Oregon Climate Protection Program: Modeling Study on Program Options

Oregon DEQ and ICF

State of Oregon Department of Environmental Quality

Modeling Analysis Study

- DEQ contracted with ICF for a modeling study to assess different greenhouse gas emissions reduction program designs for information on:
  - Forecasted greenhouse gas emissions
  - Equity, air quality, and public health co-benefits
  - Macroeconomic effects on Oregon's economy
- Modeling analysis objectives:
  - Analyze options to inform overall program design and relationships between design elements
  - Provide information on directionality and magnitude of changes when adjusting parameters of discrete program elements
- Scenarios do not represent final or complete program design proposals and not all program design elements are represented in the modeling

Notice

- The following slides include background information and modeling assumptions of the modeling study to support development of the Climate Protection Program
  - Another slide deck with initial results is available on DEQ's website

Last Updated: June 10, 2021

Greenhouse Gas Emissions

Key assumptions and data sources

Key Models and Data Sources

- DEQ Oregon GHG Reporting Program and sector-based statewide inventory
- EPA State Inventory Tool (SIT) modules and EPA emission factors
  - Consistent with methodology used by DEQ to estimate Oregon's sector-based greenhouse gas emissions inventory
  - Source for additional historical and forecasted activity and emissions data
- ICF Integrated Planning Model (IPM) for forecasted electricity generation and demand
  - Consistent with DEQ inventory accounting for estimating in-state generation and consumption emissions
  - Will build on existing in-state and out-of-state data sources
- Argonne National Laboratory VISION Model for transportation sector fuels
  - Aligning with the activity forecasting methods used in ICF's modeling study for Oregon Clean Fuels Program transportation fuel supply and demand planning analysis
- Oregon investor-owned electric and natural gas utilities' Integrated Resource Plan (IRP) base case load projections
  - Portland General Electric, PacifiCorp, Idaho Power, Northwest Natural, Cascade, AVISTA
- Oregon-specific emissions factors in alignment with DEQ GHG Reporting Program, U.S. GHG Inventory, EPA SIT, and IPCC
- For more information on ICF's integrated modeling approach, see the DEQ Modeling Brief.

Summary of Emissions Accounting

- Historic emissions estimates align with Oregon sector-based GHG Inventory (1990-2018)
  - Transportation, Electricity, Natural Gas, Industrial, Residential & Commercial, Agriculture
  - Emissions occur at end-uses (e.g., point of fuel combustion or industrial processes)
- Same sectors modeled into the future (2019-2050)

Overview of Emissions Sources by Sector

Natural Gas

- Natural gas consumption

Electricity Consumption

- In-state Electricity Generation (historical and projections)
- Electricity consumption (historical)

Residential & Commercial

- Commercial Petroleum Combustion
- Residential Petroleum Combustion
- Waste Incineration
- Residential Coal Combustion
- Commercial Coal Combustion
- Municipal Solid Waste Landfills
- Natural Gas Distribution (sector share)
- Municipal Wastewater
- Residential Combustion Byproducts
- Commercial Combustion Byproducts
- Compost
- Fertilization of Landscaped Areas
- Refrigerants, Aerosols, Fire Protection Use

Transportation

- Motor Gasoline
- Distillate Fuel
- Jet Fuel, Kerosene
- Residual Fuel
- Lubricants
- Aviation Gasoline
- LPG
- Jet Fuel, Naphtha
- Passenger & Light Vehicles
- Non-Road Vehicles & Equipment
- Heavy-Duty Vehicles
- Natural Gas Distribution (sector share)
- Refrigerants, A/C, Fire Protection Use
- Renewable Diesel
- Biodiesel
- Hydrogen

Agriculture

- Urea Fertilization
- Liming of Agricultural Soils
- Enteric Fermentation
- Manure Management
- Agricultural Residue Burning
- Agricultural Soil Management

Industrial

- Petroleum Combustion
- Cement Manufacture
- Coal Combustion
- Ammonia Production
- Urea Consumption
- Waste Incineration
- Iron & Steel Production
- Soda Ash Production & Consumption
- Limestone and Dolomite Use
- Lime Manufacture
- Pulp & Paper including wastewater
- Natural Gas Distribution & Production
- Industrial Landfills
- Combustion Byproducts
- Food Processing Wastewater
- Nitric Acid Production
- Semiconductor Manufacturing
- Refrigerant, Foam, Solvent, Aerosol Use
- Aluminum Production
- Electricity Transmission & Distribution

Policies included in Reference Case (1/2)

- Assumes policies, programs, and regulations that are currently in effect
- **Transportation and mobile sources**
  - Oregon Clean Fuels Program: 10% reduction in transportation fuel carbon intensity by 2025
  - CAFE Standards: federal corporate average fuel economy standards from 2016 rulemaking
  - SB 1044: Electric vehicle load impacts from light-duty zero emission vehicle regulations and vehicle sales by 2035
- **Pollutants with high GWPs**
  - U.S. AIM Act: 85% consumption/production reduction by 2035 relative to annual average 2011-2013 baseline

Policies included in Reference Case (2/2)

- **Electricity generation and consumption**
  - SB 1547: renewable portfolio standard (RPS) of 50% by 2040 and no coal generation attributed to OR past 2030
  - Adjacent state policies impacting Oregon generation mix: California's SB 100 goal of 100% renewable electricity by 2045; Washington Clean Energy Transformation Act (CETA); and others
  - Energy efficiency programs: included in utility IRP data and used as IPM input assumptions
- **Natural gas supply and consumption**
  - SB 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

Transportation (1/2)

Emissions Sources	Data	Relevant Policies
• Fuel combustion in light-duty, medium-duty, heavy-duty on-road vehicles, non-road vehicles and equipment, and aircraft, sector share of natural gas distribution, and refrigerants, A/C and fire protection use	• Argonne National Laboratory's VISION 2020 Model and Clean Fuels Program for transportation data • ODOT historic light-duty and medium/heavy-duty vehicle registration data • 2016-Q2 2020 fuel data from CFP (biodiesel, renewable diesel, feedstocks, etc.) • EPA SIT for fossil fuel emission factors • Argonne GREET model for bio-based and hydrogen fuel emission factors • ICF IPM for electric vehicles	• Clean Fuels Program: 10% reduction in transportation fuel carbon intensity by 2025 • Federal corporate average fuel economy (CAFE) standards from 2016 rulemaking • SB 1044: Electric load from light-duty zero emission vehicle (ZEV) regulations/vehicle sales by 2035 • 90% new vehicle LD sales electric by 2035 and 10% CI reduction for 2025+ • Emissions reductions from pollutants with high GWPs assumed to occur as a result of the U.S. AIM Act

Transportation (2/2)

Methodology: Historic Emissions	Methodology: Projected Emissions	Additional Assumptions
• OR sector-based inventory estimates • Alternative fuels (biodiesel, renewable diesel, hydrogen) estimated based on Clean Fuels Program data and renewable fuel standards	• VISION on-road fuel consumption estimates multiplied by SIT emission factors for conventional fuels and GREET (combustion only) emission factors for alternative fuels • Used historic light-duty and medium/heavy-duty vehicle registration data from ODOT to quantify annual new vehicle sales through 2019 and estimate future portion of projected national vehicle sales • Off-road emission estimates from SIT Projections Tool • Electric vehicle emissions are captured in the electricity sector	• Biogenic CO_2 emissions from alternative fuels (i.e., biodiesel and renewable diesel) are not included as they are not being considered for the regulation • Maintained compliance level of biodiesel/renewable diesel consumption into the future

Natural Gas Consumption

Emissions Sources	Data	Relevant Policies
• Natural gas use, including large and small utilities • Consumption separated by sector: residential, commercial, and industrial	• Load forecasts provided by utilities (Avista, Cascade, NW Natural) • EPA SIT CO2 Fossil Fuel Combustion Module for fossil-based gas • EPA's Emission Factors for Greenhouse Gas Inventories 2015 for renewable natural gas (assumed from biogenic sources)	• SB 98 optional RNG portfolio standard: 30% of large utility (NW Natural) natural gas supply to be RNG by 2050 • Utility load forecasts were adjusted for projected energy savings using Energy Trust of Oregon methodology (see utility IRPs for details on methodology)

Methodology: Historic Emissions	Methodology: Projected Emissions	Additional Assumptions
• OR sector-based inventory estimates	• Emissions estimated by multiplying utility load projections by SIT emission factors	• Assumed RNG to be zero-emitting for combustion • Applied historical share to EPA SIT projections for fugitive methane emissions from production, transmission, and distribution, and mapped the results to the existing DEQ inventory categories • SB 98 does not impact small gas utilities (Cascade, AVISTA) and non-utility supplied gas use

Industrial

Emissions Sources	Data	Relevant Policies
• Non-energy related industrial activities including: fossil fuel combustion, various industrial manufacturing and production, waste incineration, landfills, food processing wastewater, refrigerant, foam, solvent and aerosol use, aluminum production, and natural gas and electricity transmission and distribution	• ICF IPM for electricity use • EPA SIT CO2 Fossil Fuel Combustion Module for fossil-based gas • SIT, DEQ Greenhouse Gas Reporting Program, and EPA data for all other sources	• Emissions reductions from pollutants with high GWPs assumed to occur as a result of the U.S. AIM Act

Methodology: Historic Emissions	Methodology: Projected Emissions	Additional Assumptions
• OR sector-based inventory estimates • Natural gas transmission and distribution emissions are estimated using SIT (applies default emission factor from U.S. Greenhouse Gas Inventory); total is distributed by sector	• Depending on the emission source, one of the following were used: 1. SIT Projections Tool estimates, 2. Projections developed using GHG RP data, or 3. Projections developed using population data; methods were selected by source for consistency with historic estimates from the OR Inventory	• Added emissions from pollutants with high GWPs associated with electricity transmission and distribution

Residential and Commercial

Emissions Sources	Data	Relevant Policies
• Fossil fuel combustion, wastewater, landfilled waste, waste incineration, compost, fertilization of landscaped areas, and refrigerants, aerosols and fire protection use	• ICF IPM for electricity generation and emissions • EPA SIT CO2 Fossil Fuel Combustion Module for fossil-based gas • SIT, DEQ Greenhouse Gas Reporting Program, and DEQ Model - Materials Management Program data for all other sources	• Emissions reductions from pollutants with high GWPs assumed to occur as a result of the U.S. AIM Act

Methodology: Historic Emissions	Methodology: Projected Emissions	Additional Assumptions
• OR sector-based inventory estimates	• Depending on the emission source, one of the following were used: 1. SIT Projections Tool estimates, 2. Projections developed using GHG RP data, or 3. Projections developed using population data. Methods were selected by source for consistency with historic estimates from the OR Inventory	• N/A

Agriculture

Emissions Sources	Data	Relevant Policies
• Non-energy related activities in the agriculture sector including fugitive emissions from livestock, soil management, urea fertilization, liming of soils, and residue burning	• ICF IPM for electricity use • EPA SIT CO2 Fossil Fuel Combustion Module for fossil-based gas • SIT Agriculture Module for all other sources including Urea Fertilization (U.S. EPA), Liming of Agricultural Soils, Enteric Fermentation (U.S. EPA), Manure Management, Agricultural Residue Burning, and Agricultural Soils Management (U.S. EPA)	• N/A

Methodology: Historic Emissions	Methodology: Projected Emissions	Additional Assumptions
• OR sector-based inventory estimates • Emissions are estimated using SIT Agriculture Module (for details on methodology, see SIT User's Guide)	• SIT Projections Tool estimates used default projection data for Urea Fertilization, Liming of Agricultural Soils, Enteric Fermentation, Manure Management, and Agricultural Soils Management. Agricultural Residue Management. Agricultural Residue Burning used default projections based on historic emissions.	• N/A

Electricity (1/3)

Emissions Sources	Data	Relevant Policies
• Electricity generated in-state	• ICF IPM for projections and outputs for estimating emissions from in-state and generation sources	• SB 1547: renewable portfolio standard (RPS) varies by utility, e.g., 50% by 2040; and no coal generation attributed to Oregon past 2030 • SB 1044: Electric load from light-duty zero emission vehicle (ZEV) regulations/vehicle sales by 2035

Electricity (2/3)

Methodology: Historic Emissions	Methodology: Projected Emissions	Additional Assumptions
• OR sector-based inventory estimates • OR Greenhouse Gas Reporting Program generation data	• ICF’s IPM	• Other adjacent state RPS impacting Oregon electricity consumption mix, e.g., California’s SB 100 goal of 100% renewable electricity by 2045 and Washington CETA • Utility IRP data utilized as IPM input assumption and incorporates assumptions for energy efficiency • Does not account for emissions associated with utility power purchases, as facility-level generation does not exactly align with utility procurement of power • Assumed any increase in in-state gas generation over the current levels contributes to in-state emissions • Assumed that there is no change in the breakdown of how generation and associated emissions are shared between serving in-state consumption and external markets

Electricity (3/3)

- Load assumptions for the Reference Case are based on investor-owned utility (IOU) integrated resource plans (IRPs)
- For periods beyond the IRP projections, the average growth rate of the last three years of the IRP are assumed for each year from the end of the IRP load forecast until the end of the study period (2050)
- Electric vehicle load growth in an IRP was netted out of the forecast as ICF included its own electric vehicle load impact based on modeling in VISION
- Besides electric vehicle electrification, IRP load forecasts are not representative of expected load increases due to electrification of end-use sectors, such as fuel shifting from natural gas to electricity
  - However, existing programs on energy efficiency can impact electric load and given the utilization of the IRPs as the basis for the electric load forecast, the impacts from such programs are captured, consistent with IOU expectations

Utility IRPs

- Results from this study are not directly comparable to investor-owned utility integrated resource plan (IRP) projections
- Utilities conduct resource planning and modeling based on a set of assumptions that may or may not align with the assumptions utilized in this study
  - Utilities often include an expectation of a carbon price in the IRP analysis, which is not consistent with this study's reference case assumptions of current policies on-the-books
  - The projection timeline of this study extending beyond the IRP also limits the ability to compare to IRPs as the modeling here makes decisions based on the entirety of the forecast horizon

General Assumptions for Policy Scenarios

- 2019 greenhouse gas emissions and fuel supply data are used to determine if emissions were regulated in the policy scenarios
- Interactions at the facility or business level are not captured; modeling is conducted at the sector level (i.e., natural gas, other fuels, industrial process) and sub-sector level (e.g., residential, cement manufacturing)
- In the model, caps are applied only to the sectors that are assumed to be regulated in a given scenario
- Caps are applied to regulated sectors and begin in 2022

Key Data Sources for Policy Scenarios

- Natural gas utility integrated resource plans (IRPs)
- Energy Trust of Oregon
- NREL Electrification Futures Study
- Oregon-specific data (population, number of homes, commercial square footage, DEQ greenhouse gas reporting program data)
- Cal ETC Comparison of Medium- and Heavy-duty Technologies in California
- U.S. DOE Alternative Fuels Data Center
- U.S. EPA Global Non-CO_2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050
- U.S. DOE State Energy Database and Annual Energy Outlook
- McKinsey & Company abatement cost curve analyses for industrial processes (e.g., cement and iron and steel production)

Technical Potential Emissions Reductions

- Technical potential emissions reductions include:
  - Energy efficiency (natural gas and some other fuels)
  - Fuel switching/electrification
  - Destruction, removal, or recovery of industrial process emissions
  - Renewable natural gas
  - Hydrogen as a transportation fuel
- May be areas where additional emissions reductions could be achieved with improved technology performance or new technologies
  - For example, carbon capture and sequestration (CCS) and pipeline hydrogen were not modeled and could offer larger opportunities for reductions

Modeling Community Climate Investments

- Community Climate Investments (CCIs) allowed in each policy scenario
- Allowable CCI units are calculated as X percent of a cap in a compliance year
- Use of CCIs is calculated in two stages:
  1. Are additional reductions needed to meet the cap? If yes, then CCIs are used.
  2. Is it cheaper to use a CCI then make an actual reduction? 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.
- CCI price is assumed to be the EPA social cost of carbon using a 2.5% discount rate
- In the model CCIs can be banked or traded

Social Cost of CO_2
$2020 per metric ton

Year	2.5% Average
2020	$76
2025	$83
2030	$89
2035	$96
2040	$103
2045	$110
2050	$116

Natural Gas in the Policy Scenarios (1/2)

- Emissions reductions from reduced quantity of natural gas consumed
  - Achieved technical potential energy efficiency based on Oregon Energy Trust methods and results as presented in utility IRPs
  - Converted natural gas to electricity based on NREL Electrification Futures Study range between moderate and high electrification scenarios; considering higher electrification penetration rates for new buildings
  - Electrification gas to electric conversation factors and costs based on NREL Electrification Futures, published NREL data from Bepot modeling and ICF-developed cost estimates
  - Electrified new and existing residential and commercial buildings; only electrified part of potential new industrial applications

Natural Gas in the Policy Scenarios (2/2)

- Emissions reductions from lowering the carbon intensity of gas
  - Assumed 50% to 75% of needed gas supply would be renewable natural gas (RNG) by 2050
  - Ensured that the total supply of RNG in a given year did not exceed the amount of RNG assumed in the Reference Case, which was in line with utility provided RNG projections
  - Gas demand is decreasing in the Policy Scenarios as compared to the Reference Case. A higher portion of RNG in a Policy Scenario (i.e. greater than the percentages in Senate Bill 98) does not equate to a larger supply of RNG.

Other Fuels in the Policy Scenarios

- Assumed similar or analogous energy efficiency reductions and costs as estimated and applied for natural gas
- Transportation
  - Fleet sales amounts for 2020-2029 are based on privilege tax expected sales
    - The % of use of U.S. sales for this time period is used to determine % of future U.S. sales from VISION
  - Electrification estimates are based on ZEV2 and ACT (MD/HD MOU)
  - Vehicle miles traveled (VMT) estimates are based on VISION, and does change over time
    - VMT per year changes based on vehicle age
  - Costs are derived from CalETC and DOE Alternative Fuels Data Center data

Industrial Processes in the Policy Scenarios

- Technical potential reductions and costs derived from:
  - U.S. EPA Global Non-CO2 Greenhouse Gas Emission Projections & Mitigation Potential: 2015-2050
  - Various literature review resources (e.g., McKinsey abatement papers)
- Depending on the given policy scenario assumptions, sectors with regulated industrial process emissions may include:
  - Cement Manufacture
  - Ammonia Production
  - Iron & Steel Production
  - Soda Ash Production & Consumption
  - Limestone and Dolomite Use
  - Lime Manufacture
  - Pulp & Paper including Wastewater
  - Semiconductor Manufacturing
  - Refrigerant, Foam, Solvent, Aerosol Use

Additional Fuel Price Data Sources

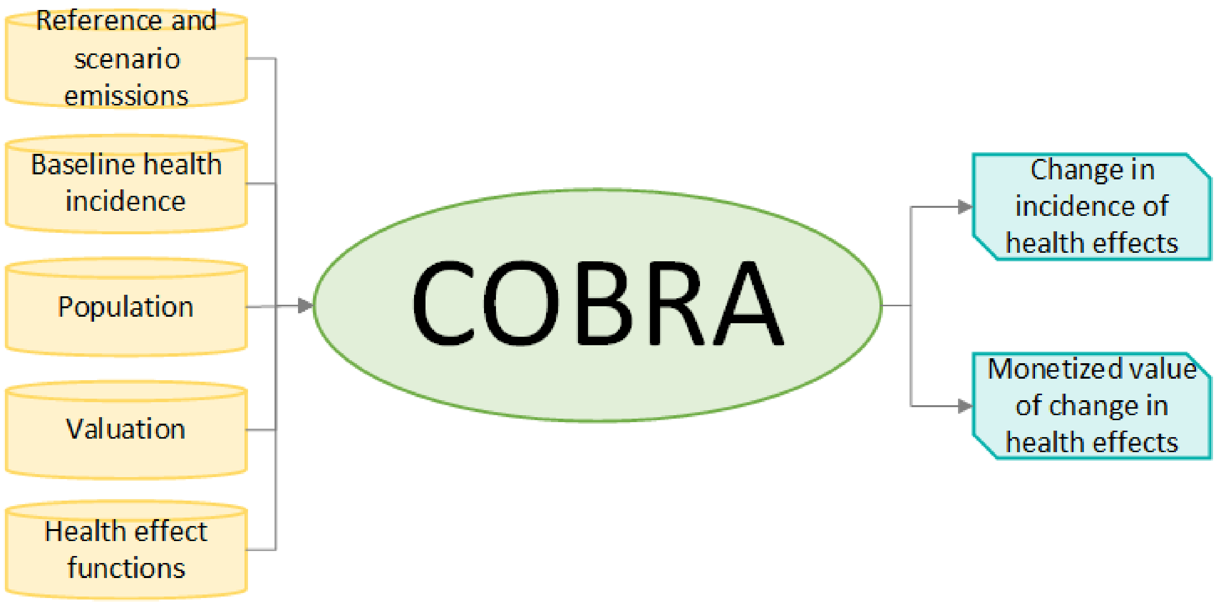
- Energy prices from the EIA State Energy Data System (SEDS)
  - SEDS provides prices for 2019 specific to Oregon and different energy types, which are used as a proxy for 2020 prices
- Energy prices are projected based on projections of national energy price trends taken from the Annual Energy Outlook (AEO) 2021
- Renewable natural gas (RNG) prices derived from the 2019 American Gas Foundation Report: Renewable Sources of Natural Gas

Health

Key assumptions and data sources

Health Analysis Model

- COBRA estimates the public health impacts of changes in emissions of particulate matter (PM2.5) and its precursors (NOx, SO2, NH3, and VOC)
- Changes in human health outcomes and their economic value are estimated at the county or state levels



Health Modeling Assumptions & Data Sources

- Monetized health benefits for scenarios as compared to reference case
  - Evaluated in comparison to a reference case for 3 years: near term (2025), mid-term (2035), and horizon (2050)
- Emission modeling results were mapped to COBRA categories
  - Sectors with no changes due to the policy scenarios (e.g. agriculture) are treated as having no change in emissions
- COBRA model captures emissions from fossil fuel combustion
  - Does not capture any industrial process emissions changes
- Health analysis also does not capture any potential benefits from CCIs

Health Modeling Assumptions & Data Sources

COBRA Input	Data Source(s)	Years Represented	Description of Data	Data Management
Health effect functions	U.S. Environmental Protection Agency (EPA)	All	Functions representing the relationship between PM and adverse human health effects; based on peer-reviewed studies	N/A
Reference health incidence	Oregon Health Authority (OHA)	2016-2019	County- and state-level age-specific counts of incidences of adverse health effects[a]	Supplemented with Census Bureau population data to obtain incidence rates (counts per total population). Some county-level data suppressed. We filled based on state-level incidences.
Reference health incidence	U.S. Environmental Protection Agency (EPA)	2014; 2025, 2035, and 2050 for mortality incidence	COBRA default incidence (2014) supplemented with mortality incidence projections from EPA's BenMAP-CE[b] model	Appended to reference health incidence data from OHA.
Valuation	ICF analysis	2025, 2035, and 2050	Value of a statistical life and willingness-to-pay valuation metrics projected to future years based on income elasticity estimates	To value reduced mortality, we project the 1990 U.S. EPA value of a statistical life and COBRA default willingness to pay to avoid mild illnesses to future years.[c]
Population	Portland State University and Metro	2025, 2035, and 2050	County level population forecast for every 5 years for all counties except Multnomah from PSU and district-level forecasts for Multnomah County from Metro for 2020, 2030, 2045, and 2050	Interpolated between known Multnomah County population estimates to obtain 2025 and 2035 data. To obtain single-year ages based on this data, we apportioned county-level totals using 2023 default COBRA single-year population data in conjunction with BenMAP-CE[b] model age 0-64 and age 65-99 population data.

Notes:
(a) OHA was able to provide 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. We use COBRA default incidence data for work loss days and acute bronchitis and we use mortality incidence datasets from BenMAP for years 2025, 2035, and 2050.
(b) Environmental Benefits Mapping and Analysis Program - Community Edition.
(c) Projections based on income elasticity estimates detailed in EPA's BenMAP-CE model and historical GDP and projected GDP from Organisation for Economic Co-operation and Development (OECD).

Health Modeling Assumptions & Data Sources

- Emission inputs from sectors are characterized for the reference case and each scenario for model years
- For Scenarios 1-3 statewide emissions from each sector are apportioned to county-level inputs using default allocations in COBRA
- For Scenario 4 emissions are at the county level for county level COBRA inputs

Emissions Source/Sector	Model(s) and Outputs	Geographic Scale[a]
Tailpipe emissions from on-road vehicles	VISION model for statewide fuel consumption by fuel type and MOVES3 model for fuel-based annual emissions factors by vehicle category[b]	Scenarios 1-3: State; Scenario 4: County
Emissions from electricity generation	Facility- and fuel-based IPM model for of emissions for electricity generating units[c]	Scenarios 1-4: County
Major stationary sources	Energy consumption by fuel by sector from the Multisectoral model[d]	Scenarios 1-3: State; Scenario 4: County
Other fuel combustion activities (e.g., home heating)	Energy consumption by fuel by sector from the Multisectoral model[d]	Scenarios 1-3: State; Scenario 4: County

Notes:
(a) Geographic scale represents emissions inputs for scenarios 1-3. Inputs for the 4th scenario are determined at the county-scale during scenario/emissions modeling.
(b) On-road direct PM emissions include exhaust, brake wear, and tire wear
(c) Limited to sources within OR and the Columbia River Valley in WA
(d) Fossil energy consumption in Bbtu converted into PM and PM precursor emissions (NOx, SO_2, NH_3, and VOC) by pairing fuel consumption amounts with relevant emission factors.

Economic

Key assumptions

Economic Analysis Overview & Data Sources

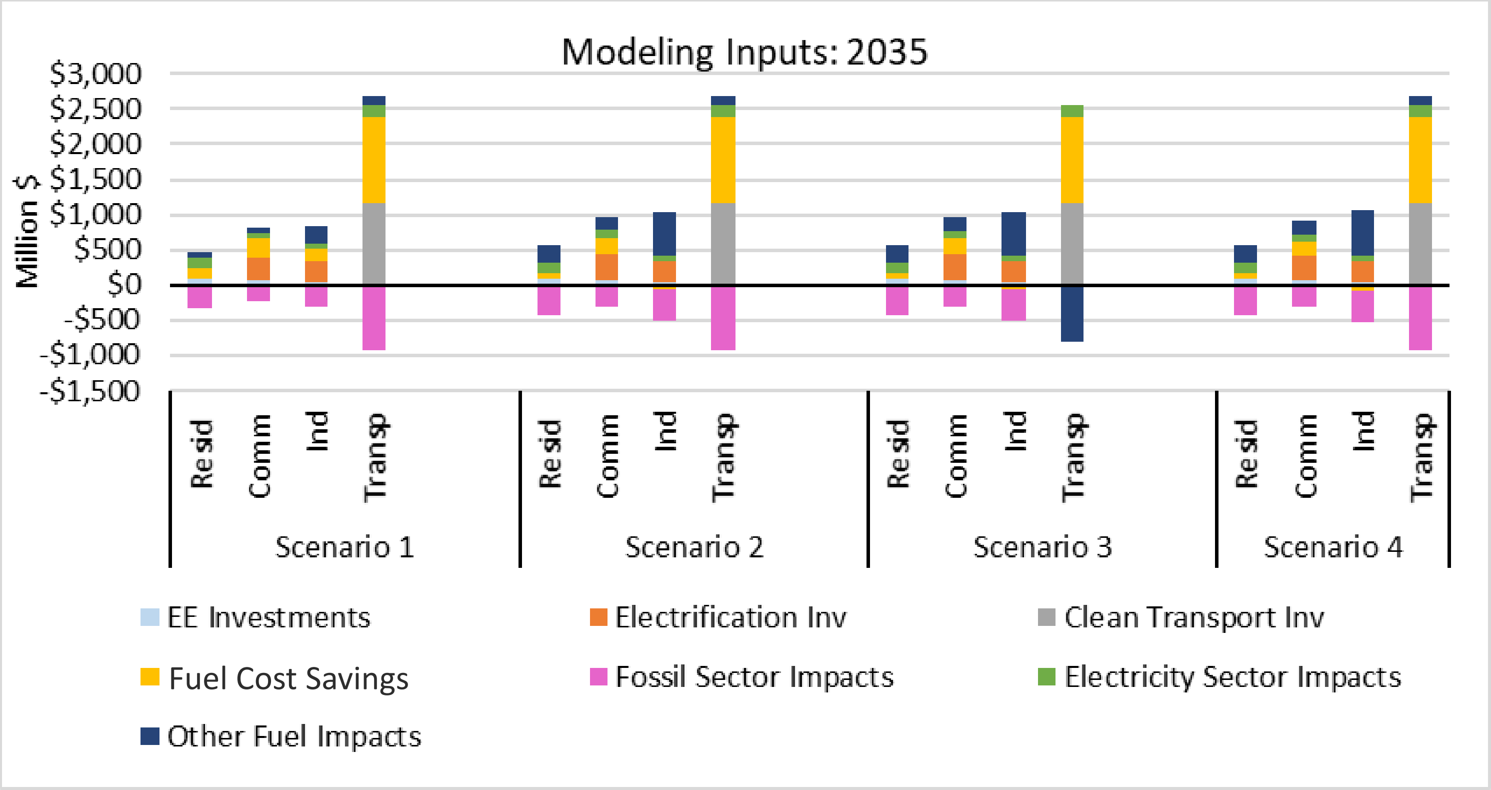
- Three primary types of impacts (multipliers) used in IMPLAN
  - **Direct**: Construction employment, direct procurement of materials, equipment rentals, etc.
  - **Indirect**: Supply-chain inputs such as supplies, parts, materials, third-party services, etc.
  - **Induced**: Increased consumption spending on housing, healthcare, goods and services, etc.
- Total impact is the sum of multiple rounds of secondary indirect and induced impacts that remain in the region
  - Accounting for shifts to other regions or states
  - IMPLAN then uses this total impact to calculate subsequent impacts
- Monetary values reported in 2020$

Economic Analysis Data Inputs

- Main modeling inputs used in IMPLAN include
  - Investments in energy efficiency
  - Investments in electrification
  - Changes in fuel cost savings
  - Impacts on energy producing sectors
    - Positive impacts of electrification
    - Negative impacts on fossil fuel
  - Budgetary impacts of investments on OR residents and businesses

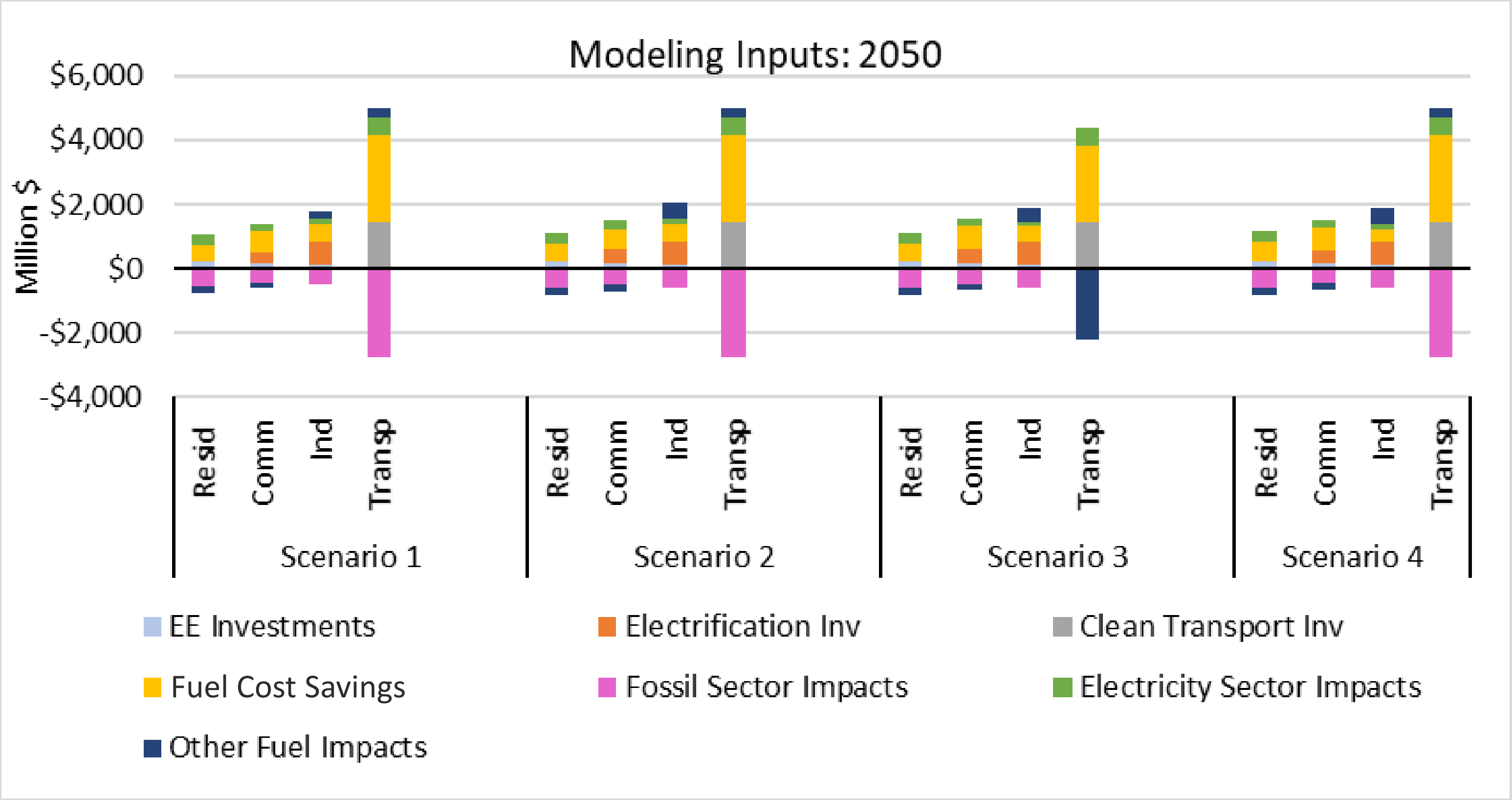
Economic Analysis Data Inputs: 2035

- Clean transportation investments are the largest driver of impacts (mainly medium/heavy-duty)
  - Fuel savings from clean transportation accrue for consumers but are offset by costs of investment
  - Corresponding negative impacts to fossil production and distribution sectors (e.g., gas stations)
- Electrification and energy efficiency (EE) investments net out bill savings
  - Fuel cost savings take time to accrue



Economic Analysis Data Inputs: 2050

- In 2050, clean transportation investment continues to be the largest driver, expanding both fuel cost savings and fossil sector impacts
  - Mainly medium/heavy-duty with some light-duty investment



Co-benefits and Equity

Key assumptions and data sources

Co-Benefits and Equity Analysis: Overview

- **Objective:** For each scenario, assess potential **co-benefits** and positive or negative impacts to **equity**
- **Approach:**
  - **Qualitative assessment** of policy scenarios against identified indicators.
  - **Two assessments:**
    - Co-benefits: *Overall* scenario co-benefits (or damages)
    - Equity: *Distribution* of benefits (or damages) among communities of concern

Indicators:

- Local air quality (health)
- Ecosystem health & resilience
- Energy Security
- Employment & workforce development
- Housing burden

Communities of Concern:

- Communities of color
- Tribal nations
- Elderly populations
- Low-income urban communities
- Low-income rural communities

Co-Benefits and Equity Analysis: Methodology

- **Qualitative rankings:**

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.

- **Key information sources:**
  - Model results from the health and economic analyses
  - Academic literature & white papers specific to the indicators

Co-Benefits and Equity Analysis: Key Assumptions/Considerations

- **Timeframe:** Cumulative to 2050, with consideration of potential near-term impacts.
- **External variables:** Constant environmental & economic conditions across scenarios (e.g., climate change).
- **Geographic differentiation:** Co-benefit rankings reflect generalization across state/community.
- **Overlapping communities:** Does not take into account compounding effects of community overlap (e.g., elderly, low-income person of color).
- **CCIs:** Assumed CCIs include funding for transit expansion/electrification; home electrification; energy efficiency improvements; freight fleet conversion.

Key Considerations by Indicator

Indicator	Rationale	Key Drivers of Results
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.	• Criteria air pollutants • Fuels used for transportation • CCIs could bring indoor and outdoor air quality benefits
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.	• Criteria air pollutants and other pollutants from industrial facilities • Reduced impacts from fossil fuel transport • CCIs could bring benefits, depending on project types
Energy security	Energy security is important to ensure that communities have access to reliable and affordable energy. Allowable CCIs could have an impact on energy intensity, energy supply, energy burden, and energy costs.	• Increased reliance on renewable energy and any reliability considerations • Energy costs may be higher in scenarios with higher emission reduction targets and less compliance flexibility
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.	• At macro-scale, some job loss in regulated with gains in other sectors • Induced net job impacts may be positive in the long-term, and these jobs may benefit low-income communities
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.	• Short-term increases in housing burden (related to energy burden), but long-term savings • Scenarios with higher energy costs equate to higher housing burden • Longer-term job gains contribute toward longer-term improvements in housing burden

Communities of Concern (1/2)

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, Latinx, Asian and Pacific Islanders, African Americans, Africans, Middle Eastern, and Slavic communities.[1] 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.[2]
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.[3] 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.[4]
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.[5] Furthermore, elderly people who work in regulated sectors may have additional considerations for workforce development or early retirement.[6]

Footnotes:
1. As identified by the Coalition of Communities of Color. https://www.coalitioncommunitiescolor.org/whoweare.
2. 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.
3. Legislative Policy and Research Office, State of Oregon. 2016. Tribal Governments in Oregon: Background Brief. https://www.oregonlegislature.gov/lpro/Publications/BB2016TribalGovernmentsinOregon.pdf.
4. 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.
5. 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.
6. 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.

Communities of Concern (2/2)

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

Contracted Study Resources

Modeling study webpage: www.oregon.gov/deq/ghgp/Pages/modelingstudy.aspx

Rulemaking webpage to develop Oregon's Climate Protection Program:

www.oregon.gov/deq/Regulations/rulemaking/Pages/rghgcr2021.aspx

Submit questions to GHGCR2021@deq.state.or.us