on the specific forecast for each load-serving entity and the target percentage based on the classification of each entity into the appropriate size group. ICF applied this approach to both the Reference Case and the policy scenarios (i.e., the carbon intensity of electric power did not change between Reference Case and the policy scenarios). Table 5 displays target percentages for the RPS by utility category.

Table 5: Utility Renewable Portfolio Standard Targets

Share of OR Retail Sales	Utility Category	RPS Standard	Year
> 3%	Large Investor-Owned	20%	2020
		27%	2025
		35%	2030
		45%	2035
		50%	2040
	Large Consumer-Owned	25%	2025
1.5-3%	Small	10%	2025
<1.5%	Smallest	5%	2025

4.2.5 Note on Costs

. ICF acknowledges that there will be costs incurred (e.g., capital costs for cleaner generating resources and infrastructure costs to handle increased load) and likely passed on to customers as the clean energy transition occurs to comply with the Oregon RPS and as electric load likely increases over time. These cost changes were not captured in this analysis.

4.3 Industrial

ICF used DEQ's estimates from Oregon's Sector-Based Inventory for industrial greenhouse gas emissions from 2010 to 2018. ICF then projected future industrial source emissions using methods such as linearly projecting a trend from Oregon GHGRP data and linearly projecting SIT Projections Tool estimates. ICF selected the method for each source based on information from DEQ describing the development of historic estimates for each industrial source in Oregon's Sector-Based Inventory to maintain consistency with DEQ's methodology. See the Natural Gas and Electricity sections for a description of methods for natural gas and electricity use in the industrial sector.

For Policy Scenarios 1-3, ICF determined emissions from large stationary sources subject to the cap by pulling data from the EPA GHGRP's Facility Level Information on GreenHouse Gases Tool (FLIGHT) database,[20] calculating process emission levels for each facility against scenario thresholds, and summing to identify total stationary source emissions subject to the cap. In Policy Scenario 4, large stationary sources were not subject to emission caps.

ICF then applied technical potential reduction assumptions to large stationary source emissions subject to the cap. ICF assumed that technical potential reductions increase linearly across the time series until meeting the full potential in 2050. Technical potential reductions assumptions vary by emission source category and are shown in Table 6 below.

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[20] U.S. EPA (2021). Facility Level Information on GreenHouse Gases Tool. Available at: https://ghgdata.epa.gov/ghgp/main.do.

Table 6: Large Stationary Source Technical Potential Reduction Assumptions by Policy Scenario

Technology	Description	PS1	PS2	PS3	PS4
Stationary Source Reductions	Cement Manufacture	40%	40%	40%	40%
	Ammonia Production	80%	80%	80%	80%
	Iron & Steel Production	80%	80%	80%	80%
	Soda Ash Production & Consumption	80%	80%	80%	80%
	Limestone and Dolomite Use	80%	80%	80%	80%
	Lime Manufacture	80%	80%	80%	80%
	Pulp & Paper including Wastewater	80%	80%	80%	80%
	Semiconductor Manufacturing	95%	95%	95%	95%
	Refrigerant, Foam, Solvent, Aerosol Use	80%	80%	80%	80%
	Aluminum Production	0%	0%	0%	0%

For estimating costs, ICF pulled cost per ton of CO_2e reduced for industrial process emissions from existing public data sources or used proxy information where no data were available. These values and sources by industry are provided below in Table 7. These costs estimates are likely more robust, capturing capital, labor, and other costs.

Table 7: Industrial Cost Source Data

Industry	Sources
Cement Manufacture	McKinsey[21]
Ammonia Production	Assumed, average per other abatement data
Iron & Steel Production	McKinsey[22]
Soda Ash Production & Consumption	Assumed, average per other abatement data

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[21] McKinsey&Company (2018). Decarbonization of Industrial Sectors: The Next Frontier. Available at: https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/how%20industry%20can%20move%20toward%20a%20low%20carbon%20future/decarbonization-of-industrial-sectors-the-next-frontier.pdf.

[22] McKinsey&Company (2018). Decarbonization of Industrial Sectors: The Next Frontier. Available at: https://www.mckinsey.com/~/media/mckinsey/business%20functions/sustainability/our%20insights/how%20industry%20can%20move%20toward%20a%20low%20carbon%20future/decarbonization-of-industrial-sectors-the-next-frontier.pdf.

Industry	Sources
Limestone and Dolomite Use	Assumed, average per other abatement data
Lime Manufacture	Assumed, average per other abatement data
Pulp & Paper including Wastewater	Assumed, average per other abatement data
Semiconductor Manufacturing	U.S. EPA Global Non-CO_2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050[23]
Refrigerant, Foam, Solvent, Aerosol Use	U.S. EPA Global Non-CO_2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050[24]

4.4 Natural Gas

ICF used the DEQ's estimates from Oregon's Sector-Based Inventory for natural gas greenhouse gas emissions from 1990 to 2018. ICF then used utility IRP and SIT Projection Tool data to develop natural gas projections. Utility IRP projections were used to estimate emissions from utility natural gas in future projections. To account for the portion of non-utility natural gas in future projections, ICF analyzed historic natural gas data provided by DEQ to identify the portion of total natural gas use that is non-utility natural gas use. ICF then assumed that the same proportion in historic estimates for future projections to estimate total natural gas use, including utility and non-utility estimates.

For each policy scenario, ICF assumed all natural gas is subject to the cap. While the point of regulation for natural gas differed across scenarios, the technologies assumed to meet technical potential reductions did not differ by point of regulation, and this distinction was not necessary for the greenhouse gas modeling. Technologies considered for natural gas reductions included energy efficiency, electrification of heating, and an increased RNG supply through alignment or a potential expansion of SB98. Technical potential reduction assumptions for each scenario are outlined in

Table 8 for 2050 and come from a range of sources, mainly utility IRPs, Oregon Energy Trust modeling (energy efficiency looking at technical potential, not cost-effective potential), NREL's Electrification Futures Report[25] high scenarios (electrification). Adoption of these measures was assumed to take a linear trajectory.

Table 8: Natural Gas Technical Potential Reduction Assumptions in 2050

Technology	Description	PS1	PS2	PS3	PS4
Energy efficiency	Energy savings per year (bbtu)	~400	~400	~400	~400
Electrification	New residential buildings electric	90%	90%	90%	90%
	Existing residential buildings retrofitted	85%	90%	90%	90%
	New commercial buildings electric	90%	90%	90%	90%

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[23] U.S. EPA (2020). Global Non-CO2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050. Available at: https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases/global-non-co2-greenhouse-gas-emission-projections.

[24] U.S. EPA (2020). Global Non-CO2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050. Available at: https://www.epa.gov/global-mitigation-non-co2-greenhouse-gases/global-non-co2-greenhouse-gas-emission-projections.

[25] NREL (2018, 2020, 2021). Electrification Futures Study. Available at: https://www.nrel.gov/analysis/electrification-futures.html.

Technology	Description	PS1	PS2	PS3	PS4
	Existing commercial buildings retrofitted	80%	90%	90%	85%
	New industrial electric	50%	50%	50%	50%
	Existing industrial electric	0%	0%	0%	0%
SB98 Expansion	2050 RNG Supply	50%	75%	75%	75%

Energy efficiency upgrade costs were estimated based on a levelized cost from the Oregon Energy Trust.[26] ICF estimated the cost of electrification costs based on the following assumptions/approach:

- **Residential**: Various costs of furnaces, air conditioners, heat pumps, water heating, stoves, and dryers were sourced from the NREL Bepot database for new and existing households.[27] These costs were applied on a per household for new and existing households along with information on number of households in Oregon, using data from the U.S. Census[28] paired with projections of Oregon population.[29]
- **Commercial**: ICF assumed that there was no cost differential for new all-electric commercial buildings.[30] For retrofit of existing commercial buildings ICF assumed replaced heating and hot water heaters using an ICF-derived cost per square foot. These costs were applied to commercial square footage in Oregon data paired with projections of Oregon's population.[31]
- **Fuel costs/savings**: Fuel costs were estimated based on Oregon-specific fuel prices from the U.S. DOE State Energy Database[32] and projected using national trends from the U.S. DOE Annual Energy Outlook.[33] Costs of renewable natural gas were sourced from the American Gas Foundation.[34]

Potential cost changes related to the maintenance of the gas infrastructure and new or potentially stranded gas infrastructure were not estimated.

Labor, maintenance, and other non-capital costs were not included.

4.5 Residential and Commercial

ICF used the DEQ's estimates from Oregon's Sector-Based Inventory for residential and commercial greenhouse gas emissions from 2010 to 2018. ICF then estimated future projections for emission sources in the residential and commercial sector using methods such as scaling historic waste source estimates used in Oregon's Sector-Based Inventory derived from DEQ's Materials Management Model with projected state population data, using projections from the SIT Projections Tool, and projected data provided by DEQ. See the Natural Gas and Electricity sections for a description of methods for natural gas and electricity use in the residential and commercial sectors.

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[26] Energy Trust of Oregon (2020). 2019 Annual Report to the Oregon Public Utility Commission & Energy Trust Board of Directors. Available at: https://www.energytrust.org/wp-content/uploads/2020/04/2019.Energy-Trust-Annual-Report.pdf.

[27] NREL (2021). National Residential Efficiency Measures Database (NREMDB). Available at: https://remdb.nrel.gov/.

[28] U.S. Census (2019). Quick Facts: Oregon. Available at: https://www.census.gov/quickfacts/OR.

[29] State of Oregon (2013). Demographic Forecast. Available at: https://www.oregon.gov/das/OEA/Pages/forecastdemographic.aspx.

[30] Synapse Energy Economics Inc (2018). Decarbonization of Heating Energy Use in California Buildings: Technology, Markets, Impacts, and Policy Solutions. Available at: https://www.synapse-energy.com/sites/default/files/Decarbonization-Heating-CA-Buildings-17-092-1.pdf.

[31] State of Oregon (2013). Demographic Forecast. Available at: https://www.oregon.gov/das/OEA/Pages/forecastdemographic.aspx.

[32] U.S. DOE (2021). State Energy Database. Available at: https://www.eia.gov/state/seds/seds-data-fuel.php?sid=US#DataFiles.

[33] EIA (2021). Annual Energy Outlook. Available at: https://www.eia.gov/outlooks/aeo/.

[34] American Gas Foundation (2019). Renewable Sources of Natural Gas: Supply and Emissions Reduction Assessment. Available at: https://gasfoundation.org/2019/12/18/renewable-sources-of-natural-gas/.

ICF estimated reductions in the residential and commercial sectors in each policy scenario by applying annual energy efficiency assumptions to non-natural gas fossil fuel combustion estimates. Table 9 provides assumptions for each scenario.

Table 9: Other Fuels Technical Potential Reduction Assumptions

Technology	Description	PS1	PS2	PS3	PS4
Energy Efficiency	Annual residential savings	1%	3%	3%	3%
	Annual commercial savings	1%	3%	3%	3%
	Annual industrial savings	0%	0%	0%	0%

4.6 Agriculture

ICF used the SIT Projection Tool to develop emission estimates for agricultural sources of emissions in the Reference Case and each Policy Scenario. Emission estimates for the Reference Case and policy scenarios are the same for this sector.

4.7 Regulated Source Greenhouse Gas Reductions from Banking, Trading, and CCIs

After estimating the technical potential reductions for each regulated source in each policy scenario, ICF analyzed opportunities for banking, trading, and CCI use to determine final reductions and to assess whether or not the cap was met in each year in each policy scenario. Of note is that this analysis was done between sectors and at the state level; entity-to-entity modeling was not conducted. Assumptions on the thresholds and use of banking, trading, and CCIs were defined by DEQ and modeled by ICF using the following approach:

- Application of CCIs
  - Allowable CCI units are calculated as X% of a cap in a compliance year
  - Use of CCIs is calculated in two stages:
    - Are additional reductions needed to meet the cap at the sector level? If yes, then CCIs are used.
    - Is it cheaper to use a CCI then make an actual reduction for a sector (based on cost estimates as described above)? If yes, then CCIs are used.
  - CCIs are limited in each year within each of these steps to the total amount of CCIs that can be used for compliance.
  - It was also assumed that one CCI would be equivalent to one ton of carbon equivalent. CCI prices per year are assumed to be the EPA social cost of carbon using a 2.5% discount rate (see Table 10)
  - In the model, CCIs can be banked or traded.

Table 10: EPA Social Cost of Carbon at a 2.5% Discount Rate[35]

Year	Social Cost of Carbon ($2020 per metric ton CO_2e)
2020	$76
2025	$83
2030	$89
2035	$96
2040	$103
2045	$110
2050	$116

- Total emission reductions with the use of CCIs and technical potential reductions in each year for each sector was then calculated.
- The model then was used to determine in which years emissions could be banked by comparing the total emission reductions with the use of CCIs and technical potential reductions in a given year to the program emissions cap in that given year. If reductions exceed the cap for a sector and overall, it was assumed that emissions could be banked for future year use or traded.
- A similar calculation was done to determine the application of banked emissions by looking at which specific years additional emission reductions were needed to meet the cap, and then applying any available banked emissions to ensure the cap is met in a given year. The calculations take into account the potential increase or decrease in available banked emissions over time based on the application of those emissions in past years in the model.
- Lastly, trading was modeled as a final layer as part of the flexible compliance approach. Trading was analyzed at the sector level as well.

5 Calculating Macroeconomic Impact

ICF used the IMpacts for PLANing (IMPLAN) model from IMPLAN Group LLC for the macroeconomic analysis. IMPLAN is an economic input-output model that combines a set of extensive databases related to economic factors, economic multipliers, and demographic statistics with a refined and detailed system of modeling software. The IMPLAN model relies on data from the U.S. Bureau of Economic Analysis, U.S. Department of Agriculture, U.S. Bureau of Labor Statistics, and the U.S. Census Bureau. The model identifies direct impacts by sector and then develops a set of indirect and induced impacts by sector using industry-specific multipliers, local purchase coefficients, income-to-output ratios, and other factors and relationships.

The benefits of the using IMPLAN are that the model is comprehensive in its level of detail, with a breakdown of the economy into roughly 500 sectors. IMPLAN also excels at determining the direct, indirect, and induced impacts. The model can be customized to the specific area being studied, and can be applied at various scales, such as at the state or county level. For this analysis, ICF used the OR state-level model.

IMPLAN uses investment and employment inputs to estimate employment, output, income, and tax trends and impacts across various industries. This structure allows ICF to develop the monetized macroeconomic impacts of investments aimed at greenhouse gas reductions.

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[35] Interagency Working Group on Social Cost of Greenhouse Gases, U.S. Government (2021). Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide: Interim Estimates Under Executive Order 13990. Available at: https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf.

5.1 Methodology

ICF modeled the following components within IMPLAN:

- **Investments in energy efficiency**: including investments in appliances such as furnaces, air conditioners, heat pumps, and dryers
- **Investments in electrification**: including the retrofit and construction of all-electric buildings and households
- **Investments in clean transportation**: including investments in light-, medium-, and heavy-duty electric vehicles as well as charging stations
- **Changes in consumer fuel costs**: including the aggregate of fuel cost changes resulting from energy efficiency, electrification, increasing vehicle electricity costs, and decreasing vehicle fossil fuel costs
- **Impacts on energy producing sectors**:
    - Positive impacts of electrification: including the increase in electricity demand from electric appliances and electric vehicles
    - Negative impacts on fossil fuel: including the decrease in natural gas and petroleum product sales as a result of electric appliances and electric vehicles
- **Budgetary impacts of investments on Oregon residents and businesses**: including the opportunity costs of investments in energy efficiency, electrification, and purchases of electric vehicles

Based on these inputs, IMPLAN modeled three types of impacts:

- **Direct impacts:** Construction employment, direct procurement of materials, equipment rentals, etc.
- **Indirect impacts**: Supply chain inputs such as supplies, parts, materials, third-party services, etc.
- **Induced impacts**: Increased consumption spending on housing, healthcare, goods and services, etc.

The total impact is the sum of the multiple rounds of secondary indirect and induced impacts that remain in the region (as opposed to “leaking out” to other regions or states). IMPLAN then uses this total impact to calculate subsequent impacts such as total jobs created. In this analysis, ICF examined impacts to total employment, gross state product (GSP), and income.

5.2 Data Sources

For of each of the modeling components described above, ICF developed inputs using the greenhouse gas Multi-Sectoral Model as follows.

For energy efficiency, ICF identified industries impacted by spending based on their energy consumption. Based on ICF’s analysis key sectors impacted by energy efficiency investments include construction of structures, professional services, retail trade, electrical appliance manufacturing, and machinery manufacturing.[36]

For electrification investments, ICF split investments into residential, commercial, and industrial components. ICF then identified the types and costs appliances to be replaced. For residential investments, examples include heat pumps, water heating, stoves, furnaces, and air conditioners. For commercial investments, investments were limited to heating and hot water retrofits. For industrial investments, investments included heating and cooling systems. ICF then identified sectoral allocation based on the types of appliances.[37]

To model investments in clean transportation, ICF generated transportation investments in the greenhouse gas Multi-Sectoral Model. ICF disaggregated these investments into two categories, 1) light duty and 2) medium and heavy duty. ICF further split these investments to vehicle and charger costs. ICF modeled vehicle costs within

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[36] ICF’s identification of sectoral impacts is based on a report by the Acadia Center that identified sectoral allocation of energy efficiency spending. Jamie Howland et al. (2009). Energy Efficient: Engine of Economic Growth: A Macroeconomic Modeling Assessment. Acadia Center (Environment Northeast). Available at: http://acadiacenter.org/wp-content/uploads/2014/10/ENE_EnergyEfficiencyEngineofEconomicGrowth_FINAL.pdf.

[37] NREL (2021). National Residential Efficiency Measures Database (NREMDB). Available at : https://remdb.nrel.gov/.

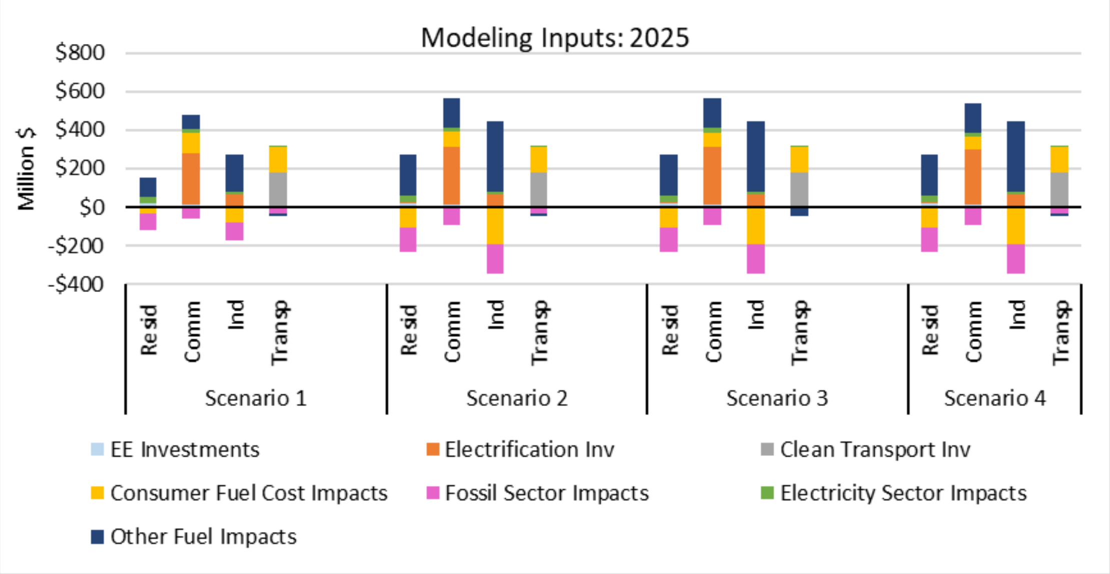
IMPLAN using motor vehicle manufacturing and electric engine manufacturing sectors. ICF also modeled changes in electric vehicle maintenance costs as a reduction in consumer spending. For fuel cost changes, ICF modeled impacts to sectors with heavy vehicle use including agriculture, construction, trade, as well as transportation and warehousing.[38]

For changes in consumer fuel costs, ICF assigned commercial and industrial fuel savings resulting from energy efficiency. ICF identified the sectors with high natural gas consumption. For the commercial sector, ICF identified education, retail trade, hospitals, real estate, and warehousing as natural gas intensive sectors.[39] For the industrial sector, ICF identified chemical manufacturing, food manufacturing, metal manufacturing, and wood product manufacturing as natural gas intensive sectors.[40]

For each investment component, ICF also modeled the budgetary impacts on Oregon residents and businesses through assessing the negative impact, or opportunity cost, of spending. This opportunity cost represents the impact on all other spending that results from increased spending on a fixed budget. The net of fuel cost savings and opportunity costs are the changes in consumer fuel costs.

Figure 2 presents the magnitudes of each input category that ICF used in the macroeconomic analysis. In 2025, most of the investments occur in the commercial and industrial sectors, largely in energy efficiency and electrification. By 2035, clean transportation investments are the largest driver of impacts (largely with investments in medium- and heavy-duty vehicles). Large investments in the transportation sector led to fuel savings for consumers and corresponding negative impacts on fossil production and distribution sectors (e.g., gas stations). A similar trend occurs in 2050, where clean transportation continues to be the largest driver, expanding both consumer fuel savings and fossil sector impacts.

Figure 2. IMPLAN Modeling Inputs



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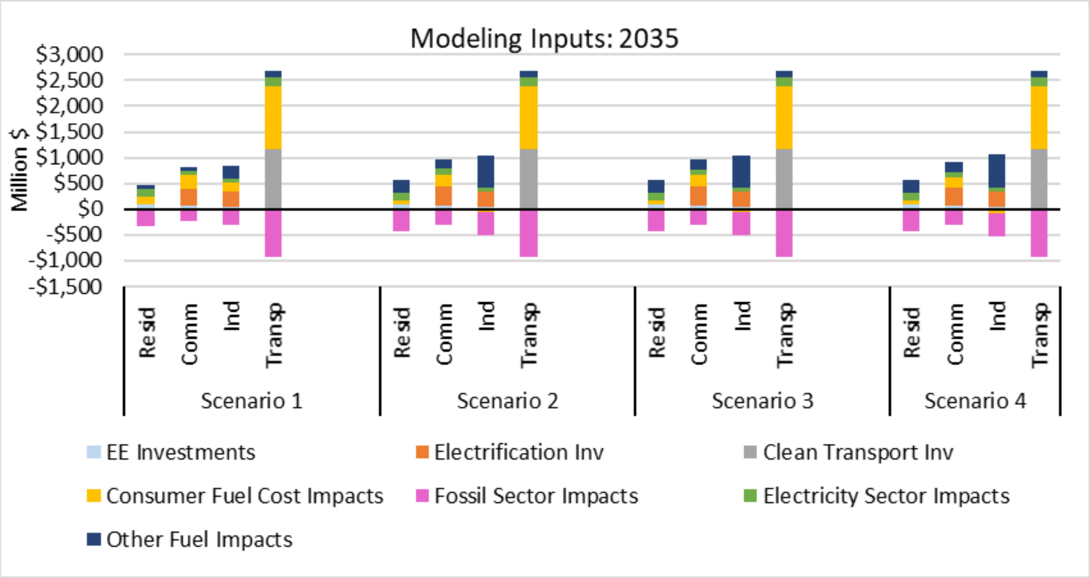
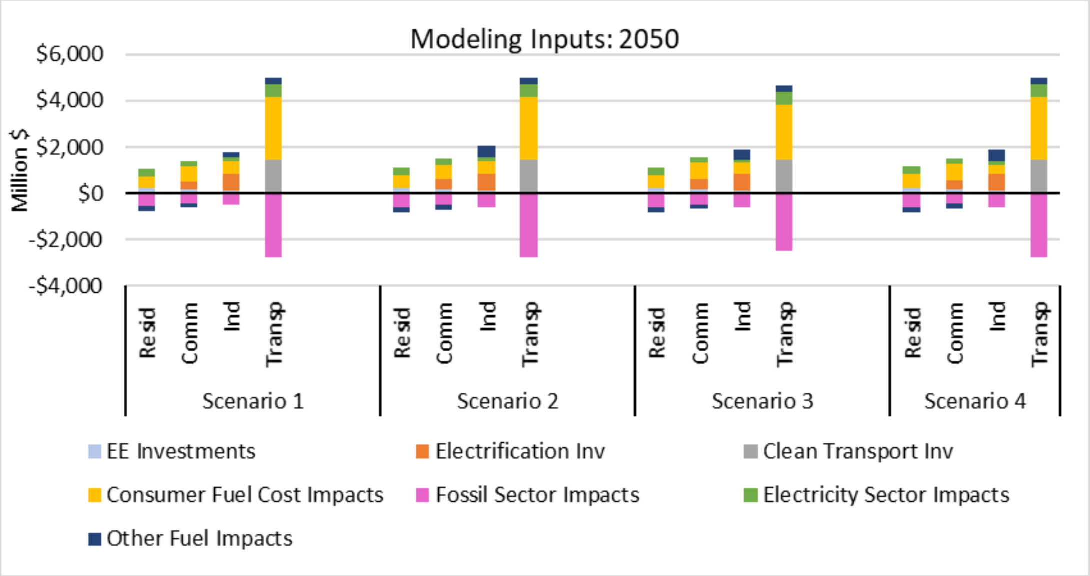
[38] U.S. Census (2020). Vehicle Use Survey. Available at: https://www2.census.gov/library/publications/economic-census/2002/vehicle-inventory-and-use-survey/ec02tv-or.pdf

[39] U.S. EIA (2021). Available at: https://www.eia.gov/consumption/commercial/data/2012/c&e/cfm/e7.php.

[40] American Petroleum Institute (API). Available at: https://www.api.org/-/media/Files/Policy/Natural-Gas-Solutions/API-Natural-Gas-Impact-Report-50-States/Oregon-API-Natural-Gas-Industry-Impact-Report.pdf.





6 Calculating Health Impacts

ICF used the U.S. EPA Co-Benefits Risk Assessment (COBRA Version 4.0) model[41] in a custom application to quantify and monetize changes in the incidence of adverse health impacts due to the modeled policy scenarios. COBRA is a screening-level air quality health benefits model that provides estimates of how the air pollution emissions changes affect ambient $PM_{2.5}$ concentrations, associated health impacts, and the monetary value of avoidable health impacts.[42]

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[41] U.S. EPA (2020). CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA): https://www.epa.gov/cobra.

[42] COBRA relies on a suite of health impact functions and valuation functions that closely approximate what EPA used in developing the Final 2006 National Ambient Air Quality Standards (NAAQS) for PM.

Reductions in fossil fuel consumption led to reduced emissions of fine particulate matter ($PM_{2.5}$) and its precursors NO_x (as nitrogen dioxide or NO_2), sulfur dioxide or SO_2, ammonia or NH_3, and volatile organic compounds or VOCs.

Human exposure to $PM_{2.5}$ results in a variety of adverse health impacts over time, such as adult and infant mortality, non-fatal heart attacks, hospital admissions for respiratory and cardiovascular (except heart attacks) illness, acute bronchitis, upper and lower respiratory symptoms, emergency room visits for asthma, minor restricted activity days, work loss days, and asthma exacerbation. Therefore, reducing emissions of $PM_{2.5}$ and its precursors can also reduce incidences of these adverse health impacts.

COBRA is a screening-level air quality health benefits model that provides estimates of the impact of air pollution emissions changes on ambient $PM_{2.5}$ concentrations, associated health effect impacts, and the monetary value of avoidable health impacts.[43] As the dominant contributor to public health impacts from air pollution, health impacts are estimated based on exposure to PM. The other pollutants listed above are also included in COBRA as precursor pollutants that form PM through atmospheric chemical and physical reactions. This analysis does not consider health effects from ozone (O_3). Nor does it consider health risks from air toxic pollutants nor health impacts related to climate change.

6.1 Methodology

COBRA uses a source-receptor (S-R) matrix to translate changes in emissions of air pollutants into changes in ambient $PM_{2.5}$ concentrations. The S-R matrix consists of fixed transfer coefficients that relate annual average $PM_{2.5}$ concentrations at a single receptor in each county and the contribution of $PM_{2.5}$ precursors to this concentration from each emission source. The S-R matrix is based on the Climatological Regional Dispersion Model (CRDM), which includes summary data collected in 1990 from meteorological sites throughout North America.[44] The CRDM relies on simple dispersion-transport functions and chemical conversions at the receptor location. COBRA contains detailed county- and source type-specific emissions estimates for the year 2023 in discrete categories. These estimates account for policy measures under consideration at the federal and state levels by May 2018.

ICF developed customized emissions changes for input into COBRA by calculating emissions by sector, county, and, where relevant, stack height.[45,46] The emission source sectors evaluated for the Reference Case and scenarios fall under five "tiers" in COBRA, as defined in the National Emissions Inventory (NEI):[47] highway vehicles, fuel combustion electric utilities, industrial fuel combustion, residential fuel combustion, and commercial fuel combustion. ICF customized the emissions in COBRA in these tiers with modeled emissions values. ICF made no adjustments to emissions for the remaining tiers in the default COBRA emissions dataset. The following summarizes the methodology used to calculate and incorporate custom emissions in COBRA.

On-road emissions are based on the statewide VISION modeling described above under the Transportation section. This modeling provides fuel use by vehicle category and fuel types under a transportation scenario and Reference Case through 2050. ICF used U.S. EPA's latest mobile source emissions factor model, MOVES3, to produce fuel-based emission factors coupled to the fuel quantities modeled with VISION. For Policy Scenarios 1-3, ICF modeled these emission factors using MOVES-defaults at the state level. ICF then apportioned state-level emissions to

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[44] The CRDM does not fully account for all chemical interactions that take place in the secondary formation of $PM_{2.5}$.

[45] Based on the National Emissions Inventory, emissions categories include three tiers, with the first tier generally reflecting the broad emissions sector and the second and third tiers reflecting more detailed information regarding the emission, such as fuel type. For example, secondary tiers for the electric utility generating sector include coal, oil, gas, other, and internal combustion. Tertiary tiers for electric utility generating sector coal emissions include bituminous, subbituminous, and anthracite & lignite. Because IPM, MOVES/VISION, and multisectoral modeling outputs did not provide this level of detail, ICF apportioned sector-level emissions to the proportions of secondary and tertiary tier values available in the 2023 default COBRA emissions baseline.

[46] Stack height apportionment was relevant to electricity generating units, stationary sources, and other fuel combustion activities. Vehicle emissions are considered area sources in COBRA.

[47] U.S EPA (2020). National Emissions Inventory. Available at: https://www.epa.gov/air-emissions-inventories/national-emissions-inventory-nei

counties using COBRA default allocations. For Policy Scenario 4, ICF determined county- and fuel-specific emission factors using MOVES. Furthermore, for Policy Scenario 4, the statewide fuel values were allocated to counties using county- and fuel-specific consumption projections in MOVES to disaggregate the statewide fuel amounts before combining with county-resolved emission factors. These county-specific emissions were then input to COBRA. On-road emissions of PM include brake and tire wear and include corrections for brake wear emission rates from electric vehicles.

Emissions from electricity production are derived directly from the IPM modeling described in the Electricity section. These emissions for all pollutants are aggregated from individual facilities to the county scale for use in COBRA. Because ICF modeled IPM emissions at the county scale, these emissions were apportioned to the 2023 default COBRA distribution of electricity generating unit emissions per emission tier subcategory[48] and stack height under all scenarios.

The multi-sectoral modeling approach described in the Industrial,

Natural Gas, and Residential and Commercial sections provided inputs for all other sectors. This approach simulated economywide fuel consumption in a variety of categories and fuels. ICF identified emissions factors for the pollutants of interest (NO_x, SO_2, VOC, PM, and NH_3) corresponding to the fuels simulated by the Multi-Sectoral Model. As economywide emission factors, they are necessarily broad and best estimates for the specific fuel consuming activities in which the fuels are used. Most of these emissions factors were taken from the 2014 National Emissions Inventory (NEI), Version 2,[49] for consistency with the COBRA model. ICF also used emissions factors for industrial gasoline from the GREET model[50] and energy density conversion factors from the U.S. Energy Information Administration (EIA) Monthly Energy Review, May 2021,[51] to complete the analysis. For each fuel and year, ICF multiplied the fuel consumption activity by the emission factor to quantify air pollutant emissions in each of the Multi-Sectoral Model's source categories.

For Policy Scenarios 1-3, ICF apportioned state-level emissions to counties and emission tier subcategories by best matching multi-sectoral categories to (groups of) COBRA categories, then distributing emissions proportionally to the default values in COBRA. Multi-Sectoral Model emissions categories for residential, commercial, industrial, and off-road transportation gas use were mapped to COBRA tiers for residential fuel combustion, commercial/institutional gas fuel combustion, industrial gas fuel combustion and off-highway: other emissions, respectively. Multi-Sectoral Model emissions categories for residential distillate fuel and residential hydrocarbon liquids were mapped to COBRA tiers for residential distillate oil and residential: other emissions, respectively. The remaining emissions from the Multi-Sectoral Model were rolled into a single category: other fuels – commercial and industrial (referred to hereafter as "OCI"),[52] to facilitate mapping to the COBRA model's tiers.

For Policy Scenarios 1-3, modeled at the state-scale, activity data (fuel consumption) from the Multi-Sectoral Model were converted to state-level PM and PM precursor pollutant emissions based on the relevant emissions factors discussed above. Then the emissions values for each pollutant were disaggregated to counties using relevant proportions from the 2023 COBRA default data. ICF apportioned total statewide emissions to counties based on ratios of county to state totals for each sector (including the OCI sector). ICF then similarly apportioned emissions to

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[48] Relevant electricity generating unit secondary COBRA tiers in Oregon and Washington include coal, natural gas, internal combustion, distillate oil, and "other." Because IPM modeling results did not include any coal emissions in 2025, 2035, and 2050, ICF did not apportion county-level electricity generating unit emissions to the secondary coal COBRA tier.

[49] U.S. EPA (2018). 2014 National Emissions Inventory, version 2 Technical Support Document: https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data

[50] Argonne National Laboratories. The Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model (GREET. Available at: https://greet.es.anl.gov

[51] U.S. Energy Information Administration (2021). Monthly Energy Review: https://www.eia.gov/totalenergy/data/monthly/

[52] The other fuels – commercial and industrial emissions category includes commercial distillate fuel, commercial gasoline, commercial hydrocarbon liquids, industrial coal, industrial distillate fuel, industrial gasoline, and industrial liquefied petroleum gas.

relevant stack (pollutant release) heights by COBRA tiers[53] based on state-level ratios by individual COBRA tier and pollutant. This use of state-level proportions in mapping emissions is consistent with the state-resolved emissions modeling. ICF also ran a sensitivity analysis to demonstrate that using county-level proportions for emission tier subcategories and stack height did not result in significantly altered benefits under Scenario 1.[54]

Under Policy Scenario 4, ICF calculated benefits based on county-resolved activity data from the Multi-Sectoral Model. In this Policy Scenario, the state-level multi-sectoral activity data results in each category were first apportioned to each county. This disaggregation of fuel consumption to counties was derived from default COBRA proportions of 2023 SO_2 emissions, which is expected to track well with total fuel volumes. These county-specific fuel consumption data from the Multi-Sectoral Model were then paired with emission factors to determine county-specific emissions, which were then disaggregated to emission tier subcategories and stack height by sector and county. Using this method to allocate fuel consumption to counties resulted in larger amounts of fuel consumed in higher-population counties, as expected. For Policy Scenario 4, ICF relied on county-level proportions to map county level emissions to individual COBRA emission tier subcategories and stack height for consistency with the county-resolved emissions modeling. The county-resolved modeling approach implemented in Policy Scenario 4 is more fine-tuned to modeled activity data because it apportions activity data to each county prior to disaggregating emissions to each COBRA emissions tier subcategory and stack height.

ICF used the customized emissions, population, and incidence input data in the COBRA model for each Policy Scenario (1, 2, 3, and 4), analysis year (2025, 2035, and 2050), and discount rate (3% and 7%). The COBRA outputs included county-level changes in the number of cases of health outcomes and the associated monetary value of those changes. ICF post-processed raw COBRA outputs to scale willingness-to-pay (WTP) values to future years and to discount monetized values to the start of the evaluation period (2022). ICF calculated the cumulative effects of each policy scenario by interpolating, assuming a linear trend between modeled years. As health impacts and benefits under Policy Scenarios 1-3 were modeled based on state-resolved emissions changes, state-level outputs are reported. Under Policy Scenario 4, ICF modeled county-resolved emissions changes and reported all outputs at both the county and state scale.

ICF processed all results of the COBRA model into a workbook of Scenario-, year-, and discount rate-specific results. For the county-resolved outputs of Policy Scenario 4, ICF also created maps showing the distribution of avoided cases and monetized benefits at the county-level, both cumulative over the analysis period and by modeled year.

6.2 Data Sources

Inputs to the COBRA model include:

- customized emissions data[55] for the Reference Case and each policy scenario,
- health effect functions,
- county-level baseline health incidence data,
- county-level population projections for future years, and
- valuation data.

This analysis relied on COBRA's default functions that relate changes in emissions to changes in pollutant concentrations, changes in concentrations to changes in health incidence, and valuation functions that monetize the changes in the incidence of health effects.

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[53] COBRA tiers that reflect the OCI emissions sector include industrial coal, industrial internal combustion, industrial oil, industrial other, commercial/institutional coal other, commercial/institutional oil other, and miscellaneous fuel combustion (except residential).

[54] Please note that the sensitivity test differs from both Policy Scenarios 1-3 and Policy Scenario 4. Policy Scenario 4 disaggregates state-level *activity* data to individual counties prior to determining county-specific emissions; the sensitivity analysis disaggregates state-level *emissions* data to individual counties and further disaggregates emissions based on county-level proportions of emission tier subcategories and stack height.

[55] Emissions data are reported in short tons per year.

ICF discusses these categories of input data below.

6.2.1 Customized Emissions Data

The health impacts assessment includes air pollutant emissions from the following sectors:

- Tailpipe emissions from on-road vehicles, plus brake and tire wear from on-road vehicles.
- Economy-wide other petroleum fuel consumption, including major stationary, industrial, and commercial sources and residential fuel combustion activities such as home heating. This includes natural gas and other petroleum fuels.
- Electricity generation (including effects of vehicle electrification, which is notably not regulated but varies with the scenarios). Electric generating sites within Oregon and in the Columbia River Basin in Washington are included given their influence on Oregon's air quality.

The health impact analysis specifically excludes air pollutant emissions changes from the following sectors:

- Refineries. Although refining emissions could be affected by fuel policies, there are none in the state.
- Wood heating. This is not included in the multi-sectoral modeling and is assumed unchanged under any scenario.
- Land use changes and agriculture.
- Any other sector and any facility not located within Oregon boundaries. These were treated as having no change in emissions under the plan and rely on the default COBRA information.

Emissions inputs for this analysis came from three sources, summarized in Table 11. All were customized for the Reference Case and each scenario in years 2025, 2035, and 2050. Any emissions that were not in these three source categories, and thus not modeled using the tools and approaches described above, were considered static in the COBRA model for all years. This means there was no change in these emissions between the baseline and policy scenarios, and thus they do not contribute to health impacts under the scenario.

Table 11: Health Analysis Emissions Sources

Emissions Source/Sector	Model(s) and Outputs	Geographic Scale
Tailpipe emissions from on-road vehicles	VISION model for statewide fuel consumption by fuel and vehicle type and MOVES3 model for fuel-based annual emissions factors by vehicle category[a]	Policy Scenarios 1-3: State; Policy Scenario 4: County
Emissions from electricity generation	Facility- and fuel-based IPM model for of emissions for electricity generating units[b]	Policy Scenarios 1-4: County
Economy-wide other petroleum fuel consumption (natural gas used in off-road transport; residential, commercial, and industrial applications; and other fuels used in residential, commercial, and industrial applications)	Energy consumption by fuel by sector from the multi-sectoral model[c]	Policy Scenarios 1-3: State; Policy Scenario 4: County

Notes:
(a) On-road direct PM emissions include exhaust, brake wear, and tire wear.
(b) Limited to sources within Oregon and the Columbia River Valley in Washington.
(c) Fossil energy consumption in Bbtu converted into PM and PM precursor emissions (NO_x, SO_2, NH_3, and VOC) by pairing fuel consumption amounts with relevant emission factors. For Scenario 4, state-level estimates scaled to county-level using SO_2 proportions from COBRA 2023 default emissions data.

6.2.2 Health Effect Functions

ICF relied on default COBRA health effect functions representing the relationship between changes in PM concentrations and adverse human health effects. The U.S. EPA selected these functions based on an assessment of the published scientific literature and criteria including study location, design, characteristics of the study population, and whether the study was peer-reviewed. For certain health endpoints (mortality and non-fatal heart attacks), COBRA uses separate health effect functions to model high-end and low-end estimates of changes in health incidence. Low estimates of health benefits are based on the mortality health effect function from Krewski et al. (2009)[56] and a non-fatal heart attack health effect function based on four acute myocardial infarction studies. High estimates of health benefits are based on the mortality health effect function from Lepeule et al. (2012)[57] and the non-fatal heart attack health effect function from Peters et al. (2001)[58]. COBRA models the remaining health effects using health effect functions based on a single study or a pooled analysis of multiple studies.

6.2.3 County-Level Baseline Health Incidence

To estimate the absolute change in annual incidences of health effects influenced by changing air quality, COBRA relies on baseline incidence rates for each health endpoint specific to single-year ages.[59]

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[56] Krewski et al. (2009). Extended follow-up and spatial analysis of the American Cancer Society study linking particulate air pollution and mortality. Res Rep Health Eff Inst(140), 5-114; discussion 115-136.

[57] Lepeule et al. (2012). Chronic exposure to fine particles and mortality: an extended follow-up of the Harvard Six Cities study from 1974 to 2009. Environ Health Perspect, 120(7), 965-970.

[58] Peters et al. (2001). Increased particulate air pollution and the triggering of myocardial infarction. Circulation, 103(23), 2810-2815.

[59] Health endpoints evaluated in COBRA include adult and infant mortality, non-fatal heart attacks, hospital admissions for respiratory and cardiovascular (except heart attacks) illness, acute bronchitis, upper and lower respiratory symptoms, emergency room visits for asthma, minor restricted activity days, work loss days, and asthma exacerbation.

ICF obtained age-, health endpoint-, and county-specific mortality incidence rates in the United States projected for the years 2025, 2035, and 2050 from the U.S. EPA Environmental Benefits Mapping and Analysis Program (BenMAP[60]) model database. The Oregon Health Authority (OHA) provided four years of age group-, state- and county-specific counts of occurrence for asthma emergency department visits, non-fatal heart attacks, all cardiovascular illnesses, all respiratory illnesses, hospital visits for asthma, and chronic lung disease.

ICF processed these data into average incidence rates per total population. To obtain the age-specific populations associated with health effect occurrence counts per age group, state, and county, ICF averaged U.S. Census ACS five-year county and state population estimates by age group between 2016 and 2019 to align with the averaged incidence counts provided by OHA from these years. Most OHA incidence counts were provided for age groups that aligned with the age groups reported in the ACS data. OHA-reported counts of asthma emergency department visits and asthma hospital visits per age group required ICF to estimate populations among age groups that did not align with standard ACS age-specific populations. ICF assumed equal annual health effect counts within the reported age group, before reassembling the data and incorporating into the standard ACS age groups. Where OHA was unable to provide county-level data for a specific endpoint or where county-level data were suppressed due to low counts under OHA's data use agreement,[61] ICF relied on state-level counts transformed into incidence rates for that county. In order to format the incidence rates for input into COBRA, ICF assigned age group-specific incidence rates to individual single-year ages. ICF relied on county-level COBRA default incidence data for the following health endpoints: minor restricted activity days, work loss days, and acute bronchitis.

In summary, ICF used OHA county-specific counts of the following health endpoints: asthma emergency department visits, non-fatal myocardial infarctions, all cardiovascular illnesses, all respiratory illnesses, hospital visits for asthma, and chronic lung disease. ICF used COBRA default incidence data for work loss days, minor restricted activity days, and acute bronchitis. ICF used mortality incidence datasets from BenMAP.

6.2.4 County-Level Population Projections

ICF relied on county-level forecasts of population data from Portland State University (PSU) and Oregon Metro as population inputs into the 2025, 2035, and 2050 COBRA models.

The PSU forecasts included population projections for every five years for all Oregon counties except Multnomah County. ICF supplemented the PSU dataset with district-level population forecasts for Multnomah County from Metro. The Metro forecasts included data for the years 2020, 2030, 2045, and 2050. To obtain Multnomah County population estimates for 2025 and 2035, ICF interpolated through known estimates using a polynomial relationship. To obtain single-year age population estimates based on this data, ICF apportioned projected county-level totals using 2023 default COBRA single-year age population data in conjunction with BenMAP model age 0-64 and age 65-99 population data for years 2025, 2035, and 2050.[62]

6.2.5 Valuation Data

COBRA reports default valuation data for all health points in 2017$. For health endpoints with valuation estimates based on WTP to avoid illness or death, ICF adjusted valuation data to reflect projected income levels per capita in

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[60] Environmental Benefits and Mapping Program-Community Edition (BenMAP-CE). BenMAP is U.S. EPA's detailed model for estimating the health impacts from air pollution. Unlike COBRA, it relies on detailed input on air pollutant concentration changes, then applies concentration-response (C-R) health impact functions. Available at: https://www.epa.gov/benmap for more information.

[61] OHA health effect counts are suppressed when there are fewer than 10 reported cases.

[62] BenMAP model county-level population projections for 2025, 2035, and 2050 are based on county-level population projections from Woods & Poole (2015) forecasts, which project age- and race/ethnicity-specific specific populations from the U.S. Census to future years considering migration. ICF used the proportions of the total population age 0-64 and 65-99 from the BenMAP population datasets to estimate the proportions of the PSU and Metro county total projections that fell into these age groups, then further apportioned the data to single-year age groups using the proportions of each single year age that fell into the 0-64 and 65-99 age groups in the default COBRA 2023 population data.

the 2025, 2035, and 2050 analysis years.[63] ICF relied on projected income growth data from the Organization for Economic Cooperation and Development (OECD) and consumer price index data from the Bureau of Labor Statistics (BLS) to project the original $4.8 million Value of a Statistical Life (VSL) estimate in 1990$ to the future years.[64,65,66] ICF used the same sources to project default COBRA estimates of WTP to avoid acute bronchitis, asthma exacerbation, and upper and lower respiratory symptoms from 2017$ to future years. ICF discounted future year benefits to the start of the evaluation period (2022) at 3% and 7% discount rates.

The applied discount rates accounted for the fact that individuals generally value future benefits and costs less than current costs and benefits. ICF used discount rates of 3% and a conservative 7%, consistent with EPA guidelines.[67,68,69] ICF reported all monetized values in 2020$ by scaling estimates in 1990$ (VSL) and 2017$ to 2020$ using annual consumer price index estimates.

6.3 Key Assumptions

Table 12 summarizes the key assumptions used in the health modeling.

Table 12: Key Assumptions for Health Modeling

Assumption	Description or Justification
ICF mapped modeled emissions under each scenario to COBRA categories (also known as “tiers”, defined in the NEI)	ICF apportioned state-level emissions to counties and other parameters in the COBRA model using the model’s default proportions for 2023 under Policy Scenarios 1, 2, and 3. ICF developed Policy Scenario 4 emissions at the county-level and apportioned emissions to secondary and tertiary emissions categories and stack heights, where relevant, using the model’s default proportions for 2023.
SO_2 emissions best track with activity	ICF apportioned state-level multi-sectoral activity to counties for Policy Scenario 4 using proportions of SO_2 emissions in the default COBRA dataset. This is assumed an improvement over population, land use, or other available metrics for these purposes.
Individual year results may be interpolated for cumulative impacts	COBRA relies on Reference Case and scenario emissions to evaluate changes in health effects in response to emissions changes on an annual basis. ICF integrated annualized benefits over the analysis period to compute cumulative impacts assuming linear trends between modeled years.

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[63] WTP valuation estimates can be projected to future years using estimates of income levels per capita and income elasticity, for which future year estimates are available. Estimates of future valuation related to medical treatment costs or lost productivity are not readily available. Therefore, ICF relied on the default valuation data in COBRA to monetize non-WTP estimates.

[64] OECD (2020). "Long-term baseline projections, No. 103", OECD Economic Outlook: Statistics and Projections (database). Available at: https://www.oecd-ilibrary.org/economics/data/oecd-economic-outlook-statistics-and-projections/long-term-baseline-projections-no-103_68465614-en.

[65] Bureau of Labor Statistics (2020). Series ID: CUUR0000SA0,CUUS0000SA0. Available at: https://data.bls.gov/pdq/SurveyOutputServlet.

[66] Because ICF adjusted VSL for the adult mortality endpoint and willingness to pay for acute bronchitis, upper respiratory symptoms, lower respiratory symptoms, and asthma exacerbation, but not other health endpoints, results may have a minor downward bias.

[67] U.S. EPA (2018). Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors. Technical Support Document. Available at: https://www.epa.gov/benmap/estimating-benefit-ton-reducing-pm25-precursors-17-sectors.

[68] U.S. EPA (2020). User’s Manual for the CO-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA). Available at: https://www.epa.gov/sites/production/files/2020-06/documents/cobra_user_manual_june_2020.pdf.

[69] U.S. EPA (2010). Guidelines for Preparing Economic Analyses.

Assumption	Description or Justification
Modeling accurately captured PM and precursor emissions changes	Certain noted sectors that are not fossil fuel combustion were assumed to not be affected by the program and were excluded. Best available emission factors were used for computing criteria emissions from multi-sectoral activity, but the breadth of potential uses of the modeled fuels in these sectors led to uncertainty in criteria pollutant emission factors.
Health analysis modeling did not capture any potential benefits from Community Climate Investments (CCIs)	These benefits were not available in the input datasets
Electricity generating facilities located outside OR and WA's Columbia River Valley do not significantly impact public health in OR.	Based on a cursory review of facilities in surrounding states and typical meteorology
ICF scaled the valuation of health endpoints to future-year values, where possible	Valuation projections were available only for certain health endpoints: mortality, acute bronchitis, asthma exacerbation, and upper and lower respiratory symptoms
ICF discounted future-year benefits to the start of the evaluation period (2022) at 3% and 7% discount rates	The discount rate accounts for the fact that individuals generally value future benefits and costs less than current costs and benefits

7 Calculating Co-Benefits and Equity Impact

ICF's subcontractor, Cascadia Consulting Group ("Cascadia"), assessed the potential **co-benefits** and positive or negative impacts to **equity** that may result from the Climate Protection Program greenhouse gas reduction strategies.

The purpose of assessing co-benefits and equity considerations was to enrich DEQ's understanding of how and to what extent policy scenarios could affect Oregon's citizens and environment.

Cascadia conducted an equity and co-benefits assessment based on established policy analysis approaches to discern how various scenarios affect equity and co-benefit indicators relative to the Reference Case scenario.[70]

The qualitative assessment included two overarching steps:

- Co-Benefits Assessment**:** Evaluate *overall scenario co-benefits (or damages)* against identified indicators (i.e., is the scenario a net good or bad overall?).
- Equity Assessment**:** Evaluate *distribution of benefits (or damages)* among certain populations of concern (i.e., is the scenario good or bad for everyone? Or only for some?).

7.1 Methodology

7.1.1 Co-Benefits Assessment

The co-benefits assessment aimed to characterize overall net co-benefits to Oregonians associated with proposed policy scenarios. It focused on the various indicators, which were identified to be most salient to proposed policy scenarios, and are shown in Table 13 below. Cascadia worked with DEQ, in consultation with advisory committee community-based organizations representatives, on the selection of co-benefit categories and community of concern for the analysis.

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[70] Bardach, E. & Patashnik, E. 2015. Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving. Washington, DC: CQ Press.

Table 13: Co-benefits Assessment Indicators

Category	Indicator	Rationale
Health	**Local air quality**	Air quality can be sensitive to local projects and contexts. Proximity to highways or high-polluting industries can disproportionately expose certain communities to fossil fuel co-pollutants. This indicator allows DEQ to assess whether regulatory differences between policy scenarios and CCIs may have direct or indirect air quality benefits or consequences to Oregon communities.
Environmental	**Ecosystem health & resilience**	Reduced local pollution and CCI projects can bring benefits for ecosystems and associated services such as carbon sequestration, improved soil and water quality, enhanced biodiversity, and preserved trees and water resources. Ecosystem health is connected to community health and well-being, can reduce exposure to future climate impacts, and improve community resilience to droughts, floods, or extreme heat.
Economic	**Energy security**	Energy security is important to ensure that communities have access to reliable and affordable energy. Allowable CCI projects could have an impact on energy intensity, energy supply, energy burden, and energy costs.
	Employment & workforce development	Transition away from carbon intensive industries can have implications for employment opportunities for multiple communities, and it will be important to identify whether a Policy Scenario may have unintended employment consequences or create new opportunities for employment and workforce development to allow for career transition.
Social	**Housing burden**	Policy scenarios can ease housing burden (e.g., decrease energy or transportation burden) or increase housing burden (e.g., green gentrification, increasing utility burden, or increasing transportation costs). It will be important to identify impacts to housing costs and burden levels from proposed policy scenarios.

Cascadia used a qualitative evaluation process to arrive at a total score for each indicator-scenario combination. Due to the lack of established quantitative tools and methods for many indicators, Cascadia qualitatively ranked each indicator using the following scale of 1 to 5, shown in Table 14.

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Table 14: Ranking for Qualitative Evaluation Process

1	**Negative**	The policy will have a *significant negative effect* on associated indicators.
2	**Slightly Negative**	The policy will have a *modest negative effect* on associated indicators.
3	**Neutral**	The policy will not have a *net neutral effect* for associated indicators.
4	**Slightly Positive**	The policy will have a *modest positive effect* on associated indicators.
5	**Positive**	The policy will have a *significant positive effect* on associated indicators.

7.1.2 Equity Assessment

While the co-benefits assessment characterizes net co-benefits for Oregonians as a whole, not all benefits will be realized equally across geographies, communities, and demographic groups. The purpose of the secondary equity assessment is to assess the distribution of benefits (or damages) across certain communities of concern.

For this assessment, “communities of concern” are categorized and defined as follows:

- Communities of color (COC)
- Tribal Nations
- Elderly populations
- Low-income urban communities
- Low-income rural communities

These communities are described in more detail in Table 15.

Generally, these communities of concern face multiple disproportionate burdens. These increased risks stem from a variety of drivers, including higher existing exposure and sensitivity to stressors such as poor air quality and housing costs, and less capacity to adapt to changing economic and social conditions due to limited access to resources such as health care and or being located in food or amenity deserts. Because of this disproportionate burden, proposed policy scenarios should be examined to determine how they may positively or negatively impact communities of concern.

The communities of concern assessed through this study were specifically selected via iterative input from DEQ, in consultation with advisory committee community-based organizations representatives. They are not mutually exclusive and are also inclusive of other potential communities of concern, such as farmworkers and undocumented workers.

Table 15: Description of Communities of Concern

Community of Concern	Definition and Context
Communities of color	Communities that hold a primary racial identify that describes shared racial characteristics among community members, including Native Americans, Latinos, Asian and Pacific Islanders, African Americans, Africans, Middle Eastern, and Slavic communities.[71] Race is one of the most accurate indicators for environmental hazard exposure and siting of hazardous sites. Furthermore, legacy impacts from historical and current policies have led to disparate health, economic, and social outcomes.[72]
Tribal Nations	Tribal Nations in Oregon are inclusive of nine federally recognized Tribes. These Tribal Nations have existed as sovereign governments before European colonization and settlement and continue to rely on the environment and environmental resources for spiritual, economic, health, and cultural purposes.[73] Because of their historical and current relationship to the environment, Tribes across the Pacific Northwest experience a greater burden of climate change and environmental hazards, leading to disproportionate and disparate health, economic, social, and cultural outcomes.[74]
Elderly populations	Elderly people, or individuals in communities aged 65 or older, face disproportionate climate impacts. Elderly people are more likely to have chronic health conditions, require medications for treatment, and have higher rates of physical and cognitive impairments. Because of these conditions, elderly people are generally more sensitive to climate impacts, such as extreme heat, poor air quality, extreme events, and vector-borne diseases.[75] Furthermore, elderly people who work in regulated sectors may have additional considerations for workforce development or early retirement.[76]
Low-income urban communities	Low-income urban communities comprise of low-income households—or households that earn an income less than or equal to 80% of the area median income—in urban areas or counties with at least one Census Bureau-defined Urban Cluster of 50,000 or more. Urban counties include Columbia, Multnomah, Washington, Clackamas, Yamhill, Marion, Polk, Benton, Lane, Deschutes, and Jackson County. Due to previous environmental injustices, these low-income communities are more likely to be geographically close to sources of pollution, such as from highway vehicle traffic and industrial sources. Low-income households also typically live in older housing units, which increase exposure to environmental hazards. They also have less access to resources that would bolster their resilience to economic, environmental, and social changes, such as health care, insurance coverage, and healthy foods.

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[71] As identified by the Coalition of Communities of Color (https://www.coalitioncommunitiescolor.org/whoweare).

[72] State of Oregon Environmental Justice Task Force (2016). Environmental Justice: Best Practices for Oregon's Natural Resource Agencies. Available at: https://www.oregon.gov/odot/Business/OCR/Documents/Oregon_EJTF_Handbook_Final.pdf.

[73] Legislative Policy and Research Office, State of Oregon (2016) Tribal Governments in Oregon: Background Brief. Available at: https://www.oregonlegislature.gov/lpro/Publications/BB2016TribalGovernmentsinOregon.pdf.

[74] May, C., C. Luce, J. Casola, M. Chang, J. Cuhaciyan, M. Dalton, S. Lowe, G. Morishima, P. Mote, A. Petersen, G. Roesch-McNally, and E. York. 2018. Northwest. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment.*

[75] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[76] Just Transition Centre (2017). Just Transition: A Report for the OECD. Available at: https://www.oecd.org/environment/cc/g20-climate/collapsecontents/Just-Transition-Centre-report-just-transition.pdf.

Community of Concern	Definition and Context
Low-income rural communities	Low-income rural communities comprise of low-income households in rural areas—or counties that do not have at least one Census Bureau-defined Urban Cluster. In addition to similar environmental injustices that low-income urban communities face, low-income rural communities also experience additional transportation burden to access resources and amenities.

The equity assessment followed a similar methodology to the co-benefits assessment. Similar to the co-benefits assessment, Cascadia evaluated indicators using qualitative rankings for each scenario. In the equity assessment, though, a separate evaluation matrix was developed for each scenario and rankings were assigned separately for each community of concern. This allowed for a clear comparison of scenario outcomes among various communities of concern—disaggregating who “wins” and “loses” under each scenario.

Similar to the co-benefits assessment, Cascadia used a matrix template to qualitatively evaluate indicators within each indicator category. Due to the lack of established quantitative tools and methods for many of these indicators, Cascadia qualitatively ranked each indicator using a defined scale of 1 to 5, as shown in Table 16.

Table 16: Co-Benefits Ranking Scale

1	**Negative**	The policy will have a *significant negative effect* on associated indicator in that community.
2	**Slightly Negative**	The policy will have a *modest negative effect* on associated indicator in that community.
3	**Neutral**	The policy will not have a *net neutral effect* for associated indicator in that community.
4	**Slightly Positive**	The policy will have a *modest positive effect* on associated indicator in that community.
5	**Positive**	The policy will have a *significant positive effect* on associated indicator in that community.

In addition to this qualitative ranking, Cascadia included a brief narrative rationale for each indicator-scenario combination. In addition to considerations of how co-benefits are distributed across groups, there may be additional considerations of how co-benefits are distributed within a group (e.g., geographic variability, nearby vs. downstream communities). Cascadia documented these considerations with additional evidence, as available, from the economic and health analysis, other similar policy assessments, academic literature, or local and lived experiences.

7.2 Data Sources and Assumptions

The approach for the co-benefits and equity impact assessment was fundamentally different from the other analyzes because it was a qualitative assessment rather than a model-driven quantitative assessment and large datasets. The data sources and assumptions were largely based on available information in the literature, as well as outputs from other analyses conducted under this project.

Please refer to the Appendix for complete information about the information used and the resulting findings.

8 More Information

Results from these analyses are detailed in the materials posted on the DEQ’s modeling study website and summarized in the document titled *Modeling Study on Program Options to Reduce Greenhouse Gas Emissions: Summary Report*.

As noted earlier, the analyses described in this document are intended to help inform the design of DEQ’s Climate Protection Program. The scenarios are not intended to represent the final program design. The modeled results are also not intended to represent actual outcomes of the program since the final program design will differ from the assumptions used in the modeling.

9 Appendix A: Methodology and Results of Co-Benefits and Equity Assessment

9.1 Methodology Overview

Cascadia conducted an equity and co-benefits assessment based on established policy analysis approaches to investigate how the various policy scenarios affect equity and co-benefit indicators relative to the Reference Case.[77]

The assessment can be summarized in two overarching steps:

1. Co-Benefits Assessment**:** Evaluate *overall scenario co-benefits (or damages)* against identified indicators (i.e., is the scenario a net good or bad overall?).
2. Equity Assessment**:** Evaluate *distribution of benefits (or damages)* among certain populations of concern (i.e., is the scenario good or bad for everyone? Or only for some?).

The sections that follow include detailed information on how co-benefits and equity were evaluated. Please also see the "Methodology Considerations" section for important assumptions, including assumptions regarding CCIs. Please see Table 2 in *Modeling Study on Program Options to Reduce Greenhouse Gas Emissions: Summary Report* for assumptions used in the four policy scenarios.

9.2 Findings Summary

9.2.1 Co-Benefits Assessment

Table 17 shows results from the co-benefits assessment. Key takeaways from the assessment are listed below.

- Overall, all policy scenarios are projected to create more co-benefits than the Reference Case.
- Policy scenarios are anticipated to benefit local air quality, ecosystem health and resilience, energy security, and employment and workforce development as compared to the Reference Case.
- Policy Scenario 1 and 4 are projected to create slightly more co-benefits than Policy Scenarios 2 and 3. Policy Scenario 4 is projected to create the most co-benefits overall.
- Benefits associated with housing burden are mixed depending on the policy scenario.
- Key scenario differentiators that drove analysis outcomes included the allowable percent use of CCI credits and trading and banking, which can ease the economic transition to lower-emissions fuel sources and create additional co-benefits.

Table 17: Results of Co-Benefits Assessment

Indicator	Reference Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Local air quality	2.5	4	4	3.5	4.5
Ecosystem health & resilience	3	4	4	3.5	4.5
Energy security	2	4	3	4	4
Employment & workforce development	2.5	4.5	4	3.5	4
Housing burden	2	2.5	1.5	2.5	2.5
TOTAL SCORE	**12**	**19**	**16.5**	**17**	**19.5**

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[77] Bardach, E. & Patashnik, E. 2015. Practical Guide for Policy Analysis: The Eightfold Path to More Effective Problem Solving. Washington, DC: CQ Press.

9.2.2 Equity Assessment

Table 18 shows results from the equity assessment. Key takeaways from the assessment are listed below.

- Overall, all policy scenarios are projected to benefit all five identified communities of concern as compared to the Reference Case.
- Policy Scenario 1 is projected to create the highest equity benefits and is closely followed by Policy Scenario 4. Both Policy Scenarios 1 and 4 have more equity benefits than Policy Scenario 2 or Scenario 3.
- Elderly populations are projected to experience the fewest benefits from policy scenarios compared to other communities of concern, largely due to changes to employment and workforce development.
- Urban low-income households and communities of color are projected to experience the most benefits from policy scenarios compared to other communities of concern. Drivers of this outcome include benefits from the CCIs and health improvements associated with air pollutant reductions from regulated sectors. This outcome is highly dependent on the assumption that CCIs are used effectively in communities with large concentrations of air pollutant, especially those with disproportionate exposure.
- Key scenario differentiators that drove analysis outcomes included the type and extent of regulated sectors (fossil fuel suppliers and stationary sources) and scope of associated emissions, the allowance of trading and banking and CCIs, and associated distribution of impacts across geographies and communities.

Table 18: Results of Equity Assessment

Policy Scenario	Communities of color	Tribes	Urban low-income	Rural low-income	Elderly	Total
Reference Case	10.5	10.5	10	10.5	9	**50.5**
Policy Scenario 1	16.5	16	17	16.5	13.5	**79.5**
Policy Scenario 2	15.5	14	15.5	14.5	12.5	**72**
Policy Scenario 3	15	13.5	15	14	12.5	**70**
Policy Scenario 4	17	15.5	17	16	13.5	**79**

9.3 Co-Benefits Assessment

9.3.1 Indicators

The co-benefits assessment aimed to characterize overall net co-benefits to Oregonians associated with proposed policy scenarios—including consideration of both benefits and risks (e.g., transitioning to electric vehicles can reduce overall resilience). Cascadia worked with DEQ, in consultation with advisory committee community-based organizations on the selection of the five co-benefit indicators shown in Table 19.

Table 19: Co-Benefits Indicators

Category	Indicator	Rationale
Health	Local air quality	Local air quality is strongly influenced by local projects, sources, and contexts. Policies that reduce greenhouse gas emissions often also reduce emissions of co-pollutants that affect local air quality and public health. As air quality is generally worse closer to these sources, proximity to sources like high-traffic roadways or high emitting industries may lead to a disproportionate air pollution burden on communities near them. This indicator allows DEQ to assess whether regulatory differences between policy scenarios and projects supported by CCIs that reduce greenhouse gas

Category	Indicator	Rationale
		emissions may have direct or indirect air quality benefits or consequences to Oregon communities.
Environmental	Ecosystem health & resilience	Reduced local pollution and CCI projects can bring benefits for ecosystems such as improved soil and water quality, enhanced biodiversity, and preserved trees and water resources. Ecosystem health is connected to community well-being; It can reduce exposure to future climate impacts and improve community resilience to droughts, floods, or extreme heat.
Economic	Energy security	Energy security is important to ensure that communities have access to reliable and affordable energy. Allowable CCI projects could have an impact on energy intensity, energy supply, and energy burden. Allowable use of CCI credits, as well as banking and trading, could also affect energy costs.
	Employment & workforce development	Transition away from carbon intensive industries can have implications for employment opportunities for multiple communities, and it will be important to identify whether a policy scenario may have unintended employment consequences or create new opportunities for employment and workforce development to allow for career transition.
Social	Housing burden	Policy scenarios can ease housing burden (e.g., decrease energy or transportation burden) or increase housing burden (e.g., green gentrification, increasing utility burden, or increasing transportation costs). It will be important to identify impacts to housing costs and burden levels from proposed policy scenarios.

9.3.2 Qualitative Ranking Approach

A **qualitative evaluation process** was used to arrive at a total score for each indicator-scenario combination. Due to the lack of established quantitative tools and methods for many indicators, each indicator was qualitatively ranked using the defined scale of 1 to 5 in Table 20, as compared to present day conditions:

Table 20: Co-Benefits Ranking Scale

1	**Negative**	The policy will have a *significant negative effect* on associated indicators.
2	**Slightly Negative**	The policy will have a *modest negative effect* on associated indicators.
3	**Neutral**	The policy will not have a *net neutral effect* for associated indicators.
4	**Slightly Positive**	The policy will have a *modest positive effect* on associated indicators.
5	**Positive**	The policy will have a *significant positive effect* on associated indicators.

9.3.3 Findings Overview

Findings from the co-benefits assessment are summarized in Table 21.

Table 21: Co-Benefits Assessment Results

Indicator	Reference Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Key Rationale/Considerations
Local air quality	2.5	4	4	3.5	4.5	• Criteria air pollutants: lowest in Policy Scenario 4. • Non-natural gas fuel suppliers: smaller scope of emissions regulated in Policy Scenario 3. • As major sources of criteria air pollutants, reductions in transportation vehicle and fuel emissions will carry significant health benefits. • Use of CCIs could benefit indoor air quality (e.g., electric appliances) and outdoor air quality (e.g., transit and freight fleet fuel conversion).
Ecosystem health & resilience	3	4	4	3.5	4.5	• Criteria air pollutants: lowest in Policy Scenario 4. • Transition from fossil fuel sources could reduce the risk of ecosystem impacts from fuel production and transport, but solar could have land use implications. • Some CCIs could carry ecosystem health co-benefits, such as transit and freight fleet fuel conversion could reduce environmental impacts associated with fuel transport.
Energy security	2	4	3	4	4	• Increased reliance on renewable energy and any reliability considerations. • Energy costs may increase in the near-term across policy scenarios but decrease substantially in the long-term as renewable energy production becomes more cost-efficient. • Energy costs may be higher in scenarios with greater emissions reduction caps and less compliance flexibility.
Employment & workforce development	2.5	4.5	4	3.5	4	• A small portion of traditional energy sector jobs are associated with fossil fuels. Coal-related jobs will be phased out by 2035 in the Reference Case. • However, there will be positive net job impacts across all scenarios. In particular, direct and induced net job impacts will be positive in the long-term for all scenarios, with Policy Scenarios 1, 2, and 4 showing the highest benefits.

Indicator	Reference Case	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Key Rationale/Considerations
						• Near-term job loss in regulated sectors across all scenarios, but jobs are often reallocated to other sectors—such as renewable energy or energy efficiency jobs—at a macro-scale so net impacts are positive.
Housing burden	2	2.5	1.5	2.5	2.5	• Housing burden impact—which relates to energy burden—may see short-term increases but long-term savings. • Generally, more significant emission caps increase energy prices and housing burden in the short-term. The allowance of trading and CCIs can alleviate housing burden through attenuation of energy price increases and provision of financial support for households (e.g., rebates for energy efficiency improvement projects). • Net job gains across scenarios over time can result in improvement in housing burden.
TOTAL SCORE	**12**	**19**	**16.5**	**17**	**19.5**	

9.3.4 Indicator Findings Summaries

9.3.4.1 Health Indicator: Local Air Quality

9.3.4.1.1 Reference Case

- Modeling suggests an **overall reduction in greenhouse gas emissions** under the Reference Case, likely also reducing the incidence of local air pollution from co-pollutants.
- The Clean Fuels Program and vehicle electrification goal established in Senate Bill 1044 is anticipated to reduce emissions in the transportation sector, and the bulk of reductions will be from light-duty vehicles—the second-largest source of criteria air pollutants in the state.
- Almost half of Oregon's diesel particulate emissions come from **on-road heavy-duty diesel vehicles** and one-third come from **non-road diesel equipment**.[78] Criteria air pollutants from heavy-duty vehicles and non-road equipment could continue to affect air quality near major roadways and construction sites under the Clean Fuels Program in the Reference Case. However, given that criteria air pollutants have declined over time in Oregon even as greenhouse gas emissions have increased or stayed constant, it is anticipated that the **trend of declining criteria air pollutants will continue downward** under the Reference Case.[79]
- Though small, projected increases in energy use and process emissions from **manufacturing growth** could increase emissions of air pollutants in those industrial locations.
- **Natural gas consumption** increases slightly in the Reference Case. A slight increase in greenhouse gas emissions by 12% between 2018 to 2050 is attributed to increased natural gas demand in the residential and commercial sectors. Natural gas production and combustion is a large source of volatile organic compounds (VOCs) and nitrogen oxides (NO_x)—precursors to ground-level ozone, which has been linked to respiratory ailments.[80] Warmer temperatures with climate change could exacerbate the health impacts of natural gas consumption by extending the ozone season and accelerating ozone formation.[81]
- Air pollution from **increased wildfire smoke** in western states is expected to increase the risk of respiratory and cardiovascular illnesses by 160% by 2050 and fire sources made up 62% of Oregon's criteria air pollutant emissions in 2017.[82,83] The increasing risk of wildfires will result in continued air quality degradation across the state into the future.

9.3.4.1.2 Policy Scenarios

- The analysis shows that all policy scenarios result in **considerable reductions in overall greenhouse gas emissions** compared to the Reference Case. These emission reductions will likely be accompanied by reductions in emissions of co-pollutants statewide.[84] Modeling of policy scenarios resulted in a cumulative net benefit ranging from $595 million–2.16 billion (all 2020$ with a 3% discount rate) in avoided health costs from greenhouse gas and co-pollutant emissions by 2050.[85] Scenario 4, which relied on a modeling approach that fine-tuned emissions changes at the county level, shows the greatest health benefits annually

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[78] Oregon Department of Environmental Quality. 2017. Diesel Emission Inventory. https://www.oregon.gov/deq/aq/programs/Pages/Diesel-Emission-Inventory.aspx

[79] Environmental Protection Agency. 2017. 2017 Oregon National Emissions Inventory Report. https://gispub.epa.gov/neireport/2017/

[80] Congressional Research Service. 2018. Methane and Other Air Pollution Issues in Natural Gas Systems. https://crsreports.congress.gov/product/pdf/R/R42986/26

[81] IQ Air. 2021. Air quality in Oregon. https://www.iqair.com/us/usa/oregon.

[82] Environmental Protection Agency. 2017. 2017 Oregon National Emissions Inventory Report. https://gispub.epa.gov/neireport/2017/

[83] Oregon Health Authority. 2020. Climate Change and Public Health in Oregon. https://www.oregon.gov/oha/ph/about/pages/healthstatusindicators.aspx.

[84] West, Jason et. al. 2013. Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health. Nature Climate Change. https://www.nature.com/articles/nclimate2009

[85] Results from state-level monetized health benefit evaluations. The lowest range is from the scenario with the least benefits, Policy Scenario 3, reported using "low estimates" of the health benefits. The high range is from the scenario with the most public health benefits (Policy Scenario 2), reported using the "high estimates" of health benefits. All reported health benefits are estimated using a discount rate of 3% and reported in 2020 dollars.

and cumulatively. Policy Scenarios 1 and 2 have comparable avoided health benefits and Policy Scenario 3 has the fewest avoided health benefits of all scenarios, though all scenarios are comparable.

- Depending on the mitigating source and type, as well as the implementation of a CCI project, the **use of CCIs** could also result in net air quality and health benefits (although CCIs were not modeled in the health analysis, assumed benefits are speculative). The health benefit of CCIs could be significant given that substantial criteria air pollutants stem from wood stoves, heavy-duty vehicles, and nonroad diesel equipment.
- **CCIs projects that transition from wood or gas to electric stoves**, for example, can reduce indoor air pollution and risks from smoke, carbon monoxide, and formaldehyde.[86]
- **CCIs projects that support freight fleet conversion to non-fossil fuels and fleet electrification** could also improve local air quality. For example, biodiesel has been shown to release fewer criteria air pollutant emissions when compared to hydrocarbon-based diesel.[87] In the health analysis, electrification and other fuel shifts resulted in reduced air pollutant emissions.
- Where and how **CCI projects are implemented** can impact the level of benefits achieved. For example, energy efficiency upgrades such as insulating and tightening the building envelope can create conditions for mold, mildew, and unhealthy indoor air quality if not paired with proper ventilation and air filtration upgrades.[88]
- Electrification and energy efficiency investments could also reduce negative air quality, such as from impacts of wildfires, through installation of air filtration equipment such as efficient HVAC systems and heat pumps.

9.3.4.2 Environmental Indicator: Ecosystem Health & Resilience

9.3.4.2.1 Reference Case

- In 2019, Oregon cities averaged an annual **air quality index (AQI)** level of 38—significantly less than the US EPA standard of less than 50.[89] Fine particle pollution ($PM_{2.5}$) is of primary concern in the state—air quality in Oregon ranging from “moderate” to “unhealthy for sensitive groups” is common in urban areas from November to February, and cool air inversions and wildfires can exacerbate these risks. In 2020, Oregon broke records for most acres burned in a single wildfire season.[90]
- Modeling suggests an **overall reduction in greenhouse gas emissions** under the Reference Case to 2050. Greenhouse gas emission reductions often coincide with **lower release of co-pollutants** that impact ecosystem health, such as particulate matter (e.g., $PM_{2.5}$) and the deposition of sulfur, nitrogen, and VOCs. These pollutants can cause acidification, eutrophication, and changes in soil and water chemistry that can stress ecosystems and changes species composition.[91] Ozone pollution, which stems from gas-powered engines and industrial processes, has been shown to adversely affect tree growth and alter tree succession, species biodiversity, and pest interactions.[92]
- Modeling under the Reference Case anticipates an increase in **industrial process emissions** due to expansion of the manufacturing sector. Processes such as cement manufacturing require large amounts of water, which

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[86] California Air Resources Board. 2021. Indoor Air Pollution from Cooking. https://ww2.arb.ca.gov/resources/documents/indoor-air-pollution-cooking#:~:text=Natural%20gas%20and%20propane%20stoves,air%20pollution%20from%20wood%20smoke.

[87] Durbin, Thomas et. al. 2013. CARB B20 Biodiesel Preliminary and Certification Testing. https://ww3.arb.ca.gov/fuels/diesel/altdiesel/20140630carb_b20_%20additive_study.pdf?_ga=2.198837030.840908223.1618080543-2096999552.1613503733.

[88] Oregon Health Authority. 2020. Climate Change and Public Health in Oregon. https://www.oregon.gov/oha/ph/about/pages/healthstatusindicators.aspx.

[89] IQ Air. 2021. Air quality in Oregon. https://www.iqair.com/us/usa/oregon.

[90] KTVZ News Sources. September 15, 2020. Wildfire smoke has brought Oregon record-poor air quality, DEQ reports. https://ktvz.com/news/oregon-northwest/2020/09/15/.

[91] U.S. Fish & Wildlife Service. 2015. Effects of Air Quality. https://www.fws.gov/refuges/airquality/effects.html.

[92] U.S. Forest Service Pacific Northwest Research Station. 2018. Ecosystem Indicators. https://www.fs.usda.gov/pnw/projects/ecosystem-indicators.

could strain water availability for natural ecosystems.[93] Cement and pulp and paper plants are also a significant source of NO_x and VOCs. NO_x and SO_x can react with water to result in the **acidification of surface waters and soil**.[94,95,96] Additionally, excess nitrogen released can lead to the increased leaching of nitrate which risks **eutrophication of coastal marine areas and harms groundwater quality**.[97]

- **Extraction and transport of fossil fuels** can bring risks to ecosystem health and resilience. Oregon has the only natural gas field in the Pacific Northwest (Mist Field), though its production has declined significantly in recent years, and there are eight underground natural gas storage projects in Oregon.[98] These gas field wells tap into porous sandstone that do not require fracking, so groundwater contamination is not a significant concern in Oregon.[99] The transportation of fossil fuels such as crude oil carries risks of spills, such as the 2016 train derailment in Mosier that released approximately 47,000 gallons of crude oil into the environment; such spills can impact local water quality and sensitive aquatic species such as plankton, fish, and waterfowl.[100,101]
- **Wildfires are anticipated to increase with climate change**, resulting in reduced forest canopy cover, water quality, and soil quality. It is also anticipated to increase soil erosion, eutrophication, water acidification, and the release of heavy metals into the atmosphere and water.[102] Wildfire impacts are assumed to be constant across the Reference Case and policy scenarios.

9.3.4.2.2 Policy Scenarios

- Modeling shows all policy scenarios result in **considerable reductions in overall greenhouse gas emissions** compared to the Reference Case, with highest statewide reductions anticipated under Policy Scenario 3. These emissions reductions will likely be accompanied by reductions in emissions of co-pollutants that impact ecosystem health, including particulate matter.[103]
- Transition away from fossil fuel sources could reduce the risk of ecosystem impacts from **fossil fuel production and transport**, such as from crude oil spills.
- The expansion of renewable energy resources such as **solar** could carry implications for **land use** and ecosystem health, depending on the location.

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[93] Miller, et. al. 2018. Impacts of booming concrete production on water resources worldwide. Nature Sustainability. https://www.nature.com/articles/s41893-017-0009-5.

[94] U.S. Environmental Protection Agency. 2019. Cement Manufacturing Enforcement Initiative. https://www.epa.gov/enforcement/cement-manufacturing-enforcement-initiative.

[95] Gavrilescu, D., et. Al. 2011. Environmental Impact of Pulp and Paper Mills. Environmental Engineer and Management Journal, 11(1), 81-85. https://www.researchgate.net/profile/Adrian-Puitel/publication/281761323_Environmental_impact_of_pulp_and_paper_mills/links/566be6ce08aea0892c4f002a/Environmental-impact-of-pulp-and-paper-mills.pdf.

[96] Lorenz, M. et. al. 2010. Air Pollution Impacts on Forests in a Changing Climate. U.S. Forest Service. https://www.fs.fed.us/psw/publications/bytnerowicz/psw_2010_bytnerowicz(lorenz)002.pdf.

[97] Ibid.

[98] U.S. Energy Information Administration. 2021. Oregon State Profile and Energy Estimates. https://www.eia.gov/state/analysis.php?sid=OR.

[99] Stewart B. 2011. Oregon Gas Drilling: Different Challenges Between Sandstone and Coal Beds. Oregon Public Broadcasting. https://www.opb.org/news/article/coal-bed-methane-creates-coos-bay-challenges/.

[100] U.S. Environmental Protection Agency. 2021. Mosier Oil Train Derailment. https://response.epa.gov/site/site_profile.aspx?site_id=11637.

[101] Horn, Matthew. 2017. A Quantitative Evaluation of Trajectory, Fate, and Effects from Crude By Rail Releases: A case study using the Proposed Shell Puget Sound Refinery Anacortes Rail Unloading Facility. International Oil Spill Conference Proceedings. https://meridian.allenpress.com/iosc/article/2017/1/2017098/197843.

[102] Bladon, K. et. al. 2014. Wildfire and the Future of Water Supply. Environmental Science and Technology, 48(16), 8936-8943. https://doi.org/10.1021/es500130g.

[103] West, Jason et. al. 2013. Co-benefits of mitigating global greenhouse gas emissions for future air quality and human health. Nature Climate Change. https://www.nature.com/articles/nclimate2009.

- Some **CCI projects** could carry ecosystem health co-benefits (transit and freight fleet fuel conversion could reduce environmental impacts associated with fuel transport), but the net impacts are unknown because it depends on the type of CCI projects and associated ecosystem impacts.[104]

9.3.4.3 Economic Indicator: Energy Security

9.3.4.3.1 Reference Case

- In the Reference Case, modeling suggests **the electricity mix will be more reliant on increased renewable energy sources**, such as hydropower, wind, and solar due to the transition away from coal by 2030.[105]
- If hydropower continues to be a significant renewable energy source, climate change could impact future supply. Warmer winter temperatures will very likely see more rain than snow in the winter months, potentially causing hydropower shortages during the summer when supply is contingent on summer snowmelt. **Summer energy supply shortages** may occur when energy demand is at its annual high—which is anticipated to worsen due to warmer summers and prolonged heat waves that drive up energy demand even more. If the supply issues are not addressed or mitigated with technological improvements or advancements, there could be power shortages,[106] potentially impacting **future electricity reliability**.
- A household's energy burden, or the percentage of income spent on energy bills, can indicate energy affordability. Energy burden in Oregon is widespread, with **approximately 433,000 of Oregon's households experiencing energy burden in 2020**.[107] While wholesale electricity prices in the Northwest have decreased substantially since 2005, future forecasts of wholesale electricity prices may slightly increase.[108] This trend could continue exacerbating energy burden, defined as the percent of household income spent on energy bills including electricity and heating fuels (e.g., natural gas).
- Energy burden, including electricity and heating, is felt most intensely in rural counties (e.g., Malheur, Lake, Wheeler, Harney, and Crook County), where some households pay up to 38% of their income for energy.[109] Additionally, rural communities have a higher percentage of older housing units that also utilize more energy due to aging or outdated infrastructure design.[110]

9.3.4.3.2 Policy Scenarios

- Previous assessments of Oregon's carbon pricing policies indicate that any carbon pricing model will likely lead to **near-term increases in energy costs**.[111,112] Despite this near-term increase, there will **likely be long-term decreases in energy costs across policy scenarios** because of the shift to renewable energy sources. While widespread electrification with equipment and conversion costs and associated increases in electric load may put upward pressure on energy prices, the shift to a renewable energy dominated electric supply

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[104] Graves, Rose et. al. 2020. Potential greenhouse gas reductions from Natural Climate Solutions in Oregon, USA. PLOS ONE 15(4). https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0230424.

[105] 78th Oregon Legislative Assembly. 2016. Senate Bill 1547: Elimination of Coal From Electricity Supply. https://olis.leg.state.or.us/liz/2016R1/Downloads/MeasureDocument/SB1547/Enrolled.

[106] Rempel, A. and M. Babbar-Sebens. 2021. Built Environment. In: *Fifth Oregon Climate Assessment*. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka.

[107] Fisher, Sheehan & Colton. 2021. Oregon: The Home Energy Affordability Gap 2020. http://homeenergyaffordabilitygap.com/02a_research.html.

[108] Northwest Power and Conservation Council. 2016. Chapter 8: Electricity and Fuel Price Forecasts. Seventh Power Plan. https://www.nwcouncil.org/reports/seventh-power-plan.

[109] Fisher, Sheehan & Colton. 2021. Oregon: County Only Home Energy Affordability Gap. http://homeenergyaffordabilitygap.com/02a_research.html.

[110] Oregon Department of Energy. 2018. Ten-Year Plan: Reducing the Energy Burden in Oregon Affordable Housing. https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Ten-Year-Plan-Energy-Burden.pdf.

[111] Ditzel, K., S. Nystrom, and E. Klein. 2016. Oregon Cap-and-Trade: An Economic Impact Analysis of SB 1574 (2016). https://olis.leg.state.or.us/liz/2017R1/Downloads/CommitteeMeetingDocument/109972.

[112] Burtaw, D., R. Morgenstern, A. Keyes, and C. Munnings. 2019. Carbon Pricing in Oregon: Memoranda for the Oregon Climate Policy Office. https://media.rff.org/documents/Rpt_19-01_Oregon.pdf.

with projected declines in production costs will likely lead to long-term cost savings for utilities and ratepayers.[113]

- However, modeling results show that policy scenarios that have **caps that require more greenhouse gas emissions reductions, coupled with less usage of CCIs, and limited trading options for regulated sectors lead to increased energy costs** relative to other policy scenarios.
- Banking and CCIs can be **mechanisms to alleviate energy burden and increase energy reliability**. The use of CCIs to support home energy efficiency could reduce energy burden, including electricity and heating, and improve overall energy reliability and resilience (e.g., less demand in summer months). Sufficient saturation of energy efficient appliances and strategies, such as demand responsive upgrades across a region, can mitigate future energy overload in the future, especially during peak demand times.[114]

9.3.4.4 Economic Indicator: Employment & Workforce Development

9.3.4.4.1 Reference Case

- In 2020, Oregon had **27,664 jobs in the traditional energy sector**, which includes electric power generation; fuels; and transmission, distribution, and storage. This is about 1.4% of Oregon's state employment. Most of the electric power generation jobs are concentrated in the renewable power generation sector. Less than 3% of the jobs in the traditional energy sector are in fossil fuel generation. A majority of the jobs related to fuels were in woody biomass, which was approximately 2,231 jobs. Less than 1% of traditional energy sector jobs related to fuels are for fossil fuels.[115]
- There has been **consistent growth in renewable and non-fossil fuel sectors**. Jobs related to motor vehicles have steady declined. In 2020, there were about 42,935 jobs in the energy efficiency sector and 26,129 jobs in the motor vehicles sector in Oregon.[116]

9.3.4.4.2 Policy Scenarios

- Consistent with other economic models on carbon policies on employment, **in the long-run, employment effects will be neutral to positive**. How quickly benefits are realized (or damages are mitigated) are dependent on how revenue is allocated. Furthermore, despite near-term job losses in directly regulated sectors and upstream sectors for the three scenarios, economic models indicate that **carbon policies frequently lead to job reallocation**, or the scenario that there will be fewer jobs in regulated industries but more jobs in other relevant industries, such as renewable energy or energy efficiency industries.[117]
- This analysis projects **positive net job impacts across all four scenarios by 2050,** shown in Table 22**.** Full results of the economic analysis are available in the summary report, *Modeling Study on Program Options to Reduce Greenhouse Gas Emissions: Summary Report*. Net job impacts account for gross economic benefits but also other investments and opportunity costs. In particular, the direct net jobs benefits and induced income benefits, which are associated with wages and spending power, will increase by 2050 across all four scenarios.
- Even with the long-term economic benefits shown across policy scenarios, higher discount rates may mean that near-term net losses are weighed more than long-term benefits.[118]

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[113] Roland-Holst, D., S. Evans, S. Neal, and D. Behnke. 2020. Oregon's Cap-and-Trade Program (HB2020): An Economic Assessment. https://olis.leg.state.or.us/liz/2019R1/Downloads/CommitteeMeetingDocument/157983.

[114] Rempel, A. and M. Babbar-Sebens. 2021. Built Environment. In: *Fifth Oregon Climate Assessment*. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka.

[115] U.S. Energy and Employment Report. 2021. U.S. Energy + Employment Report 2020: Oregon. https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5e78183f4919f8518bef2a32/1584928832521/Oregon-2020.pdf.

[116] U.S. Energy and Employment Report. 2021. U.S. Energy + Employment Report 2020: Oregon. https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5e78183f4919f8518bef2a32/1584928832521/Oregon-2020.pdf.

[117] Hafstead, M.A.C and R.C. Williams III. 2019. Jobs and Environmental Regulation. https://media.rff.org/documents/WP_19-19_Hafstead_Williams_6.pdf.

[118] Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Sciences. 2018. What are social discount rates? https://www.lse.ac.uk/granthaminstitute/explainers/what-are-social-discount-rates/.

Table 22: Net job impacts, in terms of full-time employees, across policy scenarios.

	Policy Scenario 1				**Policy Scenario 2**				**Policy Scenario 3**				**Policy Scenario 4**			
	Direct	**Indirect**	**Direct**	**Total**	**Direct**	**Indirect**	**Induced**	**Total**	**Direct**	**Indirect**	**Induced**	**Total**	**Direct**	**Indirect**	**Induced**	**Total**
2025	(400)	(400)	(1,000)	**(1,000)**	(800)	(700)	(800)	**(2,300)**	(1,000)	(700)	(800)	**(2,600)**	(900)	(700)	(800)	**(2,400)**
2035	2,100	(800)	300	**2,700**	300	(1,400)	400	**(700)**	300	(1,400)	400	**(800)**	1,400	(1,400)	700	**700**
2050	13,500	0	9,700	**19,600**	12,500	(400)	6,000	**18,000**	9,700	(600)	5,000	**14,100**	13,700	(300)	6,300	**19,700**

9.3.4.5 Social Indicator: Housing Burden

9.3.4.5.1 Reference Case

- Currently, **more than half of Oregon renters** are paying more than 30% of their gross income toward housing costs.[119]
- The analysis shows housing burden is projected to **slightly worsen** under the Reference Case due to combination of rising housing costs, increased energy prices and stagnant household income.[120] Future **climate-related income loss and damages** could increase the risk of people and families experiencing homelessness in Oregon.[121]

9.3.4.5.2 Policy Scenarios

- Previous assessments of Oregon's carbon pricing policies indicate that any carbon pricing program will likely lead to near-term increases in **energy costs**.[122,123] However, renewable energy production costs have been declining and will likely lead to long-term cost savings for utilities and ratepayers.[124] Any short- or long-term increases in energy costs would worsen average housing burden—especially for lower-income households.[125] The results of the four policy scenarios for this analysis indicate near-term increases, but longer-term decreases in energy costs, because of the shift to renewable energy sources. This is one of the main drivers in the net positive macroeconomic results for jobs, income and gross state product over time.
- **Trading of compliance instruments** could help alleviate near term energy price increases and therefore housing burden.

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[119] Oregon Housing and Community Services. 2017. Poverty Report 2017. https://www.oregon.gov/ohcs/about-us/Documents/poverty/2017-Poverty-Report-Summary.pdf.

[120] City of Portland Bureau of Planning and Sustainability. 2009. Housing Affordability: Portland Plan Background Report. https://www.portlandonline.com/portlandplan/index.cfm?a=270879&c=51427.

[121] National Low Income Housing Coalition. 2021. 2021 Oregon Housing Profile. https://nlihc.org/sites/default/files/SHP_OR.pdf.

[122] Ditzel, K., S. Nystrom, and E. Klein. 2016. Oregon Cap-and-Trade: An Economic Impact Analysis of SB 1574 (2016). https://olis.leg.state.or.us/liz/2017R1/Downloads/CommitteeMeetingDocument/109972.

[123] Burtaw, D., R. Morgenstern, A. Keyes, and C. Munnings. 2019. Carbon Pricing in Oregon: Memoranda for the Oregon Climate Policy Office. https://media.rff.org/documents/Rpt_19-01_Oregon.pdf.

[124] Roland-Holst, D., S. Evans, S. Neal, and D. Behnke. 2020. Oregon's Cap-and-Trade Program (HB2020): An Economic Assessment. https://olis.leg.state.or.us/liz/2019R1/Downloads/CommitteeMeetingDocument/157983.

[125] Resources for the Future. 2020. Carbon Pricing 104: Economic Effects across Income Groups. https://www.rff.org/publications/explainers/carbon-pricing-104-economic-effects-across-income-groups/.

- **Certain CCI project types** could also alleviate housing burden through the cost-share programs, and utility cost savings through home energy efficiency projects.[126]
- This analysis also shows net job impacts, or the net impacts when accounting gross economic benefits with other investments and opportunity costs as **positive in the long-term for all scenarios**. In particular, the induced net job impacts, which accounts for benefits such as wages and spending power increases in the mid- and long-term across all three scenarios, with Policy Scenarios 1 and 2 seeing the largest gains. This trend in the policy scenarios suggests that workers could experience minor **near-term wage loss** but **long-term wage gain**. These changes could likely worsen housing burden in the near-term but alleviate housing burden in the long-term.

9.4 Equity Assessment

9.4.1 Communities of Concern

While the co-benefits assessment characterizes net co-benefits for Oregonians as a whole, Cascadia acknowledges that not all benefits will be realized equally across geographies, communities, and demographic groups. The purpose of the secondary **equity assessment** is to assess the distribution of benefits (or damages) across certain communities of concern.

For this assessment, **"communities of concern"** include:

- Communities of color (CoC)
- Tribal Nations
- Elderly populations
- Low-income urban communities
- Low-income rural communities

Generally, these communities of concern face multiple disproportionate burdens. These increased risks stem from a variety of drivers, including higher existing exposure and sensitivity to stressors such as poor air quality and housing costs, and less capacity to adapt to changing economic and social conditions due to limited access to resources such as health care and/or being located in food or amenity deserts. Because of these disproportionate burdens, proposed policy scenarios should examine how they may positively or negatively impact communities of concern.

Cascadia worked with DEQ, in consultation with advisory committee community-based organizations, on selecting these communities of concern. They are not mutually exclusive and are also inclusive of other potential communities of concern, such as farmworkers and undocumented workers. However, for purposes of this assessment, these communities were treated as discrete communities. That is, this assessment did not consider compounding effects of belonging to multiple communities of concern (e.g., an elderly person of color residing in a low-income urban area).

Descriptions and maps of communities of concern are shown in Table 23 and

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[126] State of Oregon Department of Environmental Quality. 2021. Community Climate Investments. https://www.oregon.gov/deq/Regulations/rulemaking/RuleDocuments/GHGCR2021rac3CCI.pdf.

Figure 3, respectively.

Table 23: Description of Communities of Concern

Community of Concern	Definition and Context
Communities of color	Communities that hold a primary racial identify that describes shared racial characteristics among community members, including Native Americans, Latinos, Asian and Pacific Islanders, African Americans, Africans, Middle Eastern, and Slavic communities.[127] Race is one of the most accurate indicators for environmental hazard exposure and siting of hazardous sites. Furthermore, legacy impacts from historical and current policies have led to disparate health, economic, and social outcomes.[128]
Tribal Nations	Tribal Nations in Oregon are inclusive of nine federally recognized Tribes. These Tribal Nations have existed as sovereign governments before European colonization and settlement and continue to rely on the environment and environmental resources for spiritual, economic, health, and cultural purposes.[129] Because of their historical and current relationship to the environment, Tribes across the Pacific Northwest experience a greater burden of climate change and environmental hazards, leading to disproportionate and disparate health, economic, social, and cultural outcomes.[130]
Elderly populations	Elderly people, or individuals in communities aged 65 or older, face disproportionate climate impacts. Elderly people are more likely to have chronic health conditions, require medications for treatment, and have higher rates of physical and cognitive impairments. Because of these conditions, elderly people are generally more sensitive to climate impacts, such as extreme heat, poor air quality, extreme events, and vector-borne diseases.[131] Furthermore, elderly people who work in regulated sectors may have additional considerations for workforce development or early retirement.[132]
Low-income urban communities	Low-income urban communities comprise of low-income households—or households that earn an income less than or equal to 80% of the area median income—in urban areas or counties with at least one Census Bureau-defined Urban Cluster of 50,000 or more. Urban counties include Columbia, Multnomah, Washington, Clackamas, Yamhill, Marion, Polk, Benton, Lane, Deschutes, and Jackson County. Due to previous environmental injustices, these low-income communities are more likely to be geographically close to sources of pollution, such as from highway vehicle traffic and industrial sources. Low-income households also typically live in older housing units, which increase exposure to environmental hazards. They also have less access to resources that would bolster their resilience to economic, environmental, and social changes, such as health care, insurance coverage, and healthy foods.
Low-income rural communities	Low-income rural communities comprise of low-income households in rural areas—or counties that do not have at least one Census Bureau-defined Urban Cluster. In addition to similar environmental injustices that low-income urban communities face, low-income rural

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[127] As identified by the Coalition of Communities of Color. https://www.coalitioncommunitiescolor.org/whoweare.

[128] State of Oregon Environmental Justice Task Force. 2016. Environmental Justice: Best Practices for Oregon's Natural Resource Agencies. https://www.oregon.gov/odot/Business/OCR/Documents/Oregon_EJTF_Handbook_Final.pdf.

[129] Legislative Policy and Research Office, State of Oregon. 2016. Tribal Governments in Oregon: Background Brief. https://www.oregonlegislature.gov/lpro/Publications/BB2016TribalGovernmentsinOregon.pdf.

[130] May, C., C. Luce, J. Casola, M. Chang, J. Cuhaciyan, M. Dalton, S. Lowe, G. Morishima, P. Mote, A. Petersen, G. Roesch-McNally, and E. York. 2018. Northwest. *Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment.*

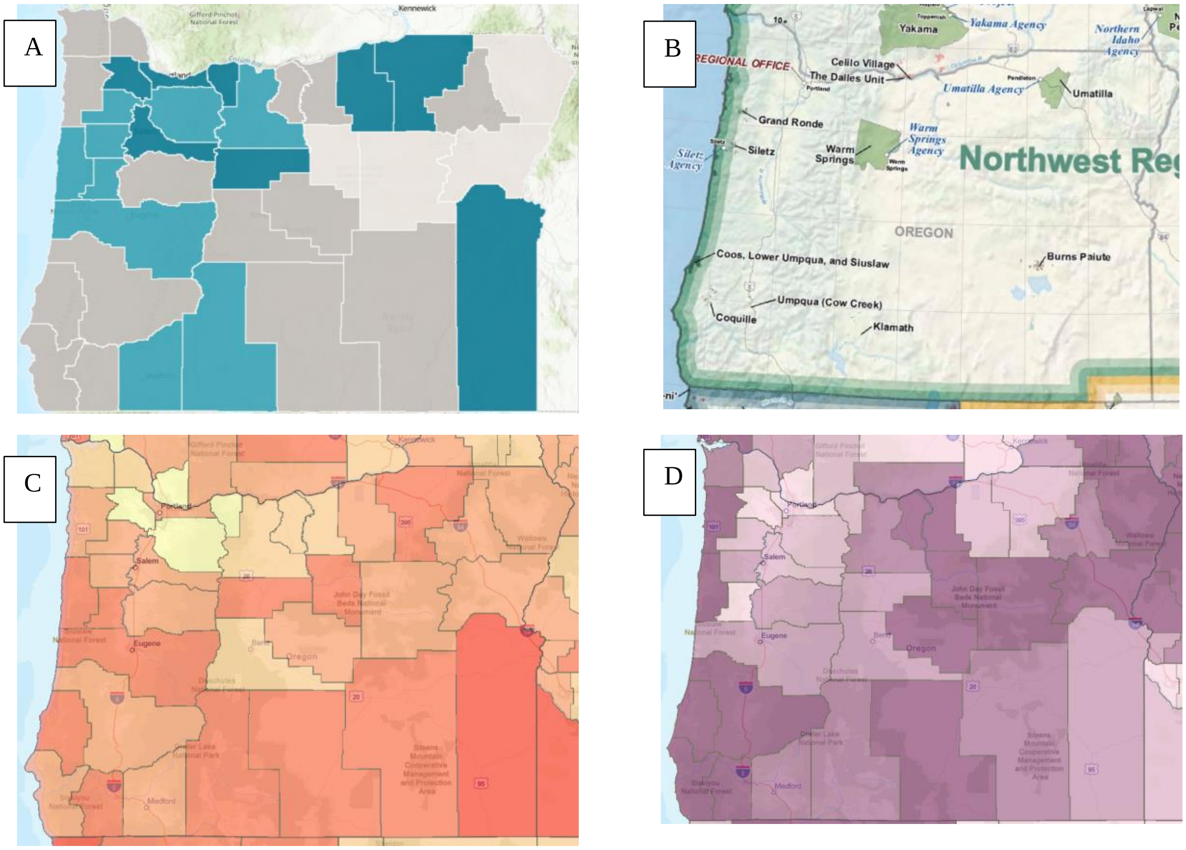
[131] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[132] Just Transition Centre. 2017. Just Transition: A Report for the OECD. https://www.oecd.org/environment/cc/g20-climate/collapsecontents/Just-Transition-Centre-report-just-transition.pdf.

Community of Concern	Definition and Context
	communities also experience additional transportation burden to access resources and amenities.

Figure 3: Maps of Communities of Concern

Notes: Map A shows the percentage of people of color across Oregon's counties. Dark blue areas indicate higher percentages of people of color (26-40%) and light gray areas indicate lower percentages of people of color (5-10%).[133] Map B shows tribal reservations in Oregon.[134] Map C shows the percentage of people living below the federal poverty level. Dark red areas indicate higher percentages of people below the poverty level (20.9-64%) and yellow areas indicate lower percentages of people below the poverty level (2-10.2%). Map D shows the percentage of people aged 65 and older. Dark purple areas indicate higher percentages of elderly people (19-43%) and light purple areas indicate lower percentages of elderly people (3.4-12.5%).[135]



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[133] Oregon Housing and Community Services. 2018. Affordable Housing Assessment. https://geo.maps.arcgis.com/apps/webappviewer/index.html?id=b1b1281da227460ead0facfa7af7abea.

[134] Bureau of Indian Affairs. 2016. Indian Lands of Federally Recognized Tribes of the United States. https://www.bia.gov/sites/bia.gov/files/assets/public/webteam/pdf/idc1-028635.pdf.

[135] Environmental Protection Agency. 2020. EJSCREEN Tool. https://ejscreen.epa.gov/mapper/. Accessed 11 April 2021.

9.4.2 Qualitative Ranking Approach

The equity assessment followed a similar methodology to the co-benefits assessment. Similar to the co-benefits assessment, indicators were evaluated using qualitative rankings for each policy scenario. For the equity assessment, t a separate evaluation matrix was developed for each policy scenario and rankings were assigned separately for each community of concern. This allowed for a clear comparison of scenario outcomes among various communities of concern, disaggregating potential benefits and potential costs under each.

Similar to the co-benefits assessment, a **matrix template** was used to qualitatively evaluate indicators within each indicator category. Due to the lack of established quantitative tools and methods for many of these indicators, each indicator is ranked qualitatively using a defined scale of 1 to 5 shown in Table 24 below.

Table 24: Equity Assessment Ranking Scale

1	**Negative**	The policy will have a *significant negative effect* on associated indicator within that community.
2	**Slightly Negative**	The policy will have a *modest negative effect* on associated indicator within that community.
3	**Neutral**	The policy will not have a *net neutral effect* for associated indicator within that community.
4	**Slightly Positive**	The policy will have a *modest positive effect* on associated indicator within that community.
5	**Positive**	The policy will have a *significant positive effect* on associated indicator within that community.

In addition to this qualitative ranking, a brief narrative is included on rationale for each indicator-scenario combination. In addition to considerations of how co-benefits are distributed across groups, there may be additional considerations of how co-benefits are distributed within a group (e.g., geographic variability, nearby vs. downstream communities). These considerations are documented with additional evidence, as available, from the economic and health analysis, other similar policy assessments, academic literature, or local and lived experiences.

9.4.3 Findings Overview

Findings from the equity assessment are summarized in Table 25.

Table 25: Equity Assessment Results

		Reference Case (Total = 50.5)					Scenario 1 (Total = 79.5)				
Indicator Category	**Indicator**	**CoC**	**Tribes**	**Urban low-income**	**Rural low-income**	**Elderly**	**CoC**	**Tribes**	**Urban low-income**	**Rural low-income**	**Elderly**
Health	Air quality	2	2.5	2	2.5	2	4	4	4	4	3.5
Environmental	Ecosystem health & resilience	2	2	2	2	2	4	4	4.5	4	4
Economic	Energy security	2	1.5	2	1.5	1.5	2.5	2	2.5	2	2.5
	Employment & workforce development	2	2	2	2	1	3.5	3.5	4	4	1
Social	Housing burden	2.5	2.5	2	2.5	2.5	2.5	2.5	2	2.5	2.5
	Total Score	**10.5**	**10.5**	**10**	**10.5**	**9**	**16.5**	**16**	**17**	**16.5**	**13.5**

		Scenario 2 (Total = 72)					Scenario 3 (Total = 70)				
Indicator Category	**Indicator**	**CoC**	**Tribes**	**Urban low-income**	**Rural low-income**	**Elderly**	**CoC**	**Tribes**	**Urban low-income**	**Rural low-income**	**Elderly**
Health	Air quality	4	3.5	4	3.5	3.5	3.5	3	3.5	3	3
Environmental	Ecosystem health & resilience	4.5	3.5	4.5	3.5	3.5	3.5	3	3.5	3	3
Economic	Energy security	2	1.5	2	1.5	2	3	2.5	3	2.5	3
	Employment & workforce development	3	3	3.5	3.5	1	2.5	2.5	3	3	1
Social	Housing burden	2	2.5	1.5	2.5	2.5	2.5	2.5	2	2.5	2.5
Total Score		**15.5**	**14**	**15.5**	**14.5**	**12.5**	**15**	**13.5**	**15**	**14**	**12.5**

		Scenario 4 (Total =79)				
Indicator Category	**Indicator**	**CoC**	**Tribes**	**Urban low-income**	**Rural low-income**	**Elderly**
Health	Air quality	4.5	4	4.5	4	3.5
Environmental	Ecosystem health & resilience	4.5	4	4.5	4	4
Economic	Energy security	2.5	2	2.5	2	2.5
	Employment & workforce development	3	3	3.5	3.5	1
Social	Housing burden	2.5	2.5	2	2.5	2.5
Total Score		**17**	**15.5**	**17**	**16**	**13.5**

9.4.4 Scenario Findings Summaries

9.4.4.1 Reference Case

A summary of results for the Reference Case are shown in Table 26.

Table 26: Reference Case Results

Indicator Category	Indicator	CoC	Tribes	Urban Low-income	Rural low-income	Elderly
Health	Air quality	2	2.5	2	2.5	2
Environmental	Ecosystem health & resilience	2	2	2	2	2
Economic	Energy security	2	1.5	2	1.5	1.5
	Employment and workforce development	2	2	2	2	1
Social	Housing burden	2.5	2.5	2	2.5	2.5
	Total Score	**10.5**	**10.5**	**10**	**10.5**	**9**

9.4.4.1.1 Health Indicator: Local Air Quality

- For all communities, acute degradation of air quality from wildfire events will continue to worsen in the future, suggesting that all groups will continue to experience **moderate negative impacts** during summer and fall months, when wildfires are more likely.[136] Elderly populations are **more biologically sensitive to a decline in air quality from wildfires**. Elderly and other sensitive populations with respiratory conditions, such as asthma and chronic obstructive pulmonary diseases, face intensification of respiratory illnesses from air pollution and poor air quality because of increasing wildfire instances.[137]
- Similarly, most high-emitting facilities are located in census tracts identified as vulnerable to climate change, which are primarily urban areas with higher percentages of communities of color and low-income.[138] These industries are expected to increase their process emissions in the Reference Case, which could potentially negatively impact air quality around these communities.
- Communities of color and low-income people in urban areas are concentrated in areas with higher traffic-related pollution, such as busy roads and highways.[139] Criteria air pollutants will decrease from light duty vehicles, but overall increase from medium and heavy diesel vehicles until around 2040. This expectation results from a projected decreased use of gasoline and diesel fuels for light-duty vehicles, and increased use of these fuels for medium- and heavy-duty vehicles in the Reference Case. Thus, in the Reference Case, **communities of color** and **urban low-income** households continue to experience higher rates of exposure to vehicle air pollution. A major cross-state highway (Route 26) also runs across the **Confederated Tribes of the Warms Springs**, and they will experience similar impacts from vehicle air pollution.

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[136] Oregon Health Authority. 2020. Climate Change and Public Health in Oregon. https://www.oregon.gov/oha/ph/about/pages/healthstatusindicators.aspx.

[137] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[138] Zapata, M.A., J.H. Liu, and M. Harris. 2017. Findings Brief for Equity Considerations for Greenhouse Gas Emissions Cap and Trade Legislation in Oregon. https://www.oregonlegislature.gov/helm/workgroup_materials/WG%204%20-%20Marisa%20A.%20Zapata%20Findings%20Brief.pdf.

[139] Oregon Health Authority. 2018. Climate and Health in Oregon. https://www.oregon.gov/oha/ph/about/pages/healthstatusindicators.aspx.

- Communities of color and low-income communities will continue to experience **higher rates of air pollution due to transportation fossil fuel combustion and potential industrial process based air pollution**.

9.4.4.1.2 Environmental Indicator: Ecosystem Health & Resilience

- For all communities, ecosystem health and resilience will remain relatively equal compared to present day. **Ozone and nitrogen oxide emissions** from transportation will be reduced due to greenhouse gas reductions from electrification, CAFE standards, and the Clean Fuels Program.
- The **transport of fossil fuels** such as crude oil is anticipated to decrease due to vehicle electrification and a reduced demand for oil. This will reduce associated risks to water resources and ecosystem health.
- **Industrial emissions are anticipated to increase**, and these facilities are disproportionately located in areas with communities of color and urban low-income households. The impact of industrial pollution on tree growth, tree succession, species composition, pest interactions, and water quality will negatively impact these communities in the future.[140]

9.4.4.1.3 Economic Indicator: Energy Security

- In the Reference Case, electric energy is projected to be more reliant on increased renewable energy sources. Energy demand is likely to increase in summer months, especially in densely populated areas, which increases the risk for **mismatches in power demand with power supply and overall, suggesting that there may be less energy resiliency for urban low-income households and communities of color**.[141] This might also have adverse health impacts for elderly people, who are more reliant on consistent energy supply for health needs (e.g., power supply for ventilators, mobility needs).[142]
- Communities of color across urban to rural areas are **currently energy burdened**.[143] **Rural low-income households (including rural communities of color) and tribal communities** may also experience additional energy burden because of lower average median incomes and older housing units that can drive up energy costs.[144]

9.4.4.1.4 Economic Indicator: Employment and Workforce Development

- Across Washington and Oregon, approximately 10% of the solar energy workforce is comprised of people of color. There is an underrepresentation of people of color in the Oregon and Washington solar workforce relative to each state's racial demographics (Washington is comprised of 23% people of color and Oregon is comprised of 25% people of color) and to national percentages of people of color in the solar workforce (approximately 26% of the national solar workforce is people of color).[145]
- The **energy industry is a racially diverse field**, with about 20% to 30% of the energy workforce identifying as people of color.[146] Despite Oregon's solar workforce being predominantly White and not reflective of racial diversity in the energy sector at a national scale, it's assumed that Oregon's energy sector is as racially diverse as national rates. Based on that assumption, any loss in jobs will disproportionately affect communities of color.

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[140] U.S. Forest Service Pacific Northwest Research Station. 2018. Ecosystem Indicators. https://www.fs.usda.gov/pnw/projects/ecosystem-indicators.

[141] Rempel, A. and M. Babbar-Sebens. 2021. Built Environment. In: *Fifth Oregon Climate Assessment*. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka.

[142] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[143] Buylova, A. 2018. Energy Use Intensity in Residential Housing in Oregon. https://osugisci.maps.arcgis.com/apps/webappviewer/index.html?id=189e21ea4f694168ad519a18ef99ef60.

[144] Oregon Department of Energy. 2018. Ten-Year Plan: Reducing the Energy Burden in Oregon Affordable Housing. https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Ten-Year-Plan-Energy-Burden.pdf.

[145] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[146] U.S. Energy and Employment Report. 2021. 2020 U.S. Energy and Employment Report. https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/5ee78423c6fcc20e01b83896/1592230956175/USEER+2020+0615.pdf.

- However, **recruitment and retention strategies** could help ensure that future jobs will benefit communities of color and tribal communities.[147]
- Furthermore, specific energy sector professions—such as production helpers, construction laborers, insulation workers, roustabouts, and assemblers and fabricators—**earn wages below the national medians**.[148] Any impact to these types of jobs will affect low-income individuals in urban and rural locations.
- While no data is available on elderly laborers in the energy sector, **any loss of jobs for elderly laborers will likely be negative** because of the lack of additional workforce development and educational opportunities.

9.4.4.1.5 Social Indicator: Housing Burden

- For communities of color and rural low-income communities, the analysis anticipates a **slight increase in housing burden** from increased utility and transportation costs. In 2019, a gallon of gasoline increased by 2.57 cents and a gallon of diesel increase by 2.94 cents.[149] Additionally, increased utility costs and expenses are partially passed onto end users, though existing programs can help offset these costs for low-income households.[150]
- Approximately 38% of American Indian and Alaskan Native households are cost burdened across the U.S. Cost burdens are generally higher in places where economies are strong and housing costs are high like the Pacific Northwest. The Reference Case would slightly **increase burden due to increased utility and transportation costs**.[151]
- Low-income households in urban areas are known to be higher in density and more cost burdened. Increased utility and transportation costs would have a negative impact on urban low-income households. **This may push urban low-income households to rural areas**, resulting in increasing transportation costs and financial burden.
- The Reference Case could slightly worsen housing burden by increasing utility costs. Transportation costs would likely remain the same as **elderly persons are mostly living in suburban areas and will likely not need to travel for work**.[152]

9.4.4.2 Policy Scenario 1

A summary of results for Policy Scenario 1 are shown in Table 27.

Table 27: Policy Scenario 1 Results

Indicator Category	Indicator	CoC	Tribes	Urban Low-income	Rural low-income	Elderly
Health	Air quality	4	4	4	4	3.5
Environmental	Ecosystem health & resilience	4	4	4.5	4	4
Economic	Energy security	2.5	2	2.5	2	2.5

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[147] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[148] National Association of State Energy Officials, Energy Futures Initiative, and BW Research Partnership. 2021. Wages, Benefits, and Change: A Supplemental Report to the Annual U.S. Energy and Employment Report. https://static1.squarespace.com/static/5a98cf80ec4eb7c5cd928c61/t/606b8771c7ee880d3110085f/1617659768456/The+Wage+Report.pdf.

[149] Danko, P. 2020. Oregon Clean Fuels Program costs inch up, but greenhouse gas reductions rise too. https://www.cleanfuelsny.org/news/oregon-clean-fuels-program-costs-inch-up-but-greenhouse-gas-reductions-rise-too#:~:text=As%20expected%2C%20Oregon's%20Clean%20Fuels,price%20of%20gasoline%20and%20diesel.&text=It%20said%20that%20in%202019,to%20the%20price%20of%20diesel.

[150] Energy Trust of Oregon. 2020. 2019 Annual Report to the Oregon Public Utility Commission & Energy Trust Board of Directors. https://www.energytrust.org/wp-content/uploads/2020/04/2019.Energy-Trust-Annual-Report.pdf.

[151] U.S. Department of Housing and Urban Development. 2017. Housing Needs of American Indians and Alaska Native Natives in Tribal Areas: A Report from the Assessment of American Indian, Alaska Native, and Native Hawaiian Housing Needs. https://www.huduser.gov/portal/sites/default/files/pdf/HNAIHousingNeeds.pdf.

[152] Jessie F. Richardson Foundation. 2018. Housing Challenges for Older Oregonians. https://jfrfoundation.org/wp-content/uploads/2018/11/Older-Oregonians-and-the-Housing-Crisis.pdf.

	Employment & workforce development	3.5	3.5	4	4	1
Social	Housing burden	2.5	2.5	2	2.5	2.5
Total Score		**16.5**	**16**	**17**	**16.5**	**13.5**

9.4.4.2.1 Health Indicator: Local Air Quality

- This assessment assumed that the **CCIs will accelerate air filtration and ventilation upgrades** and will be heavily targeted in areas with high concentrations of greenhouse gas and criteria air pollutant emissions, which will provide greater benefits to communities of color and low-income communities. However, because CCIs can be used toward compliance with the proposed program and represent emissions beyond those demonstrated with compliance instruments from the cap, these alternative compliance options could allow continued air pollution from regulated entities in areas with a higher proportion of low-income households and communities of color.[153]
- Communities of color, rural low-income households, and urban low-income households, who are often located in areas with higher traffic, will **experience less exposure to criteria air pollutants** from medium- and heavy-duty vehicles as these vehicle fuels switch to biodiesel fuels or electric power.[154]
- The use of CCIs for additional **transit and freight fleet electrification** could lead to increased benefits for communities of color, rural low-income households, and urban low-income households. Freight electrification will also benefit elderly people and tribes living in rural areas with highway traffic.

9.4.4.2.2 Environmental Indicator: Ecosystem Health & Resilience

- Ozone formation and nitrogen oxide emissions will be reduced with the regulation of fuel suppliers and an expansion of the Clean Fuels Program, which will reduce vegetation impacts from ozone and acidification of rain from nitrogen oxides particularly in **communities that are located close to highways**.
- Regulating emissions from industry will reduce nitrogen oxides and VOCs released, as compared to the Reference Case. This will increase ecosystem health and biodiversity surrounding industrial facilities, which are predominantly located by communities of color and urban-low-income communities.

9.4.4.2.3 Economic Indicator: Energy Security

- Across all policy scenarios, electricity energy will be more reliant on increased renewable energy sources such as solar power. Energy demand is likely to increase in summer months, especially in densely populated areas, which increases the risk for **mismatches in power demand with power supply and overall, suggesting that there may be less energy resiliency for urban low-income households and communities of color**.[155] This might also have adverse health impacts for elderly people, who are more reliant on consistent energy supply for health needs (e.g., power supply for ventilators, mobility needs).[156]
- Communities of color across urban to rural areas are **currently energy burdened**.[157] However, energy burden is felt most intensely in rural counties (e.g., Malheur, Lake, Wheeler, Harney, and Crook County), where some households

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[153] Cushing, L.J., M. Wander, R. Morello-Frosch, M. Pastor, A. Zhu, and J. Sadd. 2016. A preliminary environmental equity assessment of California's cap-and-trade program. https://dornsife.usc.edu/assets/sites/242/docs/Climate_Equity_Brief_CA_Cap_and_Trade_Sept2016_FINAL2.pdf.

[154] Durbin, T.D., G. Karavalakis, K.C. Johnson, M. Hajbabaei. 2013. CARB B20 Biodiesel Preliminary and Certification Testing. https://ww3.arb.ca.gov/fuels/diesel/altdiesel/20140630carb_b20_%20additive_study.pdf?_ga=2.262343882.718366847.1618167878-1230261469.1618167878.

[155] Rempel, A. and M. Babbar-Sebens. 2021. Built Environment. In: *Fifth Oregon Climate Assessment*. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka.

[156] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[157] Buylova, A. 2018. Energy Use Intensity in Residential Housing in Oregon. https://osugisci.maps.arcgis.com/apps/webappviewer/index.html?id=189e21ea4f694168ad519a18ef99ef60.

pay up to 38% of their income for energy.[158] This is inclusive of **rural low-income households (including rural communities of color) and tribal communities.** Older housing units, which are more common in rural areas, can exacerbate energy burden.[159]

- In this scenario, **energy burden will likely increase in the near-term for all communities of concern**, with tribal communities and rural low-income households being the most impacted. However, trading and CCIs can help alleviate this near-term energy burden for all groups. CCIs can also help increase energy reliability by installing energy efficient upgrades that will mitigate energy demand during peak hours.
- While there could be long-term energy cost savings, any increase in energy burden and costs will disproportionately impact communities of color, tribal communities, and low-income households. These near-term negative impacts may be weighed more than any long-term benefits.

9.4.4.2.4 Economic Indicator: Employment and Workforce Development

- This modeling analysis indicates that there are modest net job losses in 2025 for Policy Scenario 1. Any near-term job losses will affect low-income individuals the most, especially from low wage professions such as energy production helpers, construction laborers, insulation workers, roustabouts, and assemblers and fabricators. **Some of these professions have more workers of color than other sectors**—for example, Latino or Latinx workers have greater representation in roles such as assemblers or installation. [160]
- However, there will be **overall positive net job impacts**—or the net impacts when accounting for gross economic benefits with other investments and opportunity costs—for all scenarios. In particular, there will be positive direct and induced net job impacts—or income impacts such as wages or spending power from laborers—for all policy scenarios. Policy Scenarios 1 and 4 have the most net job benefits by 2050. Policy Scenario 1 also has net job benefits in 2035, whereas Policy Scenarios 2 and 3 have small net job losses in 2035.
- In Oregon, the energy workforce is generally less racially diverse than the national averages. To better serve communities of color and tribal communities, intentional recruitment and retention strategies are needed to ensure a racially diverse energy sector in the future, though for this assessment these type of strategies are assumed to be outside the scope of CCIs.
- While no data are available on elderly laborers in the energy sector, **any loss of jobs for elderly laborers will be negative** because of the lack of additional workforce development and educational opportunities.[161]

9.4.4.2.5 Social Indicator: Housing Burden

- Increased utility and transportation costs associated with this scenario will **increase additional housing-related costs** for communities of color, Tribes, urban low-income, and rural low-income households.
- CCIs purchased and banked in early years **may help communities of concern with the upfront costs of electrification** until the later years when energy costs decline overtime.
- Although there are also federal housing assistance programs for Tribes, there is limited funding to alleviate existing burden. Thus, **additional housing burden may lead to overcrowding** (having more than one person per room) to alleviate additional strain from housing burden.[162]

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[158] Fisher, Sheehan & Colton. 2021. Oregon: County Only Home Energy Affordability Gap. http://homeenergyaffordabilitygap.com/02a_research.html.

[159] Oregon Department of Energy. 2018. Ten-Year Plan: Reducing the Energy Burden in Oregon Affordable Housing. https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Ten-Year-Plan-Energy-Burden.pdf.

[160] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[161] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[162] U.S. Department of Housing and Urban Development. 2017. Housing Needs of American Indians and Alaska Native Natives in Tribal Areas: A Report from the Assessment of American Indian, Alaska Native, and Native Hawaiian Housing Needs. https://www.huduser.gov/portal/sites/default/files/pdf/HNAIHousingNeeds.pdf.

- Housing burdened urban low-income households could be driven from their homes due to **green gentrification**, or out-of-area persons moving in as neighborhood conditions improve from emissions reduction policies.[163]
- Low-income households on average occupy multifamily dwellings in dense populations.[164] Therefore, in rural low-income communities, **the transition to electric in single family homes would be more gradual**. CCIs in early years to support needed infrastructure updates can expedite this process.
- The elderly population would be **moderately impacted by additional utility costs**. Transportation costs may remain the same since it's assumed the elderly population does not need to commute for work. CCIs could similarly help this community of concern.

9.4.4.3 Policy Scenario 2

A summary of results for Policy Scenario 2 are shown in Table 28.

Table 28: Policy Scenario 2 Results

Indicator Category	Indicator	CoC	Tribes	Urban Low-income	Rural low-income	Elderly
Health	Air quality	4	3.5	4	3.5	3.5
Environmental	Ecosystem health & resilience	4.5	3.5	4.5	3.5	3.5
Economic	Energy security	2	1.5	2	1.5	2
	Employment & workforce development	3	3	3.5	3.5	1
Social	Housing burden	2	2.5	1.5	2.5	2.5
	Total Score	**15.5**	**14**	**15.5**	**14.5**	**12.5**

9.4.4.3.1 Health Indicator: Local Air Quality

- Communities of color, rural low-income households, and urban low-income households will **continue to experience consistent air quality benefits** from the reduction of criteria air pollutants from the transition away from fossil fuels, including a reduction in transportation fossil fuel consumption and fuel carbon intensity. However, this policy scenario substantially lowers the number of CCIs allowed to offset compliance obligation—resulting in about an 80% reduction in cumulative funds going towards CCIs by 2050 compared to Policy Scenario 1. This limitation could limit air quality benefits from **transit and freight electrification and home ventilation and filtration upgrades associated with CCIs.**
- This policy scenario regulates process emissions from stationary sources more stringently, which is expected to result in more criteria pollutant emissions reductions. Lower criteria air pollutant emissions will have a beneficial effect on nearby, vulnerable communities. Because a majority of Oregon's large stationary sources coincide with communities particularly vulnerable to climate change—which include communities of color and low-income households—a more stringent regulation of process emissions from stationary sources could lead to **health benefits for these communities**.

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[163] Jelks, N., Jennings, V., and Rigolon, A. 2021. Green Gentrification and Health: A Scoping Review. https://doi.org/10.3390/ijerph18030907

[164] Oregon Office of Forecasting, Research and Analysis. 2014. Areas of High Poverty Density. https://www.oregon.gov/osp/Docs/Area%20of%20High%20Poverty%20Density.pdf.

9.4.4.3.2 Environmental Indicator: Ecosystem Health & Resilience

- Ozone formation and nitrogen oxide emissions will be reduced with the regulation of fuel suppliers and an expansion of the Clean Fuels Program which will reduce vegetation impacts from ozone and acidification of rain from nitrogen oxides, particularly in communities that are **located close to highways**.
- This policy scenario **regulates an additional pulp and paper mill and regulates point sources more stringently**. With a lower allowable use of CCIs, large stationary point sources are required to make larger reductions in their greenhouse gas and co-pollutants. **Pulp and paper mills are the top stationary source of NO_x**—making up about 23% of Oregon's total NO_x emissions and releasing 3.5 million tons of NO_x annually.[165] This is followed by cement manufacturing which release 2.5 million tons of NO_x annually. NO_x emissions can react with rain to increase the acidification of soils and surface water as well as increase the risk of eutrophication of marine areas and groundwater quality. These industries are also major sources of VOCs which react with sunlight and warmth to create ozone which **damages plants and reduces plant biodiversity**.
- **Pulp and paper mills are also the second highest source of lead emissions** which have been shown to inhibit endocrine, immune, and reproductive systems in mammals—releasing about 0.592 tons of lead annually.[166] This policy scenario may result in **localized ecosystem health benefits such as improved vegetation, soil, and mammal health**, as well as improved biodiversity in areas surrounding stationary sources—particularly for the critical, coastal ecosystem surrounding the additional pulp and paper mill in unincorporated Wauna, Oregon.

9.4.4.3.3 Economic Indicator: Energy Security

- Across all policy scenarios, renewable energy sources such as solar power will be a more predominant part of the energy mix. Energy demand is likely to increase in summer months, especially in densely populated areas, which will increase the risk for **mismatches in power demand with power supply and overall, suggesting that there may be less energy resiliency for urban low-income households and communities of color**.[167] This might also have adverse health impacts for elderly people, who are more reliant on consistent energy supply for health needs (e.g., power supply for ventilators, mobility needs).[168]
- Communities of color across urban to rural areas are **currently energy burdened**.[169] However, energy burden is felt most intensely in rural counties (e.g., Malheur, Lake, Wheeler, Harney, and Crook County), where some households pay up to 38% of their income for energy.[170] This is inclusive of **rural low-income households (including rural communities of color) and tribal communities.** Older housing units, which are more common in rural areas, can exacerbate energy burden.[171]
- In this scenario, **energy burden will likely increase in the near-term for all communities of concern**, with tribal communities and rural low-income households being the most impacted. While there will be long-term energy cost savings, any increase in energy burden and costs will disproportionately impact communities of color, tribal communities, and low-income households. **These near-term negative impacts may be weighed more than long-term benefits.**

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[165] Environmental Protection Agency. 2017. 2017 Oregon National Emissions Inventory Report. https://gispub.epa.gov/neireport/2017/

[166] Lorenz, M. et. al. 2010. Air Pollution Impacts on Forests in a Changing Climate. U.S. Forest Service. https://www.fs.fed.us/psw/publications/bytnerowicz/psw_2010_bytnerowicz(lorenz)002.pdf

[167] Rempel, A. and M. Babbar-Sebens. 2021. Built Environment. In: *Fifth Oregon Climate Assessment*. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka.

[168] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[169] Buylova, A. 2018. Energy Use Intensity in Residential Housing in Oregon. https://osugisci.maps.arcgis.com/apps/webappviewer/index.html?id=189e21ea4f694168ad519a18ef99ef60.

[170] Fisher, Sheehan & Colton. 2021. Oregon: County Only Home Energy Affordability Gap. http://homeenergyaffordabilitygap.com/02a_research.html.

[171] Oregon Department of Energy. 2018. Ten-Year Plan: Reducing the Energy Burden in Oregon Affordable Housing. https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Ten-Year-Plan-Energy-Burden.pdf.

- Furthermore, since this policy scenario does not allow trading for stationary sources and has less allowable use of CCIs than the other scenarios, **there will be fewer opportunities to utilize CCIs to reduce energy burden for all communities of concern**.

9.4.4.3.4 **Economic Indicator: Employment and Workforce Development**

- Though there are little relative differences, policy Scenario 2 results in more near-term job losses by 2025 compared with Policy Scenario 1. **Some of these professions have more workers of color than other sectors**. For example, Latino or Latinx workers have greater representation in roles such as assemblers or installation, and thus might have the most to gain from these gross benefits. [172]
- However, the analysis found **overall positive net job impacts**, or the net impacts when accounting gross economic benefits with other investments and opportunity costs for all scenarios. In particular, the analysis found positive direct and induced net job impacts, or income impacts such as wages or spending power from laborers for all scenarios. Results show that Policy Scenario 2 has net job benefits by 2050. However, unlike Policy Scenario 1, it still has small net job losses by 2035.
- In Oregon, the energy workforce is generally less racially diverse than the national averages. To better serve communities of color and tribal communities, intentional recruitment and retention strategies are needed to ensure a racially diverse energy sector in the future. The analysis found that **Policy Scenario 3 has the greatest potential to add additional jobs, therefore strategies to increase racial diversity in the workforce could have added benefits for communities of color**.
- While no data is available on elderly laborers in the energy sector, **any loss of jobs for elderly laborers is found to be negative in this scenario** because of the lack of additional workforce development and educational opportunities.[173]

9.4.4.3.5 **Social Indicator: Housing Burden**

- Increased **utility costs** are seen under this scenario, with a **slight increase in transportation costs** in early years due to electrification. This leads to increased additional housing-related costs for communities of color, Tribes, urban low-income, and rural low-income households.
- Because **trading** is not permitted for stationary sources, more of the cost burden for utility providers would be transferred to consumers, which impacts all communities of concern. Allowing CCIs could help alleviate additional costs.
- Housing burdened urban low-income households could be driven from their homes due to **green gentrification**, or out-of-state persons moving in as neighborhood conditions improve from emissions reduction policies.
- The increase in housing burden **may push burdened or severely burdened urban low-income households to rural areas**, resulting in increasing transportation costs and financial burden for these displace households.
- Low-income rural households **may experience additional burden from urban households moving to exurban or rural communities**, thereby decreasing available housing stock and driving housing prices up.
- Transportation costs for the **elderly** community would likely remain the same as elderly persons are mostly living in suburban areas versus rural and will likely not need to travel for work.[174]

9.4.4.4 **Policy Scenario 3**

A summary of results for Policy Scenario 3 are shown in Table 29.

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[172] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[173] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[174] Jessie F. Richardson Foundation. 2018. Housing Challenges for Older Oregonians. https://jfrfoundation.org/wp-content/uploads/2018/11/Older-Oregonians-and-the-Housing-Crisis.pdf.

Table 29: Policy Scenario 3 Results

Indicator Category	Indicator	CoC	Tribes	Urban Low-income	Rural low-income	Elderly
Health	Air quality	3.5	3	3.5	3	3
Environmental	Ecosystem health & resilience	3.5	3	3.5	3	3
Economic	Energy security	3	2.5	3	2.5	3
	Employment & workforce development	2.5	2.5	3	3	1
Social	Housing burden	2.5	2.5	2	2.5	2.5
	Total Score	**15**	**13.5**	**15**	**14**	**12.5**

9.4.4.4.1 Health Indicator: Local Air Quality

- Communities of color and urban low-income households will **continue to experience air quality benefits** from the transition away from fossil-fuel based vehicles and transportation fuels. Additionally, if CCIs fund **transit and freight fleet electrification**, it will lead to increased benefits for communities of color and low-income households. Rural, tribal, and elderly communities will experience an improvement in air quality due to the Clean Fuels Program and the vehicle electrification goals of the state.
- This policy scenario would only regulate **larger fuel suppliers**. Unregulated emissions from propane, diesel, and gasoline from excluded fuel suppliers and used in nonroad and other equipment and vehicles would continue to exacerbate local respiratory health impacts in rural or developing areas with more agricultural and construction activities. Benefits of transportation fuel regulations may still apply to **urban-low-income** communities where large fuel suppliers are likely to be concentrated, but this will result in reduced air quality benefits in rural and elderly communities. Furthermore, this fuel supplier exclusion could reduce CCIs for electrifying heavy-duty vehicles and freight.
- Because **CCIs** can be used toward compliance with the proposed program and represent emissions beyond those demonstrated with compliance instruments from the cap, these alternative compliance options can allow some regulated entities to continue to emit in areas with a higher proportion of low-income households and communities of color.

9.4.4.4.2 Environmental Indicator: Ecosystem Health & Resilience

- Ozone formation and nitrogen oxide emissions will be reduced with the regulation of fuel suppliers and an expansion of the Clean Fuels Program, which will reduce vegetation impacts from ozone and acidification of rain from nitrogen oxides particularly in **communities that are located close to highways**. However, this policy scenario regulates a smaller scope of liquid fuels and propane compared to the other scenarios, and combustion of these fuels is a major source of VOC emissions. Thus, the benefits of improved ecosystem health and biodiversity will not be as strong for areas, potentially especially surrounding small- and medium-sized gas stations.
- Industry emissions wouldbe regulated more stringently, which could reduce nitrogen oxides and VOCs. This will **increase ecosystem health and biodiversity surrounding industrial facilities**, which are predominantly located by communities of color and urban-low-income communities.

9.4.4.4.3 Economic Indicator: Energy Security

- Across all policy scenarios, renewable energy sources such as solar power will be a more predominant part of the energy mix. Energy demand is likely to increase in summer months, especially in densely populated areas, which will increase the risk for **mismatches in power demand with power supply and overall, suggesting that there may be**

less energy resiliency for urban low-income households and communities of color.[175] This might also have adverse health impacts for elderly people, who are more reliant on consistent energy supply for health needs (e.g., power supply for ventilators, mobility needs).[176]

- Communities of color across urban to rural areas are **currently energy burdened**.[177] However, energy burden is felt most intensely in rural counties (e.g., Malheur, Lake, Wheeler, Harney, and Crook County), where some households pay up to 38% of their income for energy.[178] This is inclusive of **rural low-income households (including rural communities of color) and tribal communities.** Older housing units, which are more common in rural areas, can exacerbate energy burden.[179]
- In this scenario, **energy burden will likely increase in the near-term for all communities of concern**, with tribal communities and rural low-income households being the most impacted. However, trading and CCIs can help alleviate this near-term energy burden for all groups. CCIs can also help increase energy reliability by installing energy efficient upgrades that will mitigate energy demand during peak hours.
- In the long-term, this policy scenario may **have the greatest potential for long-term energy cost savings for all communities of concern** because of increased transition to lower-cost renewable energy sources (i.e., higher cumulative greenhouse gas emission reductions).

9.4.4.4.4 Economic Indicator: Employment and Workforce Development

- Though relative differences are small, Policy Scenario 3 predicts slightly more net jobs losses by 2025 relative to Policy Scenario 1. **Some of these professions have more workers of color than other sectors**—for example, Latino or Latinx workers have greater representation in roles such as assemblers or installation—and thus might have the most to gain from these gross benefits.[180]
- However, there will be **overall positive net job impacts**—or the net impacts when accounting gross economic benefits with other investments and opportunity costs—for all scenarios. In particular, there will be positive direct and induced net job impacts—or income impacts such as wages or spending power from laborers—for all scenarios. While Policy Scenario 3 has long-term benefits, it has the fewest net job benefits by 2050 across scenarios 1-3. Additionally, similar to Policy Scenario 2, it still has small net job losses by 2035.
- In Oregon, the energy workforce is generally less racially diverse than the national averages. To better serve communities of color and tribal communities, intentional recruitment and retention strategies are needed to ensure a racially diverse energy sector in the future, though for this assessment, these types of strategies are assumed to be outside the scope of CCIs.
- While no data is available on elderly laborers in the energy sector, **any loss of jobs for elderly laborers will be negative** because of the lack of workforce development and educational opportunities.[181]

9.4.4.4.5 Social Indicator: Housing Burden

- In general, more **stringent emissions reduction standards and interim targets** would adversely affect housing burden for all communities of concern.

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[175] Rempel, A. and M. Babbar-Sebens. 2021. Built Environment. In: *Fifth Oregon Climate Assessment*. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka.

[176] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[177] Buylova, A. 2018. Energy Use Intensity in Residential Housing in Oregon. https://osugisci.maps.arcgis.com/apps/webappviewer/index.html?id=189e21ea4f694168ad519a18ef99ef60.

[178] Fisher, Sheehan & Colton. 2021. Oregon: County Only Home Energy Affordability Gap. http://homeenergyaffordabilitygap.com/02a_research.html.

[179] Oregon Department of Energy. 2018. Ten-Year Plan: Reducing the Energy Burden in Oregon Affordable Housing. https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Ten-Year-Plan-Energy-Burden.pdf.

[180] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[181] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

- Increased **utility and transportation costs** associated with this scenario will increase additional housing-related costs for communities of color, Tribes, urban low-income, and rural low-income households.
- **Projects funded by CCIs** could help communities of concern with increased utility and transportation costs.
- Housing burdened urban low-income households could be driven from their homes due to **green gentrification**, or out-of-state persons moving in as neighborhood conditions improve from emissions reduction policies.
- Additional housing burden on **Tribes** may lead to other negative impacts such as overcrowding (having more than one person per room) to alleviate additional strain.[182]
- Transportation costs for the **elderly** community would likely remain the same as elderly persons are mostly living in suburban areas versus rural and will likely not need to travel for work.[183]

9.4.4.5 Policy Scenario 4

A summary of results for Policy Scenario 4 shown in Table 30.

Table 30: Policy Scenario 4 Results

Indicator Category	Indicator	CoC	Tribes	Urban Low-income	Rural low-income	Elderly
Health	Air quality	4.5	4	4.5	4	3.5
Environmental	Ecosystem health & resilience	4.5	4	4.5	4	4
Economic	Energy security	2.5	2	2.5	2	2.5
	Employment & workforce development	3	3	3.5	3.5	1
Social	Housing burden	2.5	2.5	2	2.5	2.5
	Total Score	**17**	**15.5**	**17**	**16**	**13.5**

9.4.4.5.1 Health Indicator: Local Air Quality

- Communities of color and urban low-income households will **continue to experience air quality benefits** from the transition away from fossil-fuel based vehicles and transportation fuels. Additionally, if CCIs fund **transit and freight fleet electrification**, it will lead to increased benefits for communities of color and low-income households. Rural, tribal, and elderly communities will experience an improvement in air quality due to the Clean Fuels Program and the vehicle electrification goals of the state.
- This policy scenario **excludes process emissions from large stationary sources** from the regulation, but they are still regulated by the Oregon DEQ. For the purposes of this analysis, it is **assumed that they are regulated to the same extent** as they would be under Policy Scenario 2. However, if this assumption does not hold true, rural low-income communities and some Tribes (such as the Confederated Tribes of Siletz Indians) could experience additional negative externalities from these stationary sources.
- The **extent in which emissions from stationary sources are regulated** would be expected to affect the air quality for low-income communities, tribes, and communities of color. This scenario excludes large stationary sources from being regulated under the emissions cap, and these are sources of emissions that are difficult to reduce. Therefore, the exclusion results in improved ability of regulated sectors (fuel suppliers) to stay under the cap. With the exclusion of stationary sources, the **transportation sector reduces its emissions and co-pollutants significantly** through electrification, biodiesel, and renewable diesel for medium- and heavy-duty trucks. This results in **improved air**

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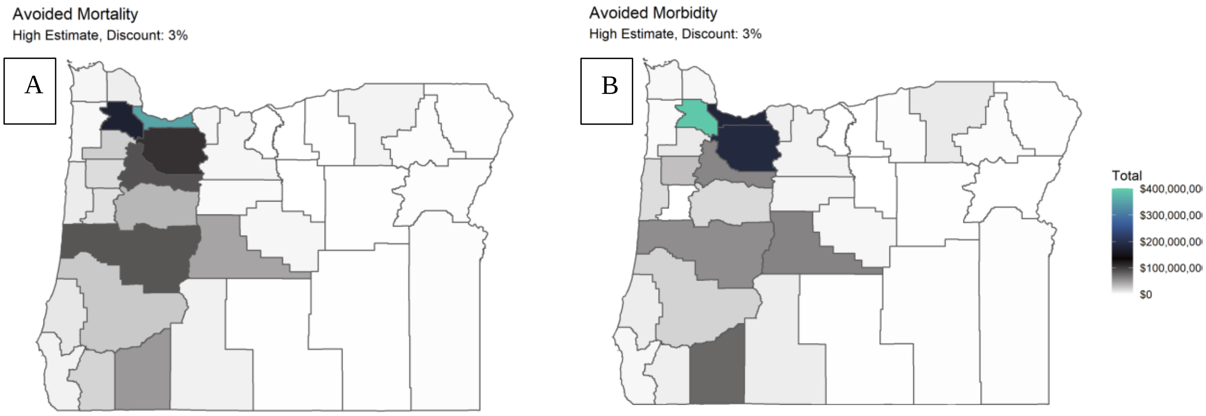
[182] U.S. Department of Housing and Urban Development. 2017. Housing Needs of American Indians and Alaska Native Natives in Tribal Areas: A Report from the Assessment of American Indian, Alaska Native, and Native Hawaiian Housing Needs. https://www.huduser.gov/portal/sites/default/files/pdf/HNAIHousingNeeds.pdf.

[183] Jessie F. Richardson Foundation. 2018. Housing Challenges for Older Oregonians. https://jfrfoundation.org/wp-content/uploads/2018/11/Older-Oregonians-and-the-Housing-Crisis.pdf.

quality for all vulnerable communities across the state and particularly for communities and low-income communities, which are **disproportionately located close to highways.**

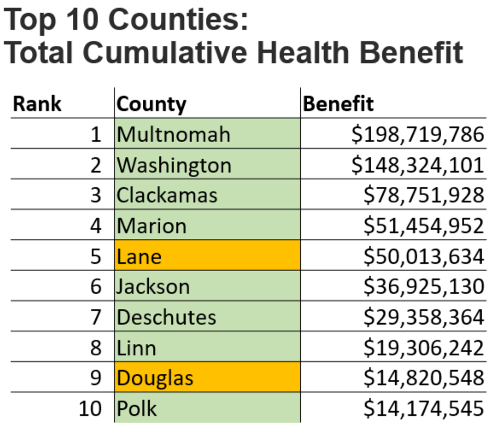
9.4.4.5.2 Health Benefits, by County

As discussed above in Section 6, ICF estimated health benefits at the county-level for Policy Scenario 4 in order to provide more granular information estimated health benefits (i.e., avoided morbidity and mortality costs).[184] Map A shows monetized mortality health benefits for Policy Scenario 4 by county. Map B shows the monetized morbidity health benefits for Policy Scenario 4 by county. Mortality and morbidity benefits are highest in densely populated urban areas where there are higher population counts. Multnomah and Washington county are two of the most populous counties in the state. Multnomah county has a cumulative net health benefit of $199-534 million (or $240-644 per capita) by 2050 and Washington county has a cumulative net health benefit of $148-567 million (or $239-914 per capita) by 2050. Note that these health benefits are compared to baseline conditions—counties may see little health benefit (i.e., avoided costs) because they are already bearing a small portion of the overall pollution burden.



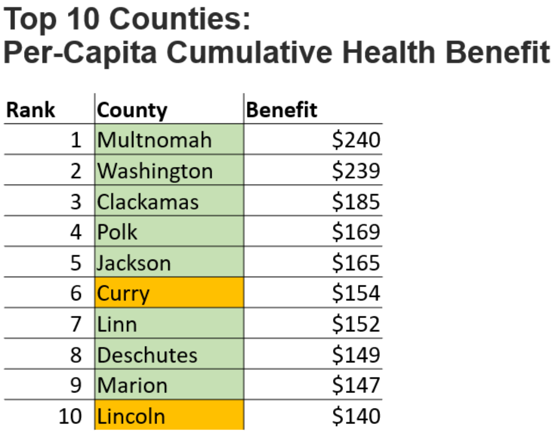
The tables below show the top 10 counties in terms of cumulative overall and per-capita health benefits. Many counties that are projected to receive higher overall health benefits are also projected to experience relatively higher health benefits on a per-capita basis. Curry and Lincoln counties are projected to experience relatively higher health benefits on a per-capita basis.

Green = in both lists | Orange = in only one list



Top 10 Counties:
Total Cumulative Health Benefit

Rank	County	Benefit
1	Multnomah	$198,719,786
2	Washington	$148,324,101
3	Clackamas	$78,751,928
4	Marion	$51,454,952
5	Lane	$50,013,634
6	Jackson	$36,925,130
7	Deschutes	$29,358,364
8	Linn	$19,306,242
9	Douglas	$14,820,548
10	Polk	$14,174,545



Top 10 Counties:
Per-Capita Cumulative Health Benefit

Rank	County	Benefit
1	Multnomah	$240
2	Washington	$239
3	Clackamas	$185
4	Polk	$169
5	Jackson	$165
6	Curry	$154
7	Linn	$152
8	Deschutes	$149
9	Marion	$147
10	Lincoln	$140

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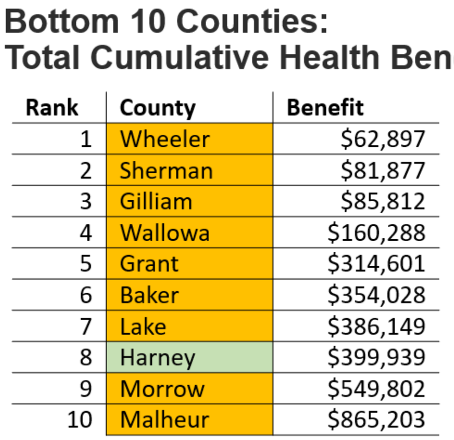
[184] Based on lower-end estimates at a 3% discount rate.

9.4.4.5.3 Health Benefits, by County (Cont'd)

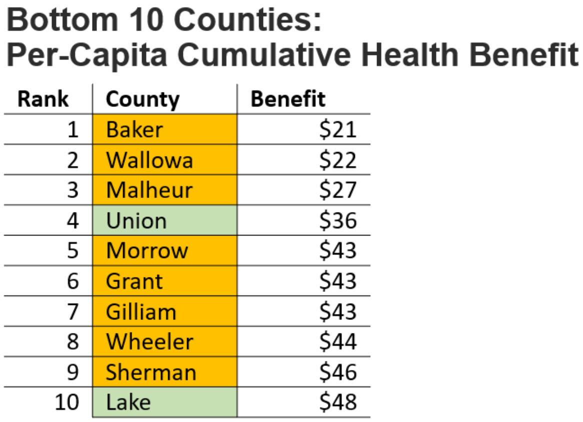
The tables below show the bottom 10 counties in terms of cumulative overall and per-capita health benefits. Many counties that are projected to receive lower overall health benefits are also projected to experience relatively lower health benefits on a per-capita basis. Union and Lake counties are projected to receive relatively lower health benefits on a per-capita basis.

Orange = in both lists | Green = in only one list



Bottom 10 Counties: Total Cumulative Health Benefit

Rank	County	Benefit
1	Wheeler	$62,897
2	Sherman	$81,877
3	Gilliam	$85,812
4	Wallowa	$160,288
5	Grant	$314,601
6	Baker	$354,028
7	Lake	$386,149
8	Harney	$399,939
9	Morrow	$549,802
10	Malheur	$865,203

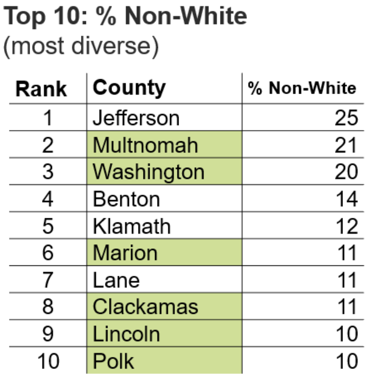


Bottom 10 Counties: Per-Capita Cumulative Health Benefit

Rank	County	Benefit
1	Baker	$21
2	Wallowa	$22
3	Malheur	$27
4	Union	$36
5	Morrow	$43
6	Grant	$43
7	Gilliam	$43
8	Wheeler	$44
9	Sherman	$46
10	Lake	$48

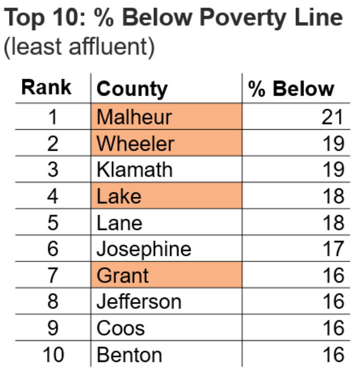
The tables below compare estimated county-level health benefits to county demographic characteristics. Communities of color projected to experience relatively more per-capita health benefits compared to other communities of concern. Orange highlighted counties have higher proportions of communities of concern (e.g., are lower income or more elderly) and are projected to receive among the lowest per-capita health benefits; these counties could benefit from CCIs.

Green = in top 10 per-capita health benefits | Orange = in bottom 10 per-capita health benefits



Top 10: % Non-White
(most diverse)

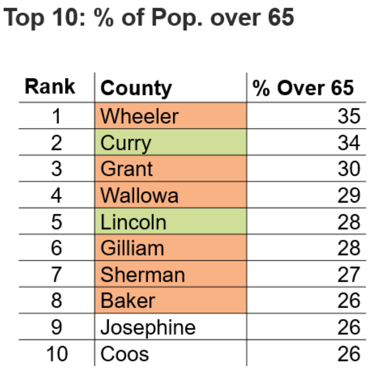
Rank	County	% Non-White
1	Jefferson	25
2	Multnomah	21
3	Washington	20
4	Benton	14
5	Klamath	12
6	Marion	11
7	Lane	11
8	Clackamas	11
9	Lincoln	10
10	Polk	10



Top 10: % Below Poverty Line
(least affluent)

Rank	County	% Below
1	Malheur	21
2	Wheeler	19
3	Klamath	19
4	Lake	18
5	Lane	18
6	Josephine	17
7	Grant	16
8	Jefferson	16
9	Coos	16
10	Benton	16

*As defined by U.S. Census Bureau



Top 10: % of Pop. over 65

Rank	County	% Over 65
1	Wheeler	35
2	Curry	34
3	Grant	30
4	Wallowa	29
5	Lincoln	28
6	Gilliam	28
7	Sherman	27
8	Baker	26
9	Josephine	26
10	Coos	26

9.4.4.5.4 Environmental Indicator: Ecosystem Health & Resilience

- Ozone formation and nitrogen oxide emissions will be reduced with the regulation of fuel suppliers and an expansion of the Clean Fuels Program which will reduce vegetation impacts from ozone and acidification of rain from nitrogen oxides, particularly in communities that are **located close to highways**.
- For the purposes of this analysis, it is assumed that the large stationary sources are regulated to the same extent as they would be under Policy Scenario 2 but outside of the emissions cap program.

- This policy scenario design could result in **localized ecosystem health benefits such as improved vegetation, soil, and mammal health**, as well as improved biodiversity in areas surrounding stationary sources, particularly for critical, coastal ecosystems.

9.4.4.5.5 Economic Indicator: Energy Security

- Across all policy scenarios, renewable energy sources such as solar power will be a more predominant part of the energy mix. Energy demand is likely to increase in summer months, especially in densely populated areas, which will increase the risk for **mismatches in power demand with power supply and overall, suggesting that there may be less energy resiliency for urban low-income households and communities of color**.[185] This might also have adverse health impacts for elderly people, who are more reliant on consistent energy supply for health needs (e.g., power supply for ventilators, mobility needs).[186]
- Communities of color across urban to rural areas are **currently energy burdened**.[187] However, energy burden is felt most intensely in rural counties (e.g., Malheur, Lake, Wheeler, Harney, and Crook County), where some households pay up to 38% of their income for energy.[188] This is inclusive of **rural low-income households (including rural communities of color) and tribal communities.** Older housing units, which are more common in rural areas, can exacerbate energy burden.[189]
- In this scenario, **energy burden will likely increase in the near-term for all communities of concern**, with tribal communities and rural low-income households being the most impacted. However, trading and CCIs can help alleviate this near-term energy burden for all groups. CCIs can also help increase energy reliability by installing energy efficient upgrades that will mitigate energy demand during peak hours.
- While there will be long-term energy cost savings, any increase in energy burden and costs will disproportionately impact communities of color, tribal communities, and low-income households. **These near-term negative impacts may be weighed more than long-term benefits.**

9.4.4.5.6 Economic Indicator: Employment and Workforce Development

- Though relative differences between scenarios are small, there will be more net job losses by 2025 as compared to Policy Scenario 1. Any near-term job losses will affect low-income individuals the most, especially from low wage professions such as energy production helpers, construction laborers, insulation workers, roustabouts, and assemblers and fabricators. **Some of these professions have more workers of color than other sectors**—for example, Latino or Latinx workers have greater representation in roles such as assemblers or installation. [190]
- However, there will be **overall positive net job impacts**, or the net impacts when accounting gross economic benefits with other investments and opportunity costs for all scenarios. In particular, there will be positive direct and induced net job impacts, or income impacts such as wages or spending power from laborers for all scenarios. Policy Scenarios 1 and 4 have the most net job benefits by 2050. Policy Scenario 4 also has a modest net job benefit by 2035, whereas Policy Scenarios 2 and 3 have small net job losses by 2035.
- In Oregon, the energy workforce is generally less racially diverse than the national averages. To better serve communities of color and tribal communities, intentional recruitment and retention strategies are needed to ensure a

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[185] Rempel, A. and M. Babbar-Sebens. 2021. Built Environment. In: *Fifth Oregon Climate Assessment*. https://oregonstate.app.box.com/s/7mynjzhda9vunbzqib6mn1dcpd6q5jka.

[186] Gamble, J.L., J. Balbus, M. Berger, K. Bouye, V. Campbell, K. Chief, K. Conlon, A. Crimmins, B. Flanagan, C. Gonzalez-Maddux, E. Hallisey, S. Hutchins, L. Jantarasami, S. Khoury, M. Kiefer, J. Krolling, K. Lynn, A. Manangan, M. McDonald, R. Morello-Frosch, M.H. Redsteer, P. Sheffield, K. Thigpen Tart, J. Watson, K.P. Whyte, and A.F. Wolkin. 2016. Populations of Concern. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*.

[187] Buylova, A. 2018. Energy Use Intensity in Residential Housing in Oregon. https://osugisci.maps.arcgis.com/apps/webappviewer/index.html?id=189e21ea4f694168ad519a18ef99ef60.

[188] Fisher, Sheehan & Colton. 2021. Oregon: County Only Home Energy Affordability Gap. http://homeenergyaffordabilitygap.com/02a_research.html.

[189] Oregon Department of Energy. 2018. Ten-Year Plan: Reducing the Energy Burden in Oregon Affordable Housing. https://www.oregon.gov/energy/Get-Involved/Documents/2018-BEEWG-Ten-Year-Plan-Energy-Burden.pdf.

[190] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

racially diverse energy sector in the future. **With the greatest potential to add additional jobs in this scenario, these strategies to increase racial diversity in the workforce could have added benefits for communities of color**.
- While no data is available on elderly laborers in the energy sector, **any loss of jobs for elderly laborers will be negative** because of the lack of additional workforce development and educational opportunities.[191]

9.4.4.5.7 Social Indicator: Housing Burden

- Increased **utility costs** under this scenario with a **slight increase in transportation costs** in early years due to electrification will increase additional housing-related costs for communities of color, Tribes, urban low-income, and rural low-income households.
- CCIs purchased and banked in early years **may help communities of concern with the upfront costs of electrification** until the later years when energy costs decline overtime.
- Housing burdened urban low-income households could be driven from their homes due to **green gentrification**, or out-of-state persons moving in as neighborhood conditions improve from emissions reduction policies.
- The increase in housing burden **may push burdened or severely burdened urban low-income households to rural areas**, resulting in increasing transportation costs and financial burden for these displace households.
- Low-income rural households **may experience additional burden from urban households moving to exurban or rural communities**, thereby decreasing available housing stock and driving housing prices up.
- Low-income households on average occupy multifamily dwellings in dense populations.[192] Therefore, in rural low-income communities, **the transition to electric in single family homes would be more gradual**. CCIs in early years to support needed infrastructure updates can expedite this process.
- Although there are also federal housing assistance programs for Tribes, there is limited funding to alleviate existing burden. Thus, **additional housing burden may lead to overcrowding** (having more than one person per room) to alleviate additional strain from housing burden.[193]
- The elderly population would be **moderately impacted by additional utility costs**. Transportation costs may remain the same since it's assumed the elderly population does not need to commute for work. CCIs could similarly help this community of concern.

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[191] The Solar Foundation. 2019. Oregon and Washington Solar Workforce Diversity Report. https://www.thesolarfoundation.org/wp-content/uploads/2019/06/ORWA-Diversity.pdf.

[192] Oregon Office of Forecasting, Research and Analysis. 2014. Areas of High Poverty Density. https://www.oregon.gov/osp/Docs/Area%20of%20High%20Poverty%20Density.pdf

[193] U.S. Department of Housing and Urban Development. 2017. Housing Needs of American Indians and Alaska Native Natives in Tribal Areas: A Report from the Assessment of American Indian, Alaska Native, and Native Hawaiian Housing Needs. https://www.huduser.gov/portal/sites/default/files/pdf/HNAIHousingNeeds.pdf.

9.5 Methodology Considerations

Additional considerations regarding the assessment methodology and findings are presented below:

- **Timeframe:** The rankings in this assessment generally reflect cumulative impacts and co-benefits through the policy duration (i.e., to 2050). Holding long-term outcomes constant, near-term negative implications for an indicator would result in a slightly lower ranking.
- **External variables:** The assessment process assumed that variables external to the policy changes (e.g., environmental changes, macro-economic conditions) remain constant. This means that the climate change impact benefits (i.e., avoided costs of climate change damages) associated with greenhouse gas emissions reductions are not considered.
- **Geographic scope:** This assessment looked at co-benefits and equity impacts within the state of Oregon. Benefits and impacts to communities outside of Oregon were not considered.
- **Geographic differentiation:** Rankings in both the co-benefits and equity assessments reflect a generalization of impacts and benefits across the state. While the equity assessment attempts to parse out impacts and benefits to particular communities, these communities vary in their geographic locations and may experience the policy scenario differently. For example, some urban low-income communities in one part of the state may benefit, while low-income communities elsewhere may be negatively affected. This kind of variability is designated with footnotes that elaborate on nuances and considerations embedded in the ranking.
- **Overlapping communities:** There is overlap among the communities of concern. For example, an elderly, low-income person of color living in a rural community would qualify under three of the communities represented through this assessment. Although not explicitly addressed through this study, it is anticipated that persons who identify within more than of the communities in this assessment will likely experience projected policy impacts and co-benefits to an even higher degree than someone who identifies within only one of the listed communities—and these compounding effects should be considered for future policy and program design.

9.6 Other Considerations for CCIs

CCIs are a concept under discussion for the Oregon Climate Protection Program. Projects that reduce greenhouse gas emissions can take many forms. For the purposes of this project, the exact details of the CCIs were not yet defined or assumed because those details still need to be determined in the actual program and there are a number of unknown factors that could influence the nature of CCIs.

However, there is significant potential co-benefit and equity implications from CCIs, and the co-benefits and equity discussion would be incomplete without making basic assumptions about CCIs. Therefore, for the purposes of the co-benefits and equity assessment only, Cascadia assumed that **eligible CCI projects** included rebates or cost-shares to fundtransit expansion with additional electric options; electric heat pump and water heater installations; energy efficiency improvements; and freight fleet conversions to non-fossil fuels. It is also assumed that CCIs would be invested in areas where those projects would result in the most benefit (e.g., areas near major freeways).

Other considerations regarding the type and use of CCIs are included below:

- Supporting **home energy efficiency** could be important for alleviating near-term energy and housing burden impacts. These projects could be especially important to support low-income households and communities of color.
- Given that wildfire smoke will remain the largest contributor to the state’s criteria air pollution, energy efficiency or electrification projects that include **air filtration and ventilation upgrades** could also carry substantial health benefits.
- The use of **active transportation projects** could bring additional public health co-benefits associated with active lifestyles.
- **Shift to renewables** such as increased use of and reliance on solar and wind energy could introduce energy security and reliability challenges and, in the case of solar, could carry implications for land use patterns and ecosystem health.
- While **workforce development and education for displaced workers** were assumed not be within the scope of CCI projects for this assessment, it is an important consideration to ensure that a transition away from a fossil fuel economy is equitable and just.