Climate Protection Program: Modeling Study on Program Options: Results Overview

To be discussed at the RAC meeting on June 17, 2021

Modeling Policy Scenario Overview

- DEQ developed four modeling scenarios informed by RAC and public engagement
- Modeling policy scenarios are to inform development of the CPP
  - Do not represent all options for CPP design or specific CPP proposals
- Modeling policy scenarios are compared against a reference case
  - Projected future world without CPP to help understand potential program outcomes
- Summary results include GHG emissions, monetized health benefits, macroeconomic metrics and co-benefits and equity assessment
- Results are both quantitative or qualitative
- Community climate investments (CCIs) are included in emissions modeling and addressed in co-benefits and equity analysis
  - CCIs not included in health and economic analysis

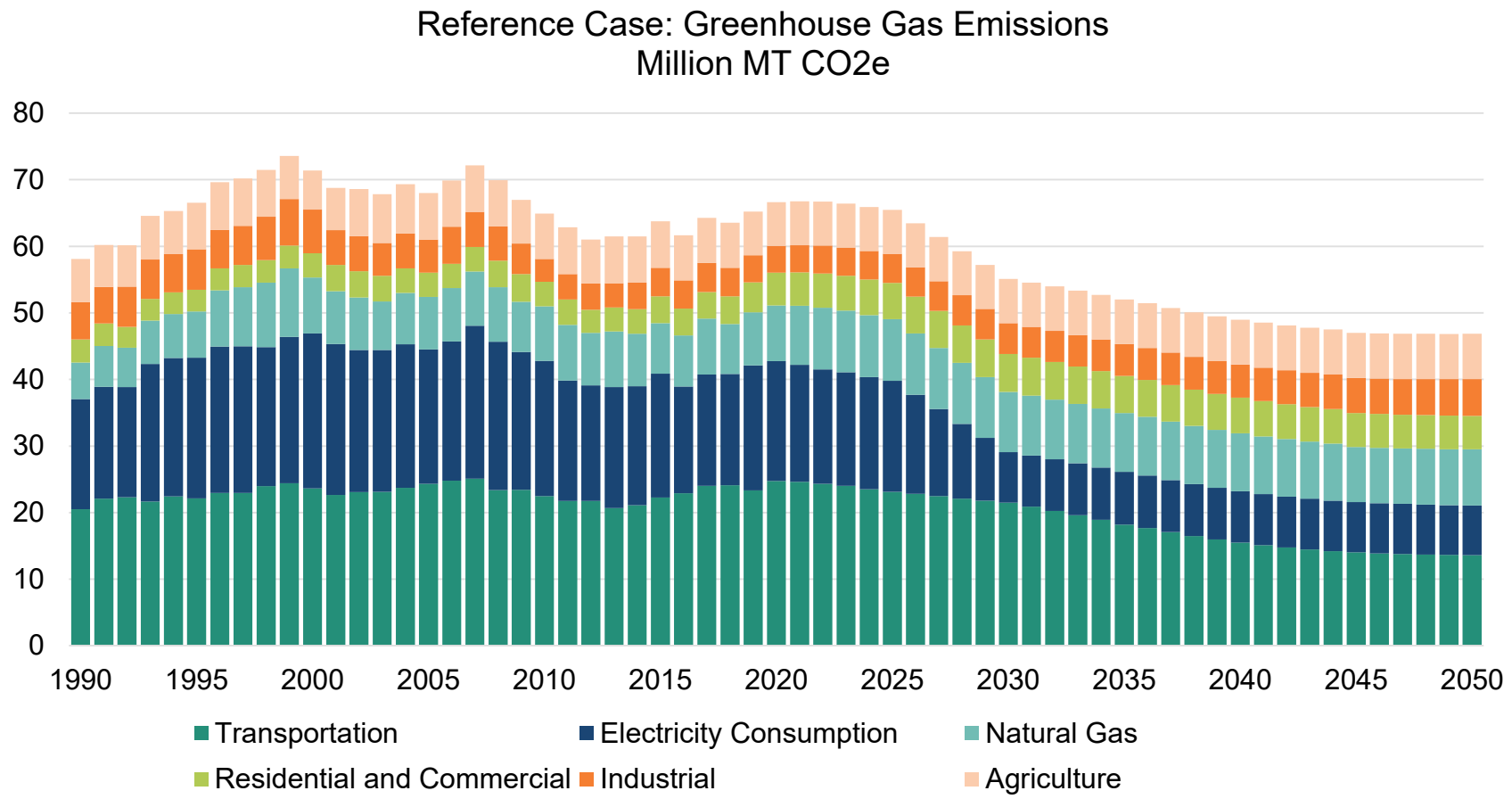
Revisions and Updates

- Initial reference case results have been updated since April 2021 RAC meeting
- Update is the result of a modeling correction for application of VISON model transportation fuel use estimates
- Reference case emissions are now higher than initially projected
  - Higher transportation sector emissions
- Since the policy scenarios look at differences from the reference case, the correction results in some emissions changes in some years for policy scenarios
  - Minor changes to co-benefits and equity analysis, which remain positive for all scenarios
  - Economic changes continue to be small overall, but now trend more positive
  - Health results are unchanged as the error was not made when applying the data in COBRA

Reference Case

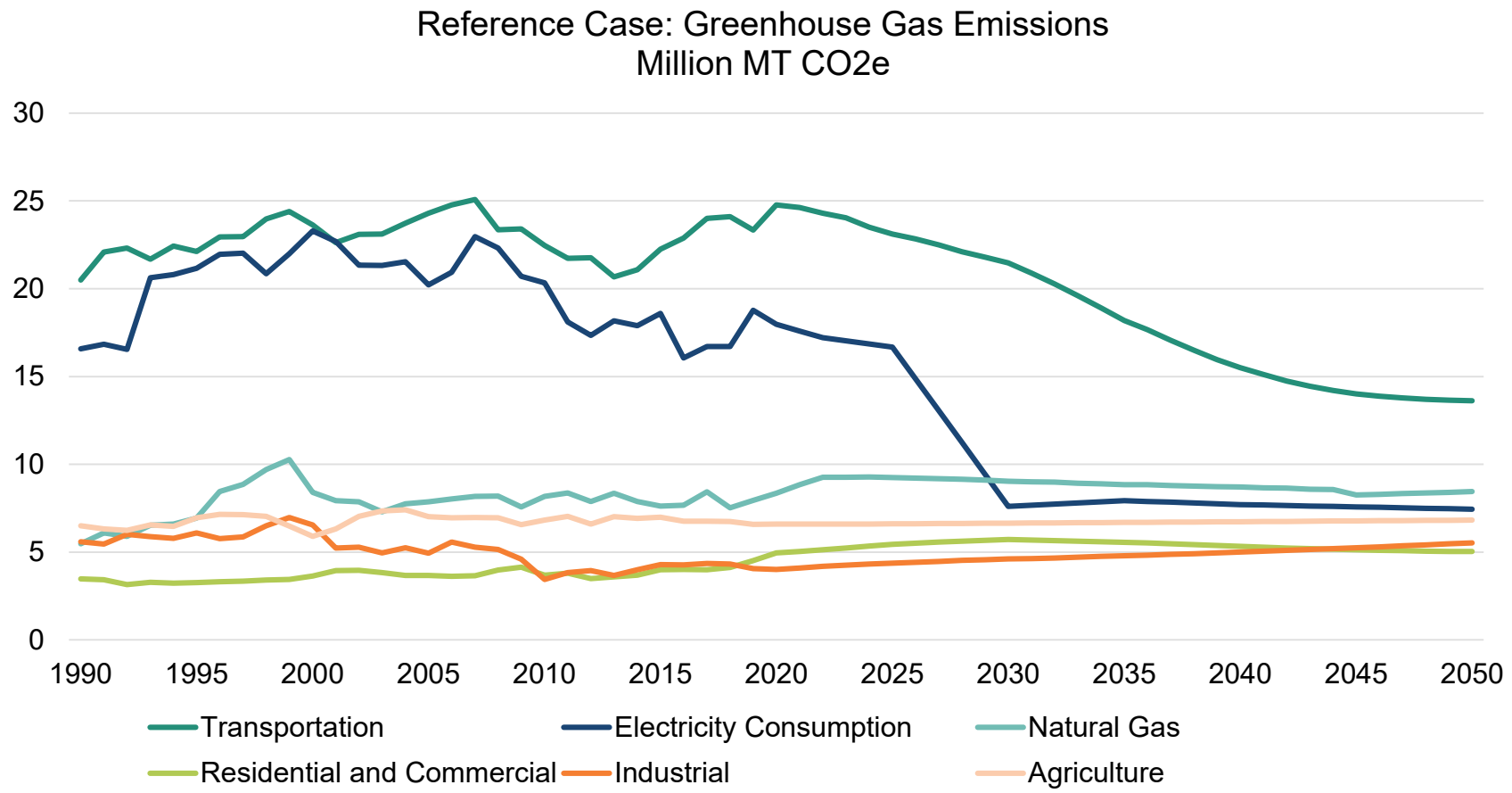
Results and takeaways

Reference Case: Results



Note: See separate assumptions slide deck for descriptions of emissions included in each sector.

Reference Case: Results



Note: See separate assumptions slide deck for descriptions of emissions included in each sector.

Reference Case: Key Takeaways

- Transportation
  - Largest source of in-state emissions by 2050
  - Emissions declines due to Clean Fuels Program and CAFE standards
- Natural gas
  - Emissions remain relatively flat
  - Minor decline over time due to renewable natural gas procurement (Senate Bill 98)
- Industrial (non-electric or gas related)
  - Emissions remain relatively small
  - Minor increase over time for increased energy use and process emissions as a result of manufacturing growth
- Electricity
  - Emissions continue to decline through 2035 due to increased renewables and coal no longer procured after 2030
- Residential and commercial
  - Minor emissions increases due to landfills and high global warming potential materials (refrigerants)

Greenhouse Gas Emissions

Results and takeaways for four policy scenarios

Policy Scenario Common Assumptions

Key Topic	4 Policy Scenarios
Cap Application	One cap applied across all sectors using 2010 data for baseline with cap beginning in 2022 *(regulated sectors and therefore scopes of regulated emissions vary by scenario)*
Banking Allowed?	Yes; unlimited through time
Community Climate Investments (CCI) allowed?	Yes, but allowable percentage for compliance varies by scenario
CCI Price *(see table)*	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*

CCI Price
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

*DEQ intends to open a rulemaking in 2021 to develop expanded Clean Fuels Program targets

Policy Scenario Different Assumptions

Key Topic	Policy Scenario 1	Policy Scenario 2	Policy Scenario 3	Policy Scenario 4
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
Trading Allowed?	Yes	Yes, excluding stationary sources	Yes	Yes
Regulated under the Cap	- 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 (includes gas supplied by interstate pipeline companies to those above threshold)	- 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 fossil fuel suppliers
Emissions not included in the Cap	- Fuels used for aviation - Process emissions below threshold	- Fuels used for aviation - Process emissions below threshold	- Fuels used for aviation - Emissions from fuel suppliers below threshold - Process emissions below threshold	- Fuels used for aviation - Large stationary sources are assumed to be regulated under a separate best available technology approach
Natural Gas Point of Regulation	All natural gas regulated at utility, not at stationary source.	Natural gas regulated at stationary sources if emissions are above threshold. Otherwise, natural gas regulated at utility.	All natural gas regulated at utility, not at stationary source.	All natural gas regulated at utility, not at stationary source.
Use of CCIs	Up to 25% of compliance per year	Up to 5% of compliance per year	Up to 25% of compliance per year	Up to 20% of compliance per year

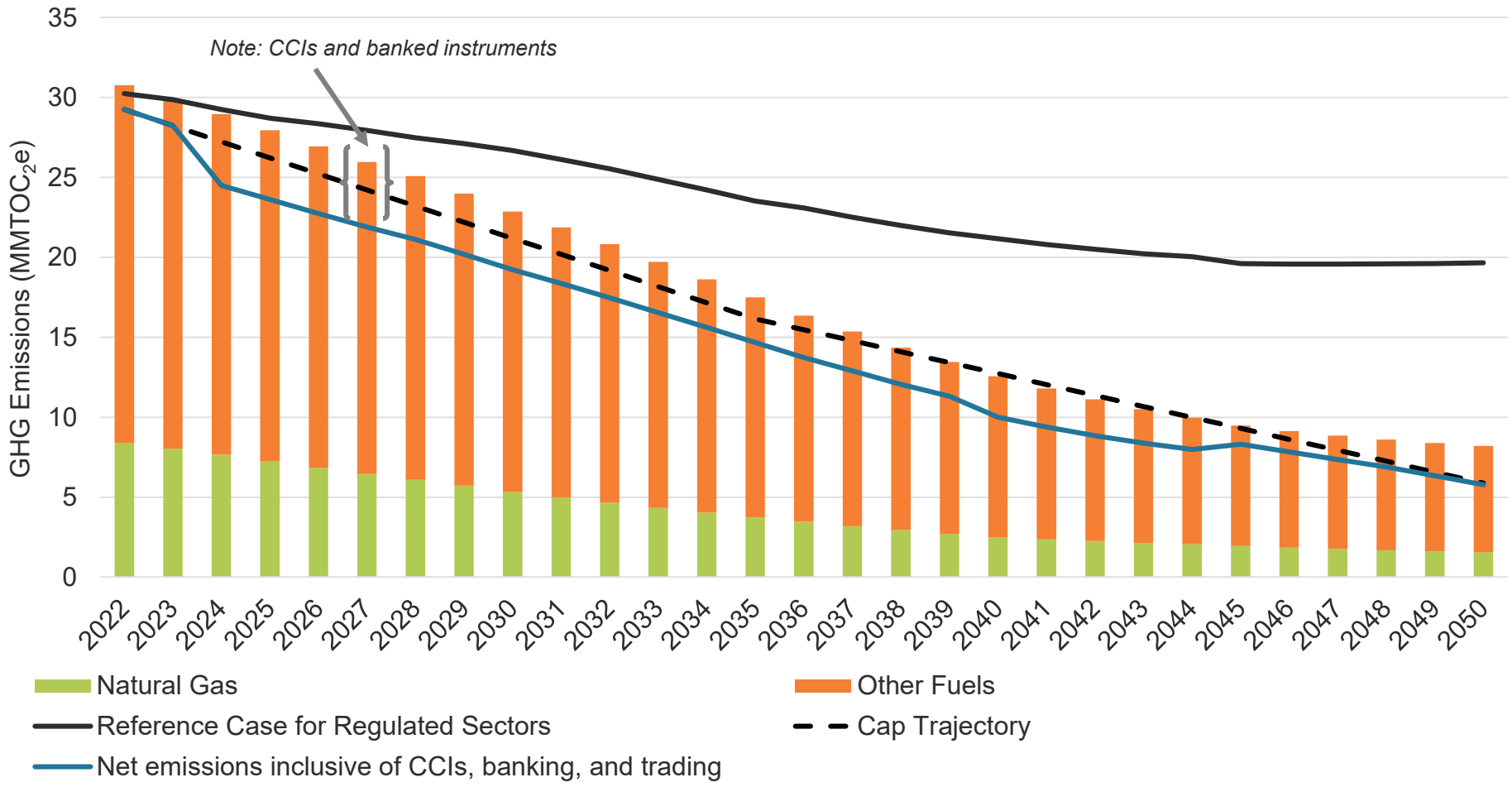
Understanding Results in Context

- Modeling assumes that the regulated entities have sufficient knowledge to make optimal decisions in the future
  - E.g., Banking versus trading
- 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
- Modeling is conducted at the sector level (i.e., natural gas, other fuels) and sub-sector level (e.g., residential, cement manufacturing)
- Results presented are for emissions from regulated sectors

Understanding Results in Context

- 2019 emissions and fuel supply data used to determine if emissions were regulated in policy scenarios
- Technical potential emissions reductions and costs per ton rely on a variety of resources
- Some modeled drivers of reductions include:
  - Energy efficiency
  - Fuel switching/electrification
  - Renewable natural gas
  - Destruction, removal, or recovery of industrial process emissions

Emissions Results: Scenario 4



Emissions Results: All

- Compliance flexibility measures play an important role in achieving emissions reductions
  - Banking used in all scenarios
  - CCIs used to the almost fullest extent in scenarios
- Trading and point of regulation had minimal effects in modeling
- Emissions reductions are driven by transportation sector
- Other reductions are achieved with building energy efficiency, electrification, and renewable natural gas

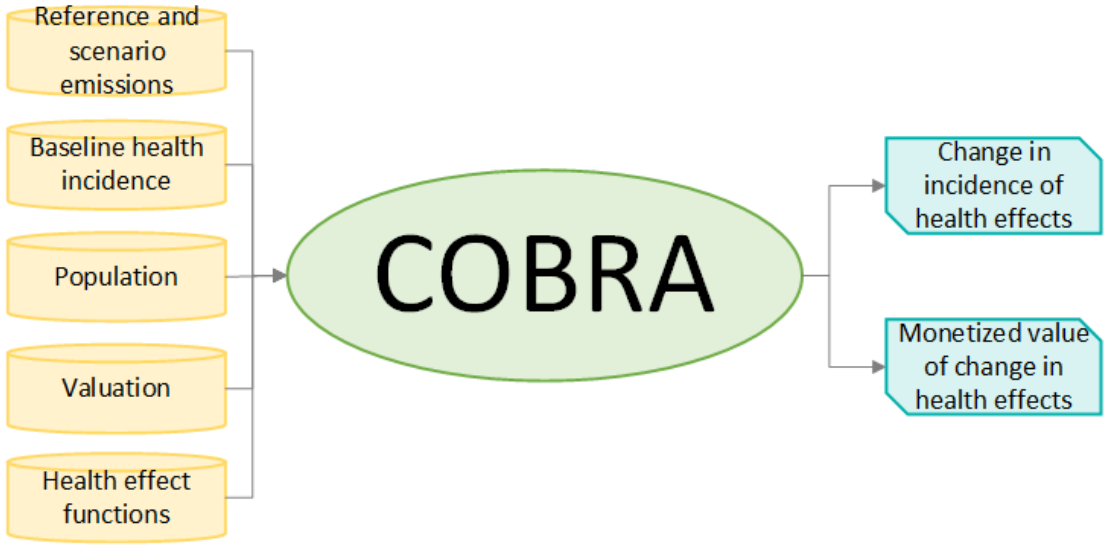
Emissions Results: All

Metric	Scenario 1	Scenario 2	Scenario 3	Scenario 4
Cap compliance	All years except 2050	Met through 2023; slightly above 2024-2050	Met through 2042; slightly above 2043-2050	All years
Key policy drivers	CCIs and banking make it possible to achieve the cap, particularly in later years.	Maximum allowable CCIs used in most years. Less availability of banked instruments. Net emissions above caps driven by combo. of interim cap target, CCIs percentage and quantity of regulated emissions.	Maximum allowable CCIs used in most years and supports achievement of cap into later years. Net emissions above cap in later period driven by combo. of lower caps (compared to other scenarios) and earlier use of banked instruments.	Use of allowable CCIs below maximum threshold, mostly in earlier years.
Drivers of emissions reductions	Largest emissions reductions come from fuels, driven by expanded CFP, energy efficiency, and electrification. Natural gas emissions reductions driven by energy efficiency, electrification and RNG.	More extensive residential and commercial electrification driving reductions. Also increased reductions from energy efficiency for non-natural gas fuels. Near maximum modeled technical potential for RNG.	Similar reductions from electrification, RNG, energy efficiency, and industrial process emissions compared to Scenario 2.	Similar reductions from electrification, RNG, and energy efficiency compared to Scenarios 2 and 3.

Health

Results and key takeaways for final four policy scenarios

Health Analysis Modeling



- COBRA used to estimate the public health impacts of emissions changes of particulate matter (PM2.5) and its precursors (NOx, SO2, NH3, and VOC)
- Emissions are from fossil fuel combustion only
- Sectors with no changes due to the policy scenarios are treated as having no change in emissions
- Does not capture any potential benefits from CCIs

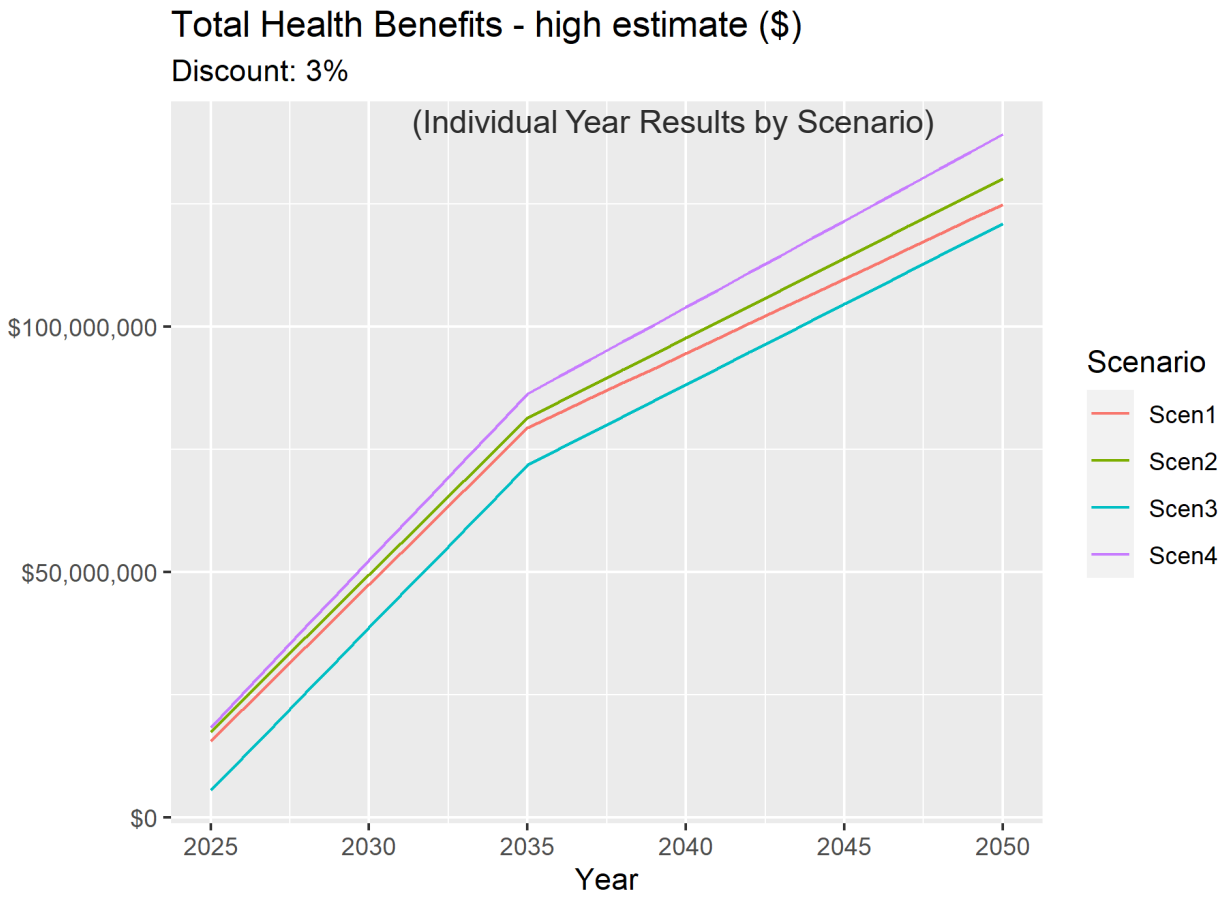
Assumptions & Results Reporting

- Health outcomes and monetized health benefits for 2025, 2035, 2050 model years
  - Valuation of health endpoints scaled to future-year values, where possible[1]
  - Future year benefits discounted to the start of the evaluation period (2022) at 3% and 7% discount rates[2] to express future economic values in present terms
- Scenario 1-3 state-level emissions apportioned to counties using model's default proportions for 2023
- Scenario 4 emissions resolved at the county scale for all sectors
- COBRA population and incidence inputs customized with data from PSU/Metro and OHA

[1]Valuation projections available only for certain endpoints (mortality, acute bronchitis, asthma exacerbation, upper and lower respiratory symptoms)
[2]The discount rate accounts for the fact that people generally value future benefits and costs less than current costs and benefits. We discount the value of premature mortality occurring in future years using rates of 3% and a conservative 7%, consistent with EPA. (Estimating the Benefit per Ton of Reducing PM2.5 Precursors from 17 Sectors, 2018; BenMAP User's Manual, 2018; Guidelines for Preparing Economic Analyses, 2010)

Health Results Monetized Values, All Outcomes by Year

- Total state-wide $ health benefits by year for the 3 modeled years
  - High estimates,[1] 2020$, discounted to the start of the evaluation period (2022) at a 3% rate[2]
- Roughly half the monetized avoided health costs are attributable to avoided mortality
- Reduced incidence of heart attacks and hospital admissions leading contributors to avoided morbidity costs



[1]High estimate reflects health impact functions for mortality and non-fatal heart attacks that result in larger benefits
[2]The discount rate expresses future economic values in present terms. Not all health effects and associated economic values occur in the year of analysis.

Health Results: Cumulative Results

Mortality: Cumulative avoided deaths and corresponding mortality valuation over the life of the program[1]

Scenario 1	Scenario 2	Scenario 3	Scenario 4
166	172	153	183
$1.01B	$1.05B	$0.916B	$1.11B

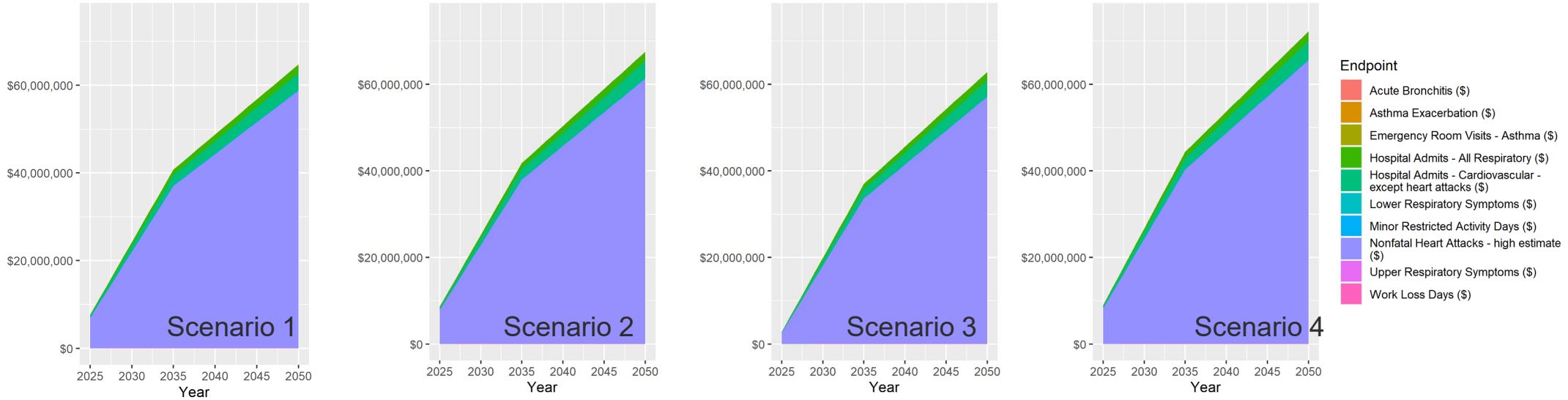
Morbidity: Cumulative avoided morbidity benefit valuation over the life of the program[1]

Scenario 1	Scenario 2	Scenario 3	Scenario 4
$1.07B	$1.11B	$0.984B	$1.18B

[1] Integrated from 2025-2050. Assumes linear trend between modeled years and no savings before 2025. Considers both adult and infant mortalities.

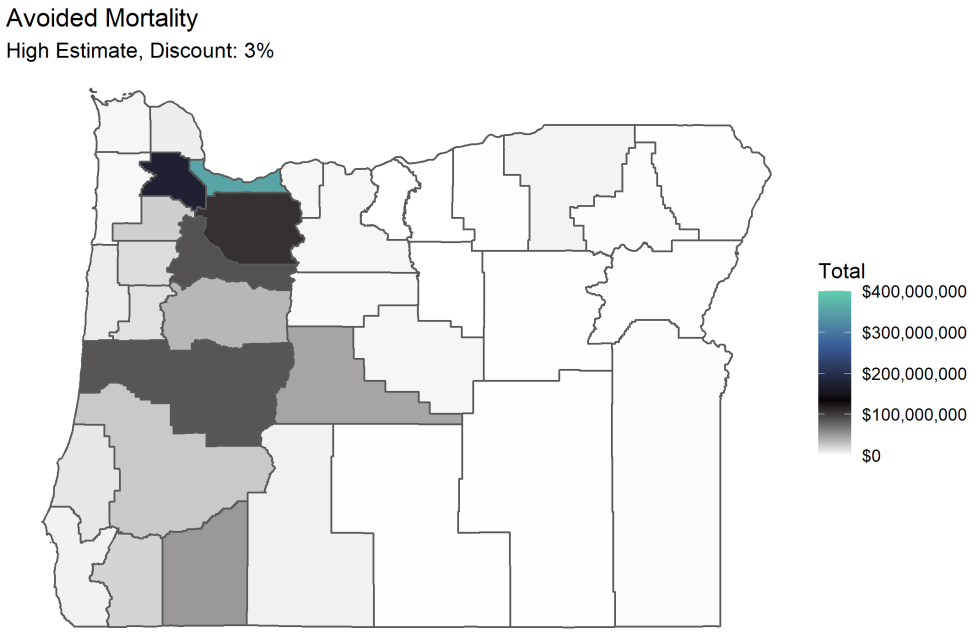
Health Results: Cost Drill Down

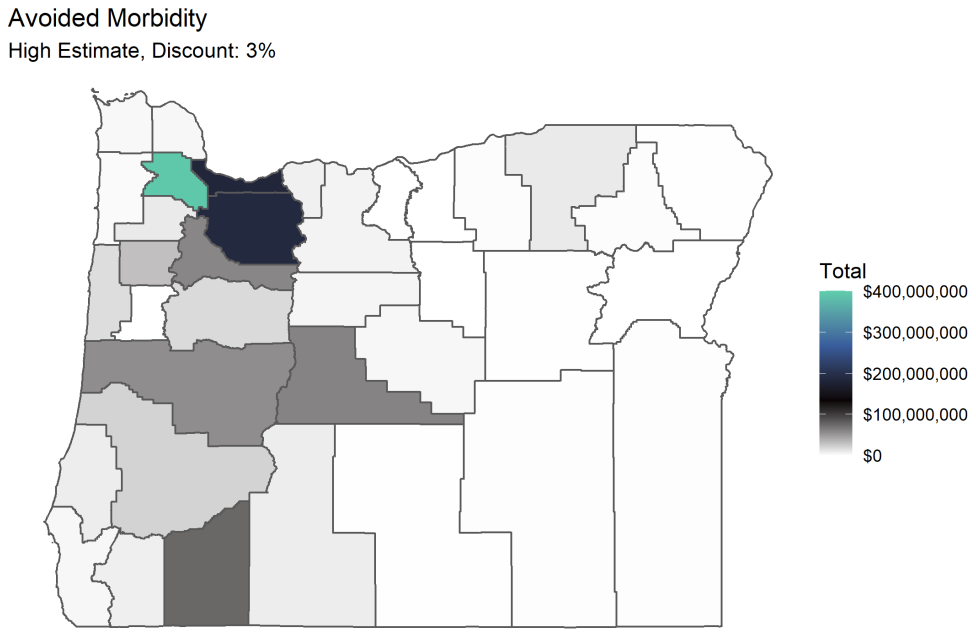
Morbidity by Endpoint: Total Monetized Benefits by Year, Discount = 3%, 2020$ (high estimates)



Scenario 4: County-Level Health Impacts

Scenario 4: Distribution of Avoided Adverse Health Outcomes





Total monetized benefits from avoided adverse health outcomes.
Cumulative from 2025-2050, by county

Avoided mortality estimates include both infants and adults.
Discount = 3%, 2020$. High estimates reflect mortality and nonfatal myocardial infarction health impact functions from Lepeule et al. (2012) and Peter et al. (2001), respectively.

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.

Health Results Summary

- All Scenarios show significant reduction statewide in adverse health impacts
  - Due to changes in criteria pollutant emissions from all modeled sectors statewide, including on-road mobile sources, electricity generation, and other sources
  - Avoided statewide due to reduced exposure to air pollution from 2025-2050 [1,2,3]
- Relatively small differences between scenarios
- Examples:
  - Scenario 2 statewide results: 172 mortalities and monetized values of $2.16B (2020$)
  - Scenario 4 statewide results: 183 mortalities and monetized values of $2.29B (2020$)

[1] High estimates, monetized at 3% discount. All monetary values discounted to 2022.
[2] Our approach to allocating emissions to COBRA values by county and source's "stack height" preferred preserving all emissions over preserving default county stack heights. A sensitivity analysis showed the latter could increase benefits very modestly (<1.5%).
[3] COBRA valuation component aims to monetize public health benefits, not calculate healthcare cost savings. Many endpoints (e.g., mortality, acute bronchitis) are valued using non-market valuation based on willingness to pay (WTP) estimates. Endpoints for which WTP is not available, valuation is approximated using healthcare cost savings and lost productivity. The valuation estimates represent an approximate value residents of Oregon would place on avoiding the statistical cases of characterized endpoints; these estimates are not comparable with market impact estimates generated by the economic analysis component.

Economic

Results and key takeaways for four policy scenarios

Economic Analysis Overview & Data Sources

- IMPLAN economic model analyzes regional economic effects of policy scenarios on a single, pre-specified region (Oregon)
  - Data vintage: 2019
  - Inputs: investments in energy efficiency and electrification, changes in fuel costs savings, impacts on energy producing sectors, budgetary impacts of investments on OR residents and businesses
- Three primary types of impacts (multipliers)
  - **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)

Economic Analysis Methodology

- Positive economic impacts associated with investments in various clean energy options that affect various industries
  - Energy efficiency, electrification, and electric vehicle adoption
- Long-term, these investments lead to fuel cost savings for OR residents
- Negative economic impacts associated with sectors bearing losses
  - Mostly fossil fuel related sectors
- Modeling also accounts for budgetary implications of the investments
  - Assuming limited resources (for businesses) and budget constraints (for households)
  - Economic results do not incorporate CCI investments or the previously discussed monetized health benefits
- Modeling results provide a holistic picture of total impacts
- Presented results are for net changes

Results: Employment, Net

- Net job changes are small compared to the overall economy but generally positive
  - Changes are small, ranging from -0.1% to 0.6% of total workforce
- Multiple drivers of impacts:
  - Positive impacts driven by electrification and clean transportation investments as well as fuel cost savings from transition in fuel consumption
  - Negative impacts driven by fossil fuel sector changes and opportunity costs of investments

	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**

Results: GSP and Income (2035 & 2050), Net

GSP: Net Gross State Product (GSP) changes are small but positive generally, especially in long run

- Investments and consumer energy cost savings have larger positive impacts than opportunity costs have negative impacts

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
($2020 Million)	2035	2050	2035	2050	2035	2050	2035	2050
Total	530	1,700	460	1,610	460	1,350	560	1,730

Income: Net income changes are small and trend upward in later years

- Scenario 4 has the highest net income by 2050, but results are comparable across scenarios
- Results driven by consumer cost changes from energy and fuel consumption
- Consumers save money on these costs and accumulated savings compensate other losses

	Scenario 1		Scenario 2		Scenario 3		Scenario 4	
($2020 Million)	2035	2050	2035	2050	2035	2050	2035	2050
Total	240	1,080	110	1,010	110	820	180	1,100

Economic Results Summary

- Overall, small changes to economy, but generally positive for GSP, income, and jobs
  - Job changes are small, ranging from -0.1% to 0.6% of total workforce
- Results are similar and comparable across the scenarios
- Drivers of results in modeled years
  - Accumulated savings from reduced energy costs outweigh costs of investments in the long run
  - Largest driver comes from transportation sector changes
    - Significant investments in clean transportation expands fuel cost savings and fossil sector impacts
  - Electrification and energy efficiency investments
- Construction and manufacturing sectors see job gains, while trade and transportation sectors see job losses
  - Installation of EE equipment and electrification measures
  - Changes in the fueling infrastructure as well as reduced repair and maintenance demand

Co-benefits and Equity

Results and key takeaways for four policy scenarios

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
  - DEQ provided assumptions for possible CCI project types

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.

Co-Benefits Results: Summary

- Overall, all policy scenarios see increased co-benefits over reference case
- Highest benefits around public and ecosystem health
  - Significant statewide reduction in adverse health impacts
- Housing burden benefits are mixed depending on policy scenario
- GHG reductions, CCIs and other compliance flexibility play an important role in equity and co-benefits

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**

Equity Analysis Results: Summary

- Overall, all policy scenarios are projected to benefit identified communities of concern as compared to the reference case
- Compared to other communities of concern:
  - Urban low-income households and communities of color experience most benefits
    - Benefits from CCIs projects and health benefits from emissions reductions from regulated sectors
  - Elderly populations experience the fewest benefits
- Key policy scenario drivers of results include:
  - Type and extent of regulated sectors
  - Allowance of compliance flexibility options like banking and CCIs
  - Associated distribution of impacts across geographies and communities
- Equity benefits of CCIs will rely on targeting areas with communities of concern and GHG and other air pollutant emissions

Equity Analysis Results: Scenarios 1-2

Indicator Category	Indicator	Reference Case (Total = 50.5)				
		Comm. of Color	Tribes	Urban Low-Income	Rural Low-Income	Elderly
Health	Local 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 & 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**

Indicator Category	Indicator	Scenario 1 (Total = 79.5)					Scenario 2 (Total = 72)				
		Comm. of Color	Tribes	Urban Low-Income	Rural Low-Income	Elderly	Comm. of Color	Tribes	Urban Low-Income	Rural Low-Income	Elderly
Health	Local air quality	4	4	4	4	3.5	4	3.5	4	3.5	3.5
Environmental	Ecosystem health & resilience	4	4	4.5	4	4	4.5	3.5	4.5	3.5	3.5
Economic	Energy security	2.5	2	2.5	2	2.5	2	1.5	2	1.5	2
	Employment & workforce development	3.5	3.5	4	4	1	3	3	3.5	3.5	1
Social	Housing burden	2.5	2.5	2	2.5	2.5	2	2.5	1.5	2.5	2.5
TOTAL SCORE		**16.5**	**16**	**17**	**16.5**	**13.5**	**15.5**	**14**	**15.5**	**14.5**	**12.5**

Equity Analysis Results: Scenarios 3-4

Indicator Category	Indicator	Reference Case (Total = 50.5)				
		Comm. of Color	Tribes	Urban Low-Income	Rural Low-Income	Elderly
Health	Local 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 & 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**

Indicator Category	Indicator	Scenario 3 (Total = 70)					Scenario 4 (Total = 79)				
		Comm. of Color	Tribes	Urban Low-Income	Rural Low-Income	Elderly	Comm. of Color	Tribes	Urban Low-Income	Rural Low-Income	Elderly
Health	Local air quality	3.5	3	3.5	3	3	4.5	4	4.5	4	3.5
Environmental	Ecosystem health & resilience	3.5	3	3.5	3	3	4.5	4	4.5	4	4
Economic	Energy security	3	2.5	3	2.5	3	2.5	2	2.5	2	2.5
	Employment & workforce development	2.5	2.5	3	3	1	3	3	3.5	3.5	1
Social	Housing burden	2.5	2.5	2	2.5	2.5	2.5	2.5	2	2.5	2.5
TOTAL SCORE		**15**	**13.5**	**15**	**14**	**12.5**	**17**	**15.5**	**17**	**16**	**13.5**

Modeling Results Summary: All Scenarios

	Metric	Scenario 1	Scenario 2	Scenario 3	Scenario 4
GHG Emissions	Cap compliance	All years except 2050	Met through 2023; slightly above 2024-2050	Met through 2042; slightly above 2043-2050	All years
Health	Cumulative premature deaths avoided	166	172	153	183**
	Cumulative monetary valuation of avoided adverse health outcomes ($Bil)	2.08	2.16	1.90	2.29**
Economics*	Net employment impacts in 2050	19,600	18,000	14,100	19,700
	Net GSP impacts in 2050 ($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

*Emissions and health impacts shown here are cumulative. Economic impacts represent annual impacts in 2050 (i.e., a snapshot of that year).
**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.

DEQ Reflections on Modeling

- Significantly reduce GHG emissions while maintaining overall health of economy
- Improve public health by reducing emissions and support equity
- Important to understand any relevant differences in scenario results
- All scenarios:
  - Significant reductions statewide in adverse health impacts
    - Cumulative monetized health benefit of approximately $2 billion (2020$)
  - Very little overall macroeconomic change
    - Small changes to economy, but net positive trends for GSP, income, and jobs
  - Increased co-benefits and benefits for identified communities of concern
    - Urban low-income households and communities of color experience the most benefits
    - Important for CCI design to effectively support and engage environmental justice and impacted communities in transition to a low-carbon future