# Modeling Study on Program Options to Reduce Greenhouse Gas Emissions

## Summary Report

**August 2021**

State of Oregon
Department of Environmental Quality

# Table of Contents

# 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
- 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 provides a summary of the methods used in conducting these analyses and key results. More detailed information is included in the materials posted on DEQ's modeling study website.

# 2 Overview of Approach

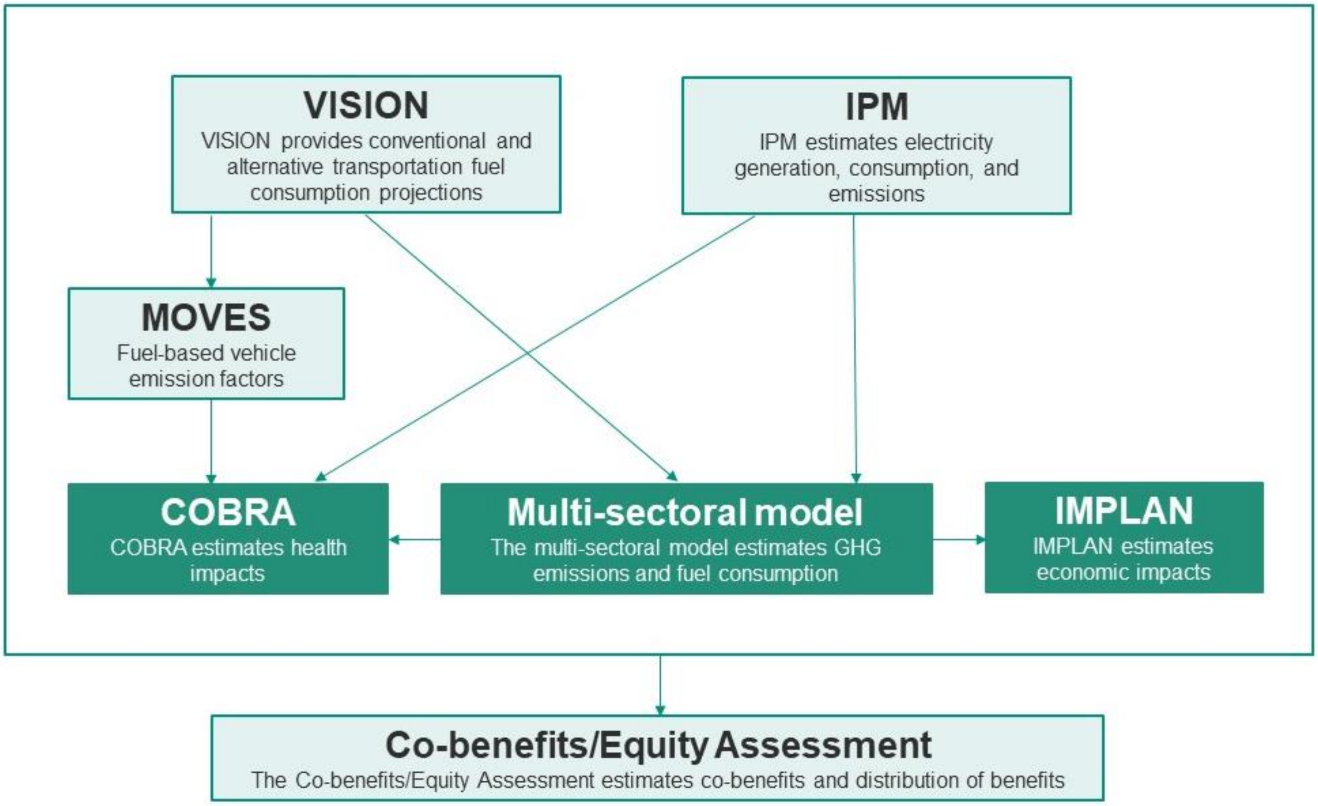
## 2.1 Types of Analyses Conducted

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

1. Reductions in greenhouse gas emissions
2. Impacts on Oregon public health due to associated reductions in air pollution
3. Macroeconomic impacts to Oregon's overall economy
4. Whether the program might result in other co-benefits in the state, and the extent to which benefits or negative impacts may 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 the reported titled *Modeling Study on Program Options to Reduce Greenhouse Gas Emissions: Assumptions, Data Sources, and Methods*. 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:

- A **Reference Case scenario**, for which ICF estimated future greenhouse gas emissions in Oregon in 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 based on 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, as defined by DEQ, are described in Table 1 below. Each policy scenario is analyzed using the Reference Case scenario as the starting point, and then also 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.

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. These insights will help inform the final program design.

*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<br>80% by 2050 | 50% by 2035<br>90% by 2050 | 45% by 2035<br>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<br>Non-natural gas fossil fuel suppliers<br>Large stationary sources with process emissions ≥25,000 | Natural gas utilities<br>Non-natural gas fossil fuel suppliers<br>Large stationary sources with process emissions plus natural gas emissions ≥25,000 | Natural gas utilities<br>Non-natural gas fuel suppliers with emissions ≥ 300,000<br>Large stationary sources with process emissions ≥25,000 | Natural gas utilities<br>Non-natural gas fuel suppliers |
| Sector not Included under the Greenhouse Gas Emissions Caps | All natural gas supplied by interstate pipeline companies<br>Fuels used for aviation<br>Landfills; Electric Generators; stationary source process emissions below threshold | Natural gas supplied by interstate pipeline companies that is not regulated at stationary sources<br>Fuels used for aviation<br>Landfills; Electric Generators; stationary source process emissions below threshold | All natural gas supplied by interstate pipeline companies<br>Fuels used for aviation; emissions from fuel suppliers below threshold<br>Landfills; Electric Generators; stationary source process emissions below threshold | Landfills<br>Electric generators<br>Fuels used for aviation<br>Stationary sources |
| Natural Gas Point of Regulation | All natural gas regulated at utility, not at stationary source.<br>Stationary sources are only regulated directly for | Regulated at stationary sources if emissions are above threshold. Natural gas used at smaller stationary sources is | All natural gas regulated at utility, not at stationary source.<br>Stationary sources are only regulated directly for | All natural gas regulated at utility (and covered by the cap), not at stationary source. |

| Key Topic | Policy Scenario 1 | Policy Scenario 2 | Policy Scenario 3 | Policy Scenario 4 |
|---|---|---|---|---|
| | process emissions above threshold. | regulated at utility supplier.<br>Emissions from other uses such as at homes and commercial buildings is regulated at utility supplier. | process emissions above threshold. | |
| Use of 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 |
| CCI Price | EPA Social Cost of Carbon using a 2.5% discount rate<br>(starts at $76 and increases to $116 in 2020$) | EPA Social Cost of Carbon using a 2.5% discount rate<br>(starts at $76 and increases to $116 in 2020$) | EPA Social Cost of Carbon using a 2.5% discount rate<br>(starts at $76 and increases to $116 in 2020$) | EPA Social Cost of Carbon using a 2.5% discount rate<br>(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 |

## 2.3 Limitations

DEQ provided ICF with assumptions for policy scenarios which ICF modeled to provide insights around potential program design elements. The modeling uses existing public data and resources, as well as simplifying assumptions around how the program would work. Emissions reductions are estimated using a technical potential approach; 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.

# 3 Key Results

## 3.1 Overarching Key Findings

There are some key overarching takeaways from the modeling results. These takeaways were discussed between DEQ and ICF, and based primarily on DEQ reflections from the modeling.

First, the modeling indicated that **the program can be designed in a way that significantly reduces greenhouse gas emissions while maintaining the overall health of the economy, improving public health, and supporting equity.** Under all modeled scenarios, there were significant reductions in adverse health impacts, increased co-benefits, and increased benefits to communities of concern. Meanwhile, while relatively small compared to the size of the economy, the overall economic impacts were net positive for gross state product, income, and jobs.

**Greenhouse gas emission reductions are the most significant for the transportation sector, but significant changes are expected across all of the regulated sectors.** The transportation sector is the only sector within the Policy Scenarios that includes a change to a specified complementary policy, which is an expansion of the state Clean Fuels Program. Other key drivers of emission reductions in other sectors include building energy efficiency, electrification, and renewable natural gas.

The greenhouse gas emissions modeling demonstrated that **compliance flexibility will be important to achieving ambitious greenhouse gas reduction goals**. In all scenarios, banking of compliance instruments played an important role, and community climate investments (CCIs) were used almost to the fullest extent permitted for each scenario. The scenario that permitted the lowest use of CCIs (Scenario 2) was also the scenario with the fewest years in compliance with the cap. Trading of compliance instruments, however, had minimal effects in modeling. It should be noted that the information in this analysis does not represent any specific facility or entity that may be subject to the DEQ climate program; therefore, how actual entities subject to the program may act could vary.

**Point of regulation appears to have minimal impacts on the modeled results**. However, which potentially regulated sectors are included under the program (i.e., not including industrial process sources in Scenario 4) and the threshold at which regulated entities are included in the cap (i.e., fuel suppliers in Scenario 3) did appear to drive some modeled costs and benefits of the program.

**The details of the CCIs design will be very important in terms of how benefits are distributed**. It will be important to engage communities of concern to help ensure that the design supports those communities. It will also be important to consider the specifics of how the CCI part of the program will work, such as the emissions reductions of projects supported by CCI funds.

## 3.2 Scenario Results Summaries

A summary of the analysis results for all policy scenarios is shown in Table 2 below.

*Table 2. Summary of Analysis Results by Scenario*

| | Metric | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|---|
| Greenhouse Gas Emissions | Cap compliance | All years except 2050 | Met through 2023; slightly above 2024-2050 | Met through 2042; slightly above 2043-2050 | All years |
| | Cumulative greenhouse gas reductions statewide from Ref. Case, including use of CCIs: 2022-2050 (Mil. MTCO2e) | -298 | -210 | -309 | -269 |
| Health | Cumulative premature deaths avoided (2025-2050) | 166 | 172 | 153 | 183** |
| | Cumulative monetary valuation of avoided adverse health outcomes ($Bil; 2025-2050) | 2.08 | 2.16 | 1.90 | 2.29** |
| Economics* | Net employment impacts in 2050 | 19,600 | 18,000 | 14,100 | 19,700 |
| | Net Gross State Product impacts in 2050 ($Mil) | 1,700 | 1,610 | 1,350 | 1,730 |
| | Net income impacts in 2050 ($Mil) | 1,080 | 1,010 | 820 | 1,100 |
| Co-Benefits & Equity | Co-benefits analysis score | 19 | 16.5 | 17 | 19.5 |
| | Equity analysis score | 79.5 | 72 | 70 | 79 |

Notes:
*Emissions and health impacts shown here are cumulative. Economic impacts represent annual impacts in 2050 (i.e., a snapshot of that year). Economic impacts do not include overall economic impacts on invested CCIs or monetized public health benefits.
** For the health modeling, Scenario 4 used a different resolution (more detailed county-level data). Differences from Scenarios 1-3 will be due to both changes in the methodology and the underlying data.

## 3.3 Greenhouse Gas Results

Greenhouse gas emission reductions were modeled based on high-level estimates of technical potential of key measures (i.e., efficiency, electrification, alternative vehicles, renewable natural gas) that could reduce greenhouse gas emissions, derived from public sources of information, in combination with the application of the compliance flexibility measures of CCIs, trading, and banking of emissions over time. All four policy scenarios were designed to achieve significant greenhouse gas reductions, at 80% to 90% from a 2010 baseline year by 2050, with some scenarios also having interim greenhouse gas reduction targets in 2035 (see Table 1). Because of the ambitious reduction level, **all four scenarios model significant emissions reductions and compliance flexibility measures play an important role in achieving emissions reductions.**

Banking is used in all scenarios to a large extent over time, and plays a role throughout the modeled time period, and as emissions limits become more stringent in later years. CCIs are used to the almost fullest extent in all scenarios, and the allowable amount of CCIs per year appears to have significant impact on compliance with the program emissions limits throughout the modeled time period (especially Policy Scenario 4). For some years in some scenarios, net emissions inclusive of CCIs, banking, and trading may still be above the cap; for two scenarios this only occurs near the end of the modeling time horizon (Policy Scenarios 1 and 3).

It is important to remember that the greenhouse gas modeling assumes that regulated sectors have sufficient knowledge through 2050 to make optimal decisions for the future (e.g., whether to bank or trade). It also important to consider that current technologies and costs are used in the modeling, but available technologies and their costs are likely to change and decline in the future, which would influence actual program outcomes along with program design features. Emission reductions are estimated using a technical potential approach; there may be other more or less cost-effective approaches to reducing emissions based on specific circumstances.

*The series of figures below (*

Figure 2 through

Figure 5) present the results of greenhouse gas emission reductions for each policy scenario for the potentially regulated sectors of the program. Brief observations about each scenario are also provided in Table 3.

*Figure 2: Policy Scenario 1 Greenhouse Gas Results*

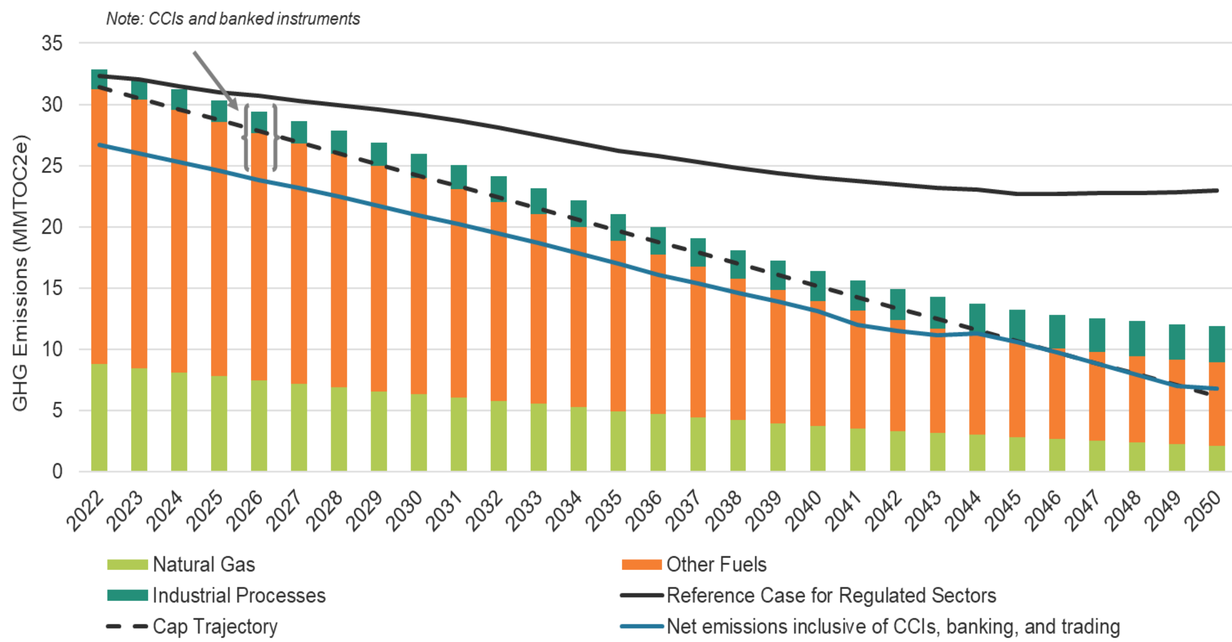


*Figure 3: Policy Scenario 2 Greenhouse Gas Results*

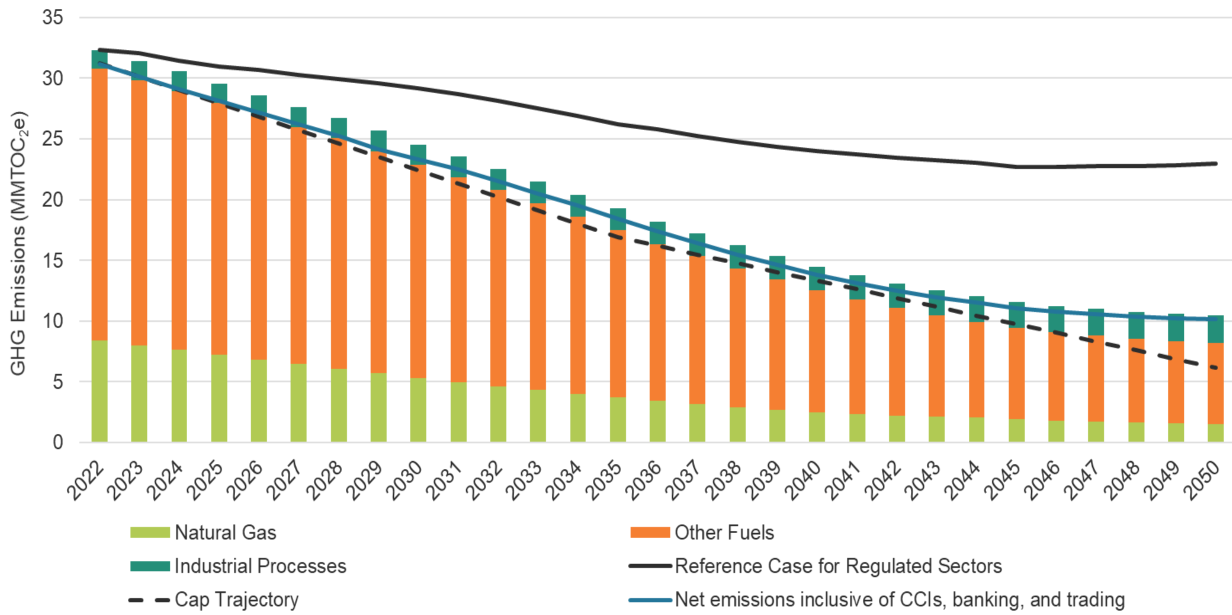



Figure 4: Policy Scenario 3 Greenhouse Gas Results

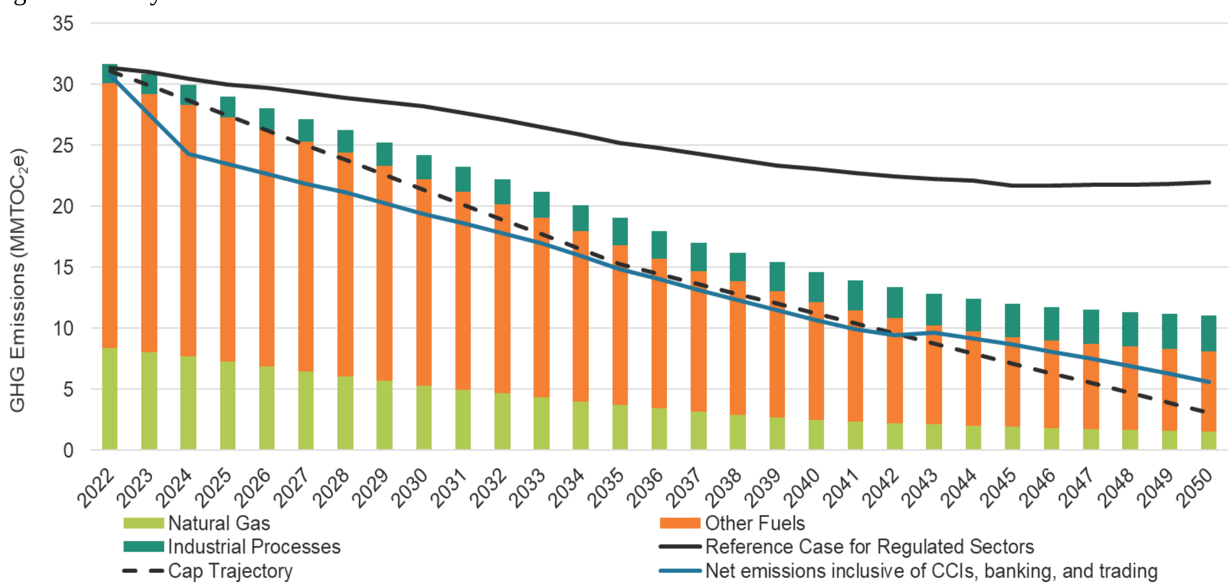


*Figure 5: Policy Scenario 4 Greenhouse Gas Results*

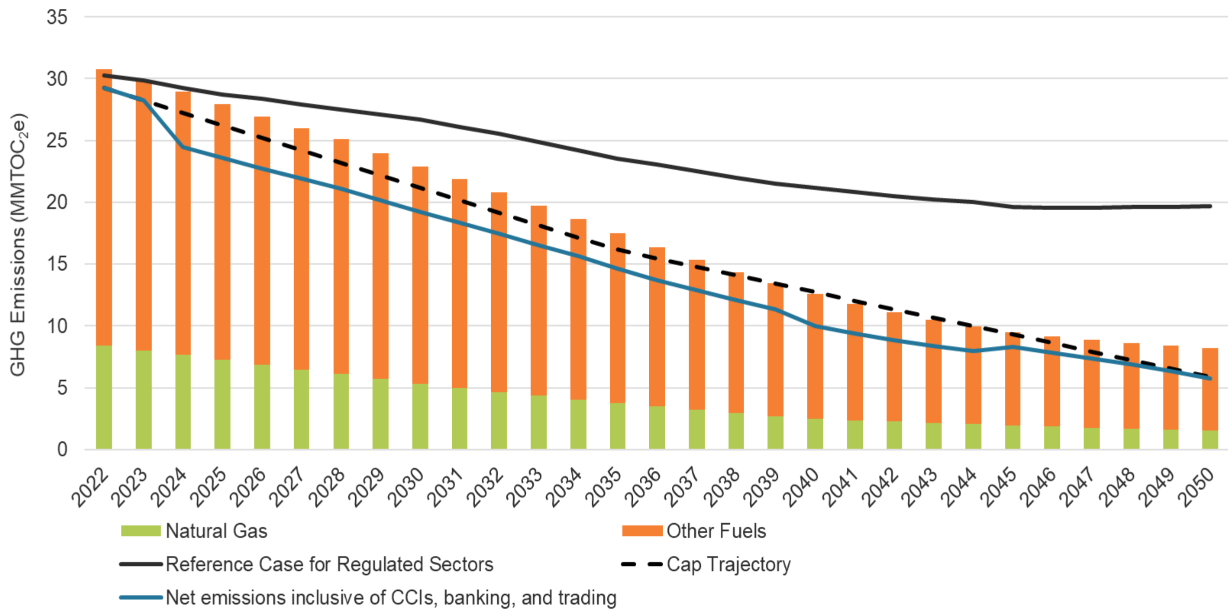


*Table 3: Key Greenhouse Gas Findings for each Policy Scenario*

| Policy Scenario | Key Findings |
|---|---|
| Scenario 1 | • Cap is met in all years except 2050.<br>• CCIs and banking make it possible to achieve the cap, particularly in later years.<br>• Trading does not appear to have a significant impact.<br>• Largest emissions reductions come from fuels, driven by expanded CFP, energy efficiency, and electrification.<br>• Natural gas emissions reductions driven by energy efficiency, electrification and RNG.<br>• Though a smaller source of regulated emissions, reductions in industrial process emissions requires achieving technical potential. |
| Scenario 2 | • Cap is met through 2023; net emissions slightly above cap 2024-2050.<br>• Maximum allowable CCIs used in most years.<br>• Less availability of banked compliance instruments.<br>• Net emissions above caps driven by combination of interim cap target, limit on use of CCIs, and largest quantity of regulated emissions.<br>• Largest emissions reductions come from fuels, driven by expanded CFP, energy efficiency, and electrification.<br>• Natural gas emissions reductions driven by energy efficiency, electrification and RNG.<br>• More extensive residential and commercial electrification driving reductions (than Policy Scenario 1).<br>• Increased reductions from energy efficiency for non-natural gas fuels (than Policy Scenario 1).<br>• Additional potential expansion of SB98 to drive RNG. |
| Scenario 3 | • Cap is met 2022-2042; net emissions above cap 2043-2050.<br>• Maximum allowable CCIs used in most years.<br>• Net emissions above cap in later period mainly driven by combination of lower caps compared to other scenarios and earlier full use of banked compliance instruments.<br>• Available CCIs supports achievement of cap into later years.<br>• Similar reductions (compared to Policy Scenario 2) from electrification, RNG, energy efficiency, and industrial processes; same reductions from expanded CFP. |
| Scenario 4 | • Cap is met in all years.<br>• Use of allowable CCIs below maximum threshold, mostly in earlier years.<br>• Similar reductions (compared to Policy Scenarios 2 and 3) from electrification, RNG, energy efficiency, and industrial processes; same reductions from expanded CFP. |

## 3.4 Health Results

**The health analysis showed that all four policy scenarios lead to significant reductions in adverse health impacts statewide, with relatively small differences among the four** (Table 4). The health analysis modeling indicated that total monetized health benefits (reported in 2020$) range from $1.9 billion (Policy Scenario 3) to $2.3 billion (Policy Scenario 4). This represents cumulative health benefits over the modeled period from 2025 through 2050, compared to the reference case. Monetized health benefits represent a range of avoided adverse outcomes, from lost workdays to asthma and respiratory effects, to fatal outcomes. Roughly half of the monetized value of avoided health outcomes is attributable to avoided mortality – nearly all adult mortality, but with a small fraction of avoided infant mortalities. Reduced morbidities make up the other approximately half of monetized avoided adverse health outcomes. Of these, reduced incidences of nonfatal heart attacks and hospital admissions are the leading contributors to avoided monetized impacts. This set of contributors is consistent across the difference policy scenarios.

*Table 4: Summary of High-Estimate Cumulative Avoided Mortality Cases and Benefits of Avoided Mortality and Morbidity from 2025-2050 (Reported in 2020$, 3% Discount Rate), by Scenario*

| Description | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 |
|---|---|---|---|---|
| Avoided Cases of Premature Mortality[a,b] | 166 | 172 | 153 | 183 |
| Value of Avoided Mortality (Billions, 2020$)[a,b] | $1.01 | $1.05 | $0.916 | $1.11 |
| Value of Avoided Morbidity ( Billions, 2020$) [a,c] | $1.07 | $1.11 | $0.984 | $1.18 |

Notes:
(a) Values integrated from 2025-2050 assuming linear trend between modeled years and no savings prior to 2025.
(b) Considers both adult and infant mortalities. High estimate for adult mortality based on mortality health effect function from Lepeule et al. (2013).
(c) Considers all non-mortality health effects. High estimate for non-fatal heart attacks based on health effect function from Peters et al. (2001).

Figure 6 illustrates the total, monetized, avoided health impacts – both mortalities and nonfatal outcomes – for each of the three modeled years (2025, 2035, and 2050) for all four policy scenarios. Policy Scenario 4 showed the greatest health benefits in all three years, followed relatively closely by Scenario 2. Scenario 4 employed a unique, county-resolved modeling approach, whereas Scenarios 1 through 3 rely on state-resolved emissions changes from vehicles, major stationary sources, and other fuel combustion activities. The total emissions changes at the state-level were similar between Scenarios 2 and 4, demonstrating that the more finely resolved county-level apportionment of emissions in Scenario 4 better pairs emissions reductions with populations, and results in higher overall health benefits. Also shown in Figure 6 is the impact of discounting, as the 2035-2050 period shows a smaller slope than the 2025-2035 period.

*Figure 6: Modeled Health Benefits per Scenario and Year, High Estimate, 3% Discount Rate*

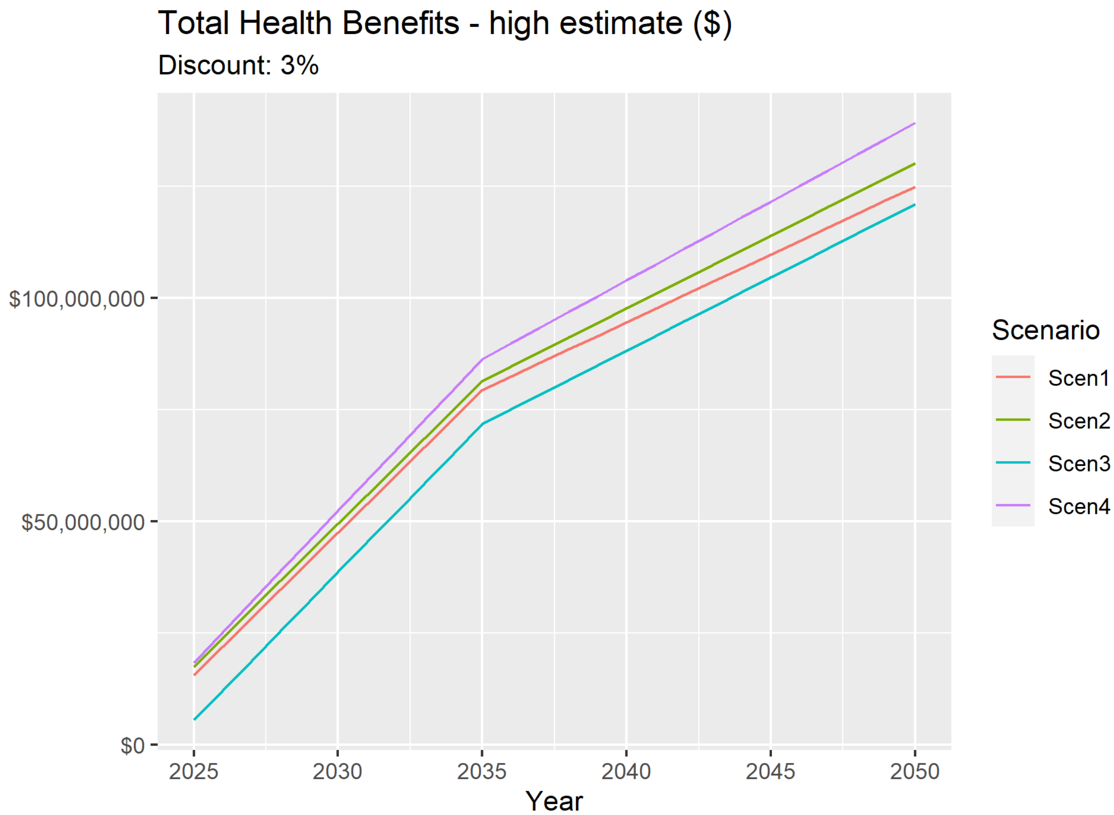



Figure 7 and Figure 8 show the distribution of total morbidity and mortality values by county across Oregon for Scenario 4. These values are cumulative over 2025 through 2050 and represent high estimates with a 3% discount rate. These are not per capita, thus in both cases benefits generally track with population, as expected. Total benefits under Scenario 4 are related to higher population, with counties such as Multnomah, Washington, and Clackamas Counties showing the most avoided costs. However, health benefits are products of the changes in emissions, the proximity of emission sources to population, the atmospheric conditions of the area, the total population, and the underlying health of the population. The differences in these two maps illustrates these influences. Nonfatal benefits are highest for Washington County (Figure 8) where the available baseline incidence data from Oregon Health Authority (OHA) showed higher non-fatal myocardial infarction incidence in Washington County than Multnomah for ages 65+, whereas Figure 7 shows the highest cumulative mortality benefits under scenario 4 were in Multnomah county.

It is difficult to directly attribute differences in health benefits between policy scenarios (as can be seen in Table 4) to the scenario designs (described in Table 1). This is due to the complex relationship between changes in emissions and health benefits, and between the different policy scenario designs and changes in magnitude and distribution of emissions across sectors of the economy. However, the one trend is the impact of different scopes of regulated fuels on emissions. Given the application of a 300,000 metric tons of emissions threshold in Scenario 3, the scope of regulated fuels in this scenario is smaller compared to the other scenarios. This smaller scope of regulated emissions from fuels, particularly liquid fuels, (non-road and on-road fuel uses) shrinks the overall emissions reductions achieved, leading to Scenario 3 showing the lowest health benefits of the policy scenarios, though the differences in the health benefits among the scenarios are minor.

Note that CCIs are not included in this health benefit evaluation. These results assume no benefits prior to 2025.

*Figure 7: County-Level Distribution of Monetized Benefits of Avoided Premature Mortality, High Estimate, 3% Discount Rate*

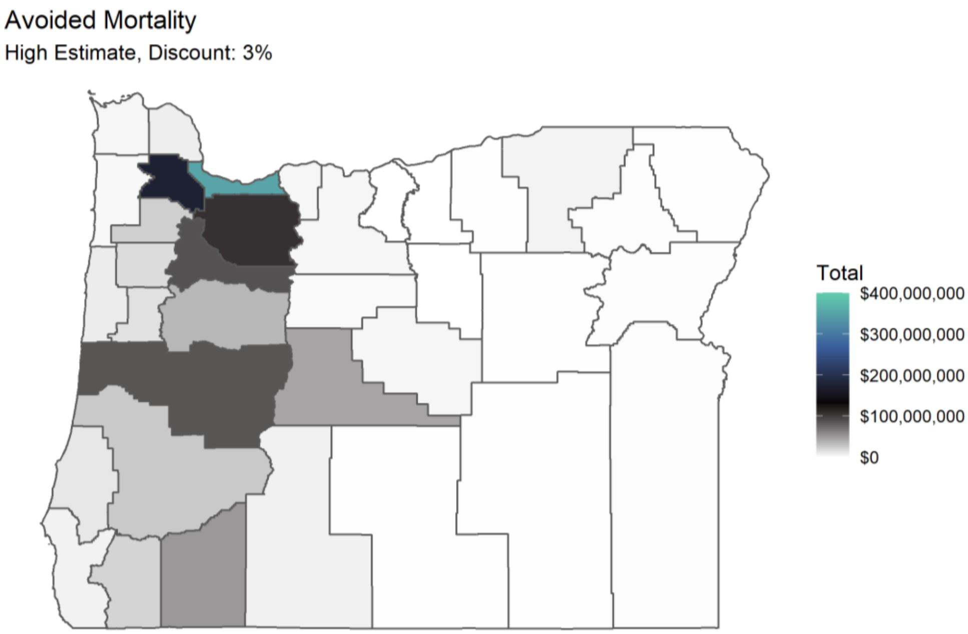
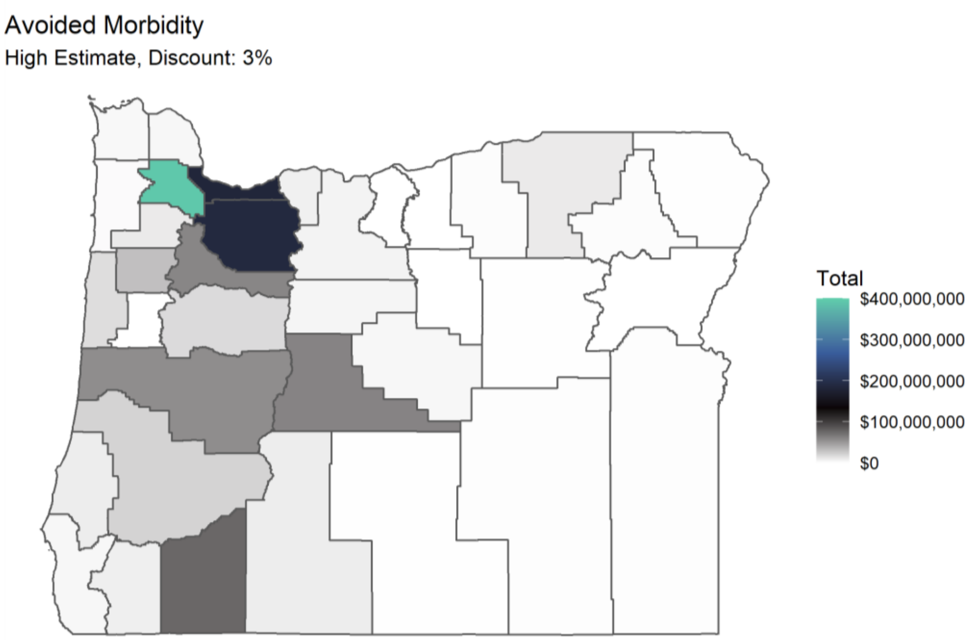



*Figure 8: County-Level Distribution of Monetized Benefits of Avoided Morbidity, High Estimate, 3% Discount Rate*



## 3.5 Economic Results

Overall, the modeled scenarios show positive, albeit, **small changes to the economy in the long run.** Net Job losses expected in the early years are driven by the high cost of investing in emissions reductions, but these short-term net losses are a tenth of a percent or smaller when compared to job losses expected during business-as-usual. As savings from reduced energy costs begin to accrue and outweigh the costs of investment, net job impacts become positive in the longer term. Similarly, accumulated savings from reduced energy costs outweigh the costs of investments, resulting in net positive gross state product and income impacts. Results are comparable across all four scenarios. The modeling results are strongly driven by significant investments in clean transportation, followed by smaller investments in energy efficiency, and electricity. This is due to early investments in light-duty electric vehicles, which are then expected to switch to a mix of light-, medium-, and heavy-duty vehicle investments by 2050. Additionally, the installation of energy efficiency equipment and electrification measures drove job gains in the construction and manufacturing sectors. Trade and transportation sectors saw job losses driven by changes in the fueling infrastructure, as well as reduced repair and maintenance demand.

These results do not account for CCI investments or the previously discussed monetized health benefits.

Altogether, these results indicate that the ambitious targets of the program can be achieved while still maintaining the economic health of the state.

More detailed results on impacts on employment, gross state product, and net income are discussed in the paragraphs and tables that follow.

### 3.5.1 Employment

Table 9 shows modeling results of the net direct, indirect, induced, and total **employment changes** for each scenario in 2025, 2035, and 2050. The net job changes in the total workforce are small compared to the overall economy, ranging from a -0.1% change in employment projections (the largest negative impact, occurring in Scenario 3 for 2025) to a 0.6% change in employment projections (the largest positive impact, occurring in Scenario 4 for 2050). Job changes are initially negative, but turn positive over time. Scenario 4 has the largest total net employment change in the long run, having a net change of 19,600 FTEs in 2050. Fossil fuel sector changes and opportunity costs of investments are negative drivers of impact, leading to net reduction in employment impacts in the short run. Over time, however, investments in electrification and clean transportation, as well as customer cost savings from transitions that reduce energy consumption, drive significant positive employment impacts, ensuring the net impacts turn positive in the long run.

*Table 5: Net Employment (FTE) Changes by Scenario*

| | Scenario 1 | | | Scenario 2 | | | Scenario 3 | | | Scenario 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** |
| **Direct** | (400) | 2,100 | 13,500 | (800) | 300 | 12,500 | (1,000) | 300 | 9,700 | (900) | 1,400 | 13,700 |
| **Indirect** | (400) | (760) | (30) | (700) | (1,400) | (400) | (700) | (1,400) | (600) | (700) | (1,400) | (300) |
| **Induced** | (200) | 1,400 | 6,100 | (800) | 400 | 6,000 | (800) | 400 | 5,000 | (800) | 700 | 6,300 |
| **Total** | **(1,000)** | **2,700** | **19,600** | **(2,300)** | **(700)** | **18,000** | **(2,600)** | **(700)** | **14,100** | **(2,400)** | **700** | **19,700** |

### 3.5.2 Gross State Product

Table 10 shows the modeling results of net direct, indirect, induced, and total **gross state product changes** by scenario in 2035 and 2050. The net gross state product changes are small, but positive over time. The largest positive impact at $1,730 ($ Million) occurs in Scenario 4 for 2050, but results are comparable for all scenarios. Investments and savings from customer energy costs have larger positive impacts than negative impacts driven by opportunity costs.

*Table 6: Net Gross State Product Changes by Scenario (2025, 2035, 2050)*

| Impact | Scenario 1 | | | Scenario 2 | | | Scenario 3 | | | Scenario 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **($ Million)** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** |
| **Direct** | 120 | 410 | 1,060 | 190 | 450 | 1,030 | 180 | 450 | 880 | 180 | 520 | 1,100 |
| **Indirect** | 0 | (10) | 50 | 10 | (20) | 30 | 0 | (20) | 10 | 10 | (10) | 40 |
| **Induced** | (20) | 130 | 560 | (70) | 30 | 550 | (80) | 30 | 460 | (70) | 60 | 580 |
| **Total** | **100** | **530** | **1,700** | **130** | **460** | **1,610** | **100** | **460** | **1,350** | **120** | **560** | **1,730** |

### 3.5.3 Income

Table 7 shows the modeling results of net direct, indirect, induced, and total **income changes** by scenario in 2035 and 2050. Net total income changes are small but positive; they are smaller in earlier years and trend upward in later years. Scenario 4 has the highest net income by 2050, but other scenarios are comparable. Results are mainly driven by consumer cost changes from energy and fuel consumption. Over time, consumers save money on energy costs and those accumulated savings compensate for other losses.

*Table 7: Net Income Changes by Scenario (2025, 2035, 2050)*

| Impact | Scenario 1 | | | Scenario 2 | | | Scenario 3 | | | Scenario 4 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **($ Million)** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** | **2025** | **2035** | **2050** |
| **Direct** | 40 | 220 | 790 | 50 | 170 | 750 | 40 | 170 | 610 | 50 | 220 | 800 |
| **Indirect** | (20) | (50) | (20) | (30) | (80) | (40) | (30) | (80) | (50) | (30) | (80) | (30) |
| **Induced** | (10) | 70 | 310 | (40) | 20 | 300 | (40) | 20 | 260 | (40) | 30 | 330 |
| **Total** | **20** | **240** | **1,080** | **(20)** | **110** | **1,010** | **(30)** | **110** | **820** | **(20)** | **180** | **1,100** |

## 3.6 Co-Benefits and Equity Results

Cascadia's analysis indicates that there are positive co-benefits and equity benefits in all policy scenarios compared to the reference case. 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. Of the five categories of co-benefits assessed,[1] the greatest amount of benefits are indicated for ecosystem and public health.

The five categories of co-benefits include: local air quality; ecosystem health & resilience; energy security; employment & workforce development; and housing burden. Of these categories, the results for housing burden—which considers impacts on utility, transportation, and housing costs—are more mixed, and warrants consideration of mechanisms to ensure potential negative housing burden impacts are mitigated. The design of CCIs, in particular, could be critical to alleviating housing burden through the provision of rebates, cost-share programs, and utility cost

[1] Local air quality, ecosystem health & resilience, energy security, employment & workforce development, and housing burden.

savings through home energy efficiency projects and upgrades. Trading of compliance instruments can also be a mechanism for keeping energy costs low, which is an important driver in housing burden.

Cascadia's assessment indicates all policy scenarios could bring benefits to all communities of concern evaluated.[2] Urban low-income households and communities of color experience the most benefits. Meanwhile, the assessment indicates that elderly populations are the communities of concern that would experience the lowest—but still positive—overall benefits.

The drivers of the equity benefits include assumed benefits from the use of CCIs, as well as health improvements associated with greenhouse gas reductions from regulated sectors. Thus, the design of CCIs will be critical from the perspective of benefits to communities of color.

Table 9 and Table 10, below, summarize the findings of the co-benefits and equity assessments, respectively. The scores and colors are based on the following qualitative ranking scale (Table 8):

*Table 8. Qualitative Ranking Scale for Co-Benefits and Equity Assessment*

| | | |
|---|---|---|
| 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. |

[2] Communities of color, tribal nations, elderly populations, low-income urban communities, low-income rural communities.

*Table 9. Summary of Co-Benefits Findings*

| 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 Scenario 4.<br>• Non-natural gas fuel suppliers: smaller scope of emissions regulated in Scenario 3.<br>• As major sources of criteria air pollutants, reductions in transportation vehicle and fuel emissions will carry significant health benefits.<br>• Use of CCIs could benefit indoor air quality (e.g., electric appliances) and outdoor air quality (transit and freight fleet fuel conversion). |
| Ecosystem health & resilience | 3 | 4 | 4 | 3.5 | 4.5 | • Criteria air pollutants: lowest in Scenario 4.<br>• Transition from fossil fuel sources could reduce the risk of ecosystem impacts from fuel production and transport, but solar could have land use implications.<br>• 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.<br>• 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.<br>• 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.<br>• 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 Scenario 1, 2, and 4 showing the highest benefits.<br>• 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.<br>• 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). |

| Indicator | Reference Case | Scenario 1 | Scenario 2 | Scenario 3 | Scenario 4 | Key Rationale/Considerations |
|---|---|---|---|---|---|---|
| | | | | | | • Net job gains across scenarios over time can result in improvement in housing burden. |
| TOTAL SCORE | 12 | 19 | 16.5 | 17 | 19.5 | |

*Table 10. Summary of Equity Findings*

| | | 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 |

Additional co-benefits and equity assessment results, along with methods used in the assessment are available in the Appendix: Methodology and Results of Co-Benefits and Equity Assessment in *Modeling Study on Program Options to Reduce Greenhouse Gas Emissions: Assumptions, Data Sources, and Methods*.