

Transportation & Climate Initiative

Webinar on program design, modeling,
and the implications of COVID-19

September 16, 2020

www.transportationandclimate.org



Vicki Arroyo
Executive Director
Georgetown Climate Center

Today's speakers:



Vicki Arroyo
Georgetown Climate Center



Sec. Kathleen Theoharides
Massachusetts Executive
Office of Energy and
Environmental Affairs



Dep. Sec. R. Earl Lewis, Jr.
Maryland Department of
Transportation



Michelle Boomhower
Vermont Agency of
Transportation



Chris Hoagland
Maryland Department
of the Environment



Frances Wood
OnLocation, Inc.



Comm. Martin Suuberg
Massachusetts Department
of Environmental Protection

Respondents for Q&A



Comm. Martin Suuberg
Massachusetts Department
of Environmental Protection



James Bradbury
Georgetown Climate Center



Joe Kruger
Georgetown Climate Center



Chris Hoagland
Maryland Department
of the Environment



Chris Porter
Cambridge Systematics



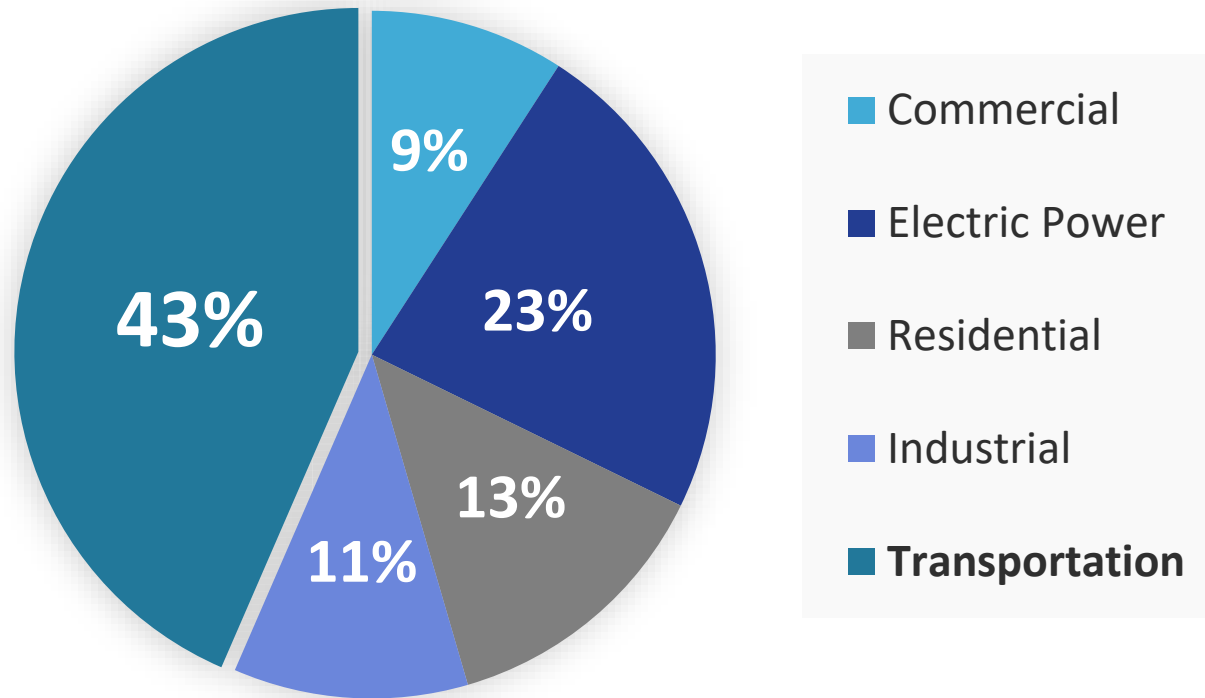
Frances Wood
OnLocation, Inc.



Kathleen Theoharides
Secretary,
Massachusetts Executive Office of
Energy and Environmental Affairs

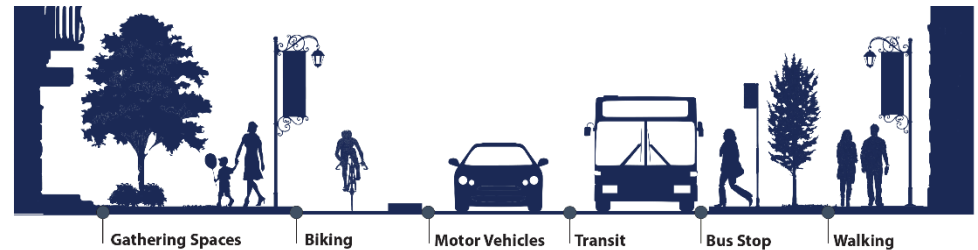
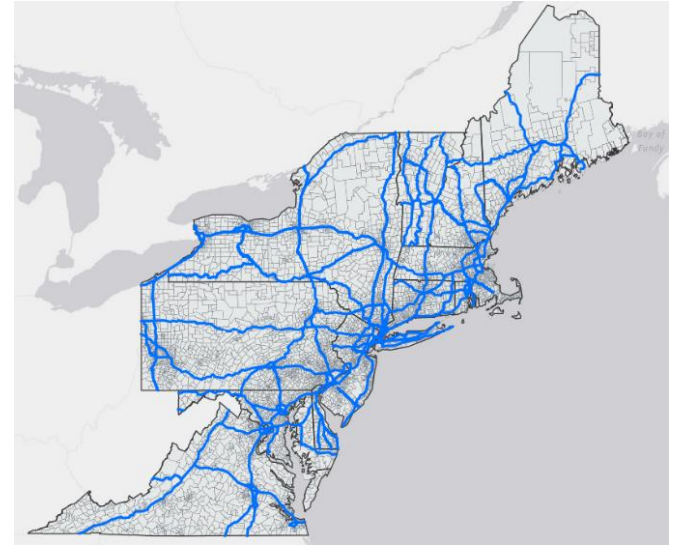
Transportation is the Largest Source of Carbon Pollution in the TCI Region

Sources of Carbon Dioxide Emissions in the TCI Region



Scale of the TCI Opportunity

- 72 million people
- \$5.3 trillion in GDP
- 52 million registered vehicles
- Modeled TCI cap would cover more than three times the carbon pollution currently covered by the RGGI cap





R. Earl Lewis, Jr.
Deputy Secretary for Policy, Planning, &
Enterprise Services
Maryland Department of Transportation

TCI States Engaged with People, Communities, and Businesses

Events in 2019

- Three regional TCI workshops with participation of 1,000 people
- 4,300 submissions to TCI public input portal representing the views of over 10,000 individuals
- Community engagement by individual states

Upcoming TCI webinar

- *Ensuring environmental justice and equity in a regional low-carbon transportation program: September 29, 4 to 6 pm*





Michele Boomhower
Division Director
Policy, Planning & Intermodal Development
Vermont Agency of Transportation

Presentation Outline

- Introducing TCI and Cap-and-Invest
- Modeling Background
- Benefits of a Regional Cap-and-Invest Program
- Informing Program Design with New Modeling
- TCI COVID-19 Recession Sensitivity Modeling
- Designing the Program to Manage Uncertainty
- Inventory of Materials Being Released: Inputs, Outputs, Scenarios
- Public Input Process and Timeline
- Question and Answer

Draft Memorandum of Understanding

- Draft MOU Includes:
 - Program Goals and Schedule
 - Elements of a Model Rule
 - Investments & Equity
 - Regional Organization
 - Program Monitoring and Review
- Final MOU: Late Fall 2020

**Draft Memorandum of Understanding
of the Transportation and Climate Initiative**

For Stakeholder Input

Draft - 12/17/2019

WHEREAS, climate change has resulted in the increased frequency and severity of extreme weather events that have adversely impacted every Signatory Jurisdiction; and

WHEREAS, climate change poses a clear, present, and increasingly dangerous threat to the communities and economic security of each Signatory Jurisdiction; and

WHEREAS, these jurisdictions participate in the Transportation and Climate Initiative, which was founded in 2010 as a collaboration of states and the District of Columbia to develop strategies to reduce greenhouse gas emissions from the transportation sector; and

WHEREAS, Signatory Jurisdictions have individually committed to mitigate the risks of climate change through strategies intended to reduce greenhouse gas emissions across all sectors; and

WHEREAS, transportation currently accounts for approximately 40 percent of greenhouse gas emissions in the Signatory Jurisdictions; and

WHEREAS, Signatory Jurisdictions will need to implement bold initiatives to mitigate the impacts of greenhouse gas emissions from the transportation sector; and

WHEREAS, Signatory Jurisdictions remain committed to working with communities and businesses to develop and implement a regional program that addresses the urgent need to mitigate greenhouse gas emissions and other harmful pollutants generated by the transportation sector; and

WHEREAS, accelerating the transition to cleaner, more efficient transportation sector will improve public health, create new economic opportunities, and provide enhanced mobility options for all communities; and

WHEREAS, Signatory Jurisdictions recognize and are committed to investing in and mitigating the impacts on low-income and disadvantaged communities that are disproportionately burdened by vehicular pollution, the costs of the current transportation system, the lack of access to clean transportation options, and vulnerable to the impacts of a changing climate; and

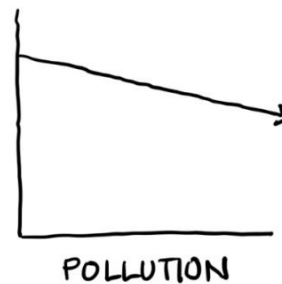
WHEREAS, continued collaboration on clean transportation strategies, including regional electric vehicle charging infrastructure; improved multi-modal transit infrastructure; more sustainable freight movement, and support for lower carbon fuels will provide greater economic, social and public health benefits to residents and communities across the region than if each jurisdiction acted alone;

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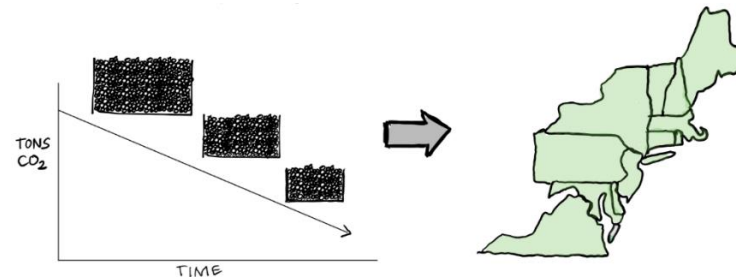
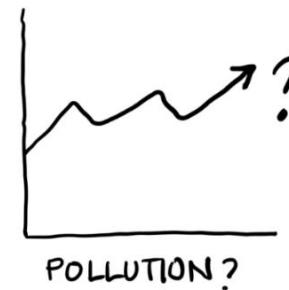
Features of Regional Cap & Invest Approach

- Guarantees Pollution Reduction
- Regional Consistency of Allowance Prices
- Offers Flexibility in Compliance
- Drives Innovation and Investments in Low Carbon Transportation Programs

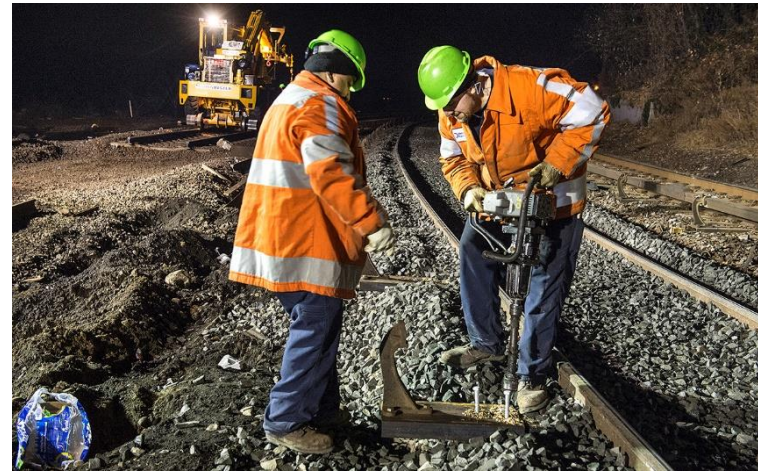
CAP AND INVEST



TAX



Reducing Pollution Delivers Multiple Benefits





Chris Hoagland
Climate Change Program Manager
Maryland Department of the Environment

Modeling Background

2019 TCI Modeling & Analysis Overview

- Develop Reference Case assumptions
 - Public input following webinar
- Run Reference Case ('what happens with no cap?')
 - Public input following webinar
- Revised Reference Case
- Run emissions cap scenarios ('what happens with emissions caps?')
- Conduct macroeconomic & initial public health analysis
- Release modeling results and solicit stakeholder input on policy scenarios

Completed and released December 17, 2019 for comment.

2020 TCI Modeling & Analysis Overview

- Run additional sensitivity cases (e.g., What happens if federal policy changes?)
 - COVID-19 introduced new uncertainties to consider
- Run additional policy cases with varying caps and investment portfolios
- Evaluate market stability mechanisms (e.g., What are potential trigger prices for cost containment? How big should the cost containment reserve be?)
- Release additional analysis and solicit input on program design

More Information on Modeling Framework

Multiple 2019 webinars on model construction, assumptions, and results:

April 30, 2019: In-person Technical Workshop

May 23, 2019: Modeling Assumptions Webinar

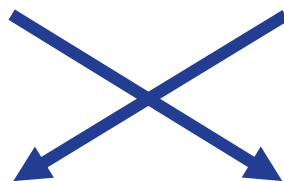
August 8, 2019: Reference Case Results Webinar

December 17, 2019: Policy Case Results and Benefits Webinar

www.transportationandclimate.org/main-menu/tcis-regional-policy-design-process-2019

How does the **CAP** affect the transportation sector (& others)?

How do the **INVESTMENTS** affect the transportation sector?



What are the impacts from the program?
(economic effects, public health benefits)







How are the benefits and costs distributed?

Modeling Cap Reduction Scenarios

All policy scenarios assume a regional CO₂ emissions cap is applied to the fossil portion of motor gasoline and on-road diesel combusted in vehicles (e.g., light-duty cars and trucks, commercial light trucks, freight trucks, and buses).

Model Run	Projected Emissions*
Reference Case (No TCI Policy)	19% CO ₂ reductions from 2022 to 2032
<i>Policy Cases with multiple investment portfolios</i>	
Policy: 20% Cap Reduction	20% CO ₂ reductions from 2022 to 2032
Policy: 22% Cap Reduction	22% CO ₂ reductions from 2022 to 2032
Policy: 25% Cap Reduction	25% CO ₂ reductions from 2022 to 2032

Illustrative Portfolios of Clean Transportation Investments

	A	B*	C	
	5%	30%	54%	Electric cars, light trucks and vans
	21%	23%	27%	Low & zero-emission buses and trucks
	35%	18%	-	Transit expansion and upkeep
	16%	14%	10%	Pedestrian and bike safety, ride sharing
	7%	8%	8%	System efficiency
	17%	8%	-	Indirect/ Other

*Scenario B is the illustrative portfolio used for most TCI cap reduction scenarios, including those used as the basis for economic and health benefit analysis.

Benefits of a Regional Cap and Invest Program

Clean Transportation Investments to Reduce Pollution in Modeled TCI Scenarios

- **Electric Transit Buses:**
Up to 44,000 transit buses by 2032
- **Bus Service and Transit Improvements:**
Up to \$1.1 billion annually
- **Electric School Buses:**
Up to 42,000 by 2032
- **Electric Trucks:**
Up to 84,000 by 2032
- **Bike Lanes and Sidewalks:**
Up to \$5.6 billion region-wide through 2032



Estimated Benefits From TCI Program *(in 2032)*

Macroeconomic

- ↑ GDP ~ \$0.7 B to \$3 B
- ↑ Income ~ \$0.5 B to \$2 B
- ↑ Jobs ~ 2 K to 9 K



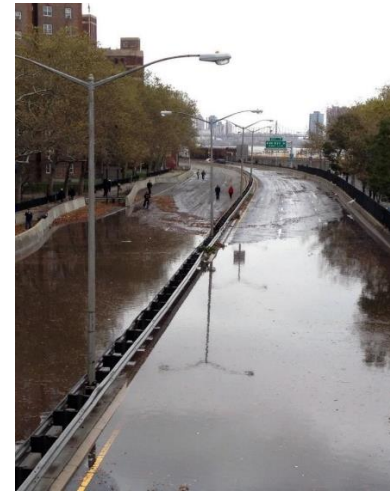
Public Health

- \$3 - \$10 B (preliminary*)
- ↓ Premature deaths
- ↓ Asthma symptoms
- ↓ Traffic-related injuries



Avoided Climate Damages

\$249 M – \$892 M



*Research update with more sophisticated, county-scale analysis will be published by the Harvard-led TRECH research team on October 6

Conclusions from Macroeconomic and Public Health Modeling

- A declining emissions cap would ensure a decline in carbon dioxide emissions through 2032 and drive additional reductions throughout the region.
- The modeled program would have a modest positive impact on GDP, income, and jobs, all of which would be greater than business as usual in 2032 and substantially net positive over the 2022-2040 timeframe.
- Significant region-wide benefits to public health would result from improvements to air quality, public safety, and greater access to active transportation options, including walking and cycling.

We can reduce pollution, improve public health, strengthen our economies while investing in clean transportation in underserved and overburdened communities

Informing Program Design with New Modeling

Program Design Decisions Discussed Today

Program Ambition: Where does the carbon cap start, and how quickly does it decline?

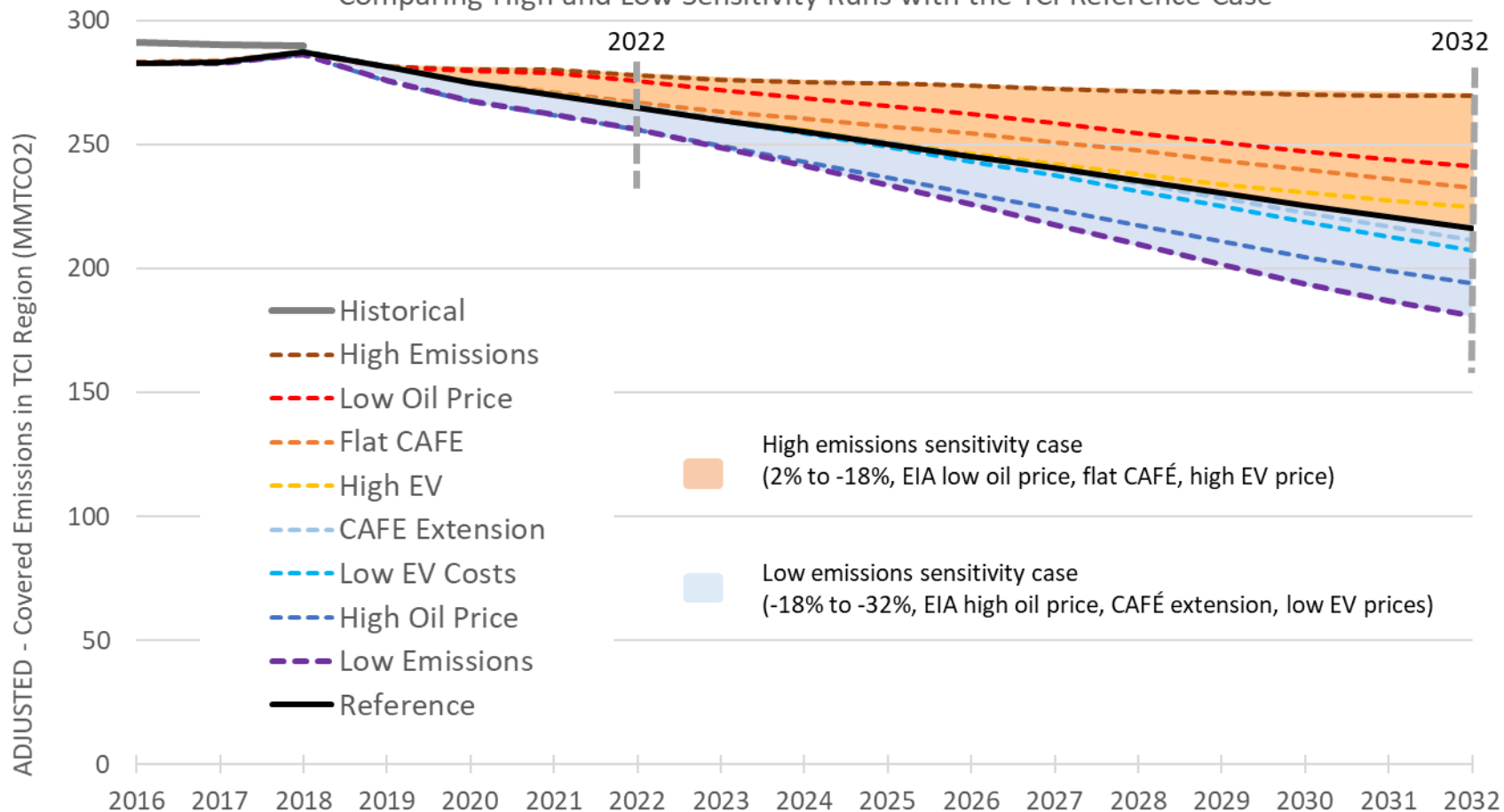
Program Flexibility and Market Stability: How will the program respond to uncertainty in the future and still deliver what we need it to?

- Cost Containment Reserve (CCR): At what price will the CCR release additional allowances to mitigate price increases? How many allowances will it release?
- Emissions Containment Reserve (ECR): At what price will the ECR reduce the cap to harness more cost-effective reductions? How much will it reduce?

TCI Reference and Sensitivity Case Modeling Runs

	Model Run Description
	TCI Reference Case
High Emissions Sensitivity Cases	Low Oil Price Sensitivity (EIA's AEO2018 side case)
	Roll back of federal emissions standards for light-duty vehicles
	High electric vehicle costs
	Combined high emissions sensitivity
Low Emissions Sensitivity Cases	High oil price sensitivity (EIA's AEO 2018 side case)
	Low electric vehicle costs
	Extension of federal emissions standards for light-duty vehicles
	Combined low emissions sensitivity
COVID-19 Recession Sensitivity Cases	COVID-19 High (recession scenario with high VMT and EIA's Low Oil Prices)
	COVID-19 Low 1 (recession scenario with low VMT and EIA's Low Oil Prices)
	COVID-19 Low 2 (recession scenario with low VMT and Reference Oil Prices)

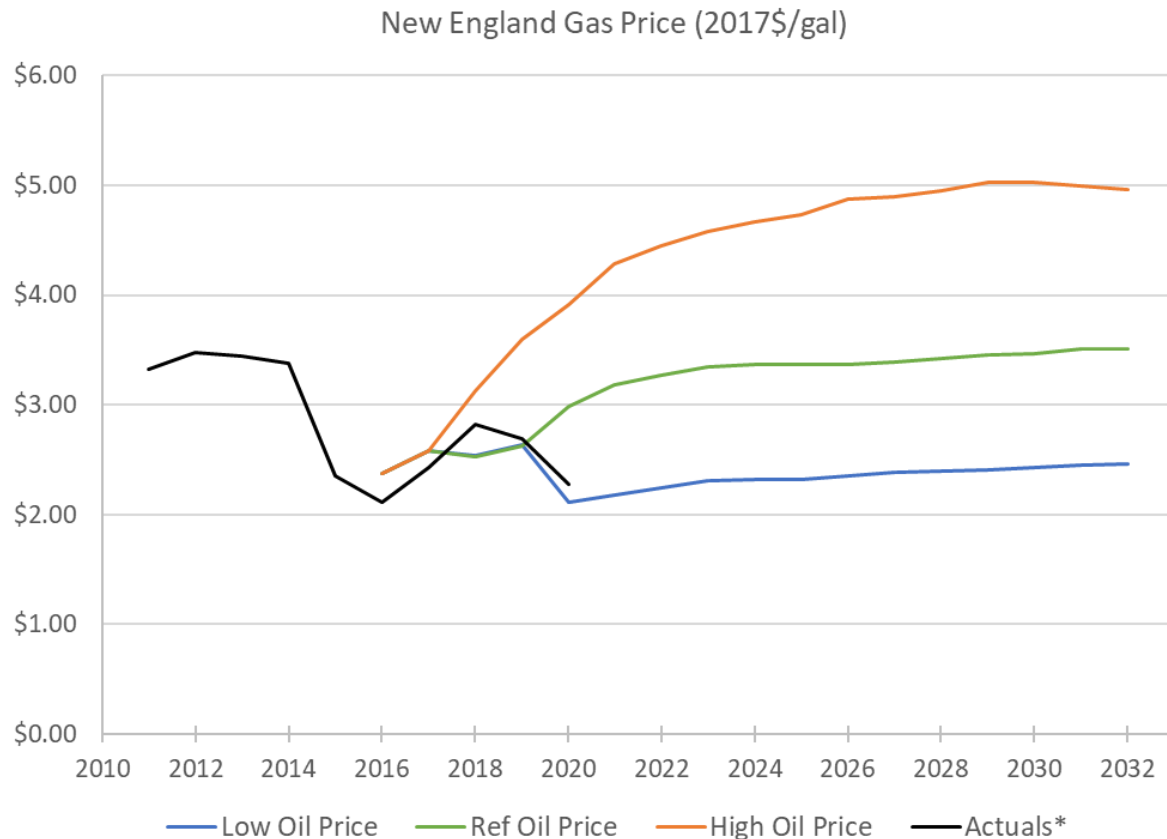
Observed and Projected CO₂ Emissions from Covered Sources – No Policy Comparing High and Low Sensitivity Runs with the TCI Reference Case



Observations

- The oil price sensitivity cases result in the greatest change in projected “BAU” emissions
- Federal vehicle standard rollbacks are also projected to have a material impact

TCI-Modeled Gasoline Prices in Reference Case Scenarios *Compared with recent historical values*



Data sources:

- TCI-NEMS outputs for Reference case and Reference case sensitivity runs with EIA's low and high oil price side cases.
- "Actuals" are based on EIA-reported PADD 1A prices, adjusted to 2017\$.

Adjusted Emissions Totals

Emissions totals presented today are slightly higher than December modeling release due to adjustments made to model output:

- Estimating non-road gasoline use that isn't captured in NEMS transportation module
- Re-calibrating NEMS diesel estimates to better reflect recent consumption data

Modeling results shown today account for these adjustments through post-processing (i.e., after TCI-NEMS modeling was completed). These emissions will be directly accounted for in future modeling.



Frances Wood
Director
OnLocation, Inc.

TCI COVID-19 Recession Sensitivity Modeling

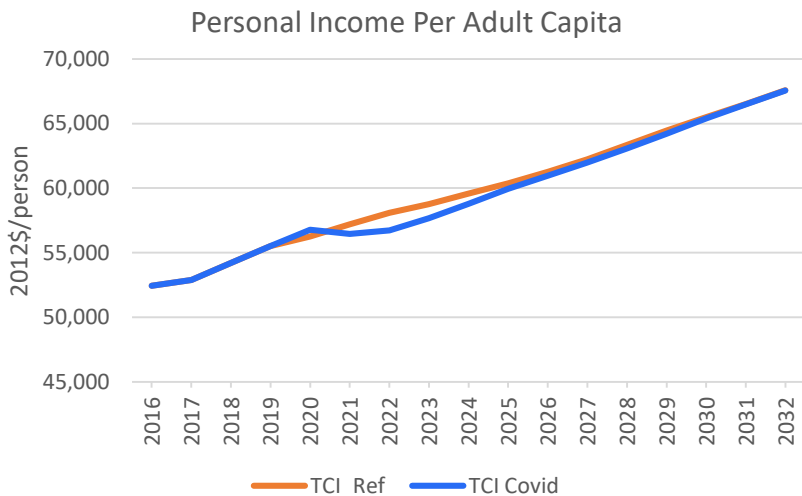
COVID-19 Scenario Assumptions

TCI Reference Case assumptions apply to all three COVID-19 recession scenarios with the following exceptions:

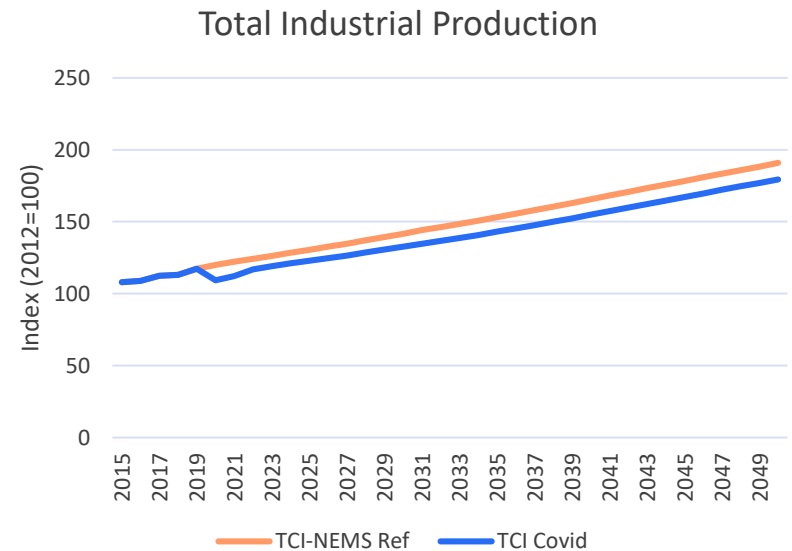
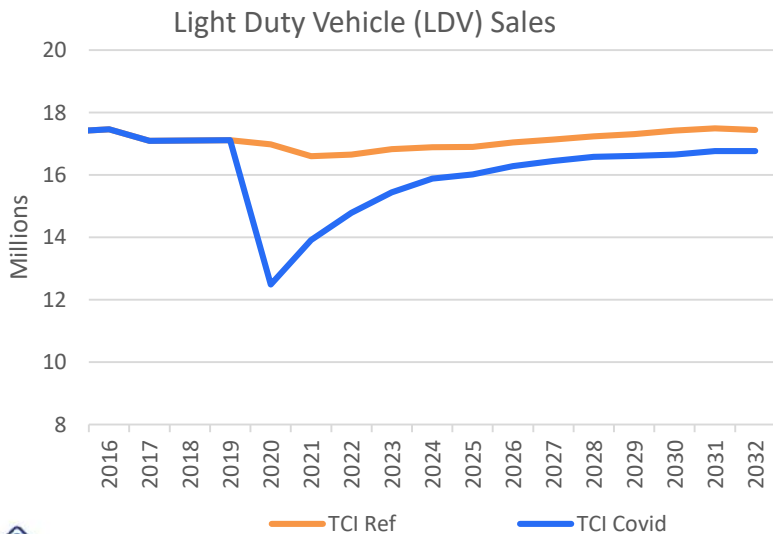
- **Economic recession.** All COVID-19 scenarios use macroeconomic inputs to reflect recession conditions in the transportation and industrial modules.
- **Oil Prices:**
 - Two of the recession scenarios use the AEO2018 low oil price scenario.
 - One of the recession scenarios uses the same oil prices as the TCI Reference Case.
- **Personal light duty vehicle (LDV) vehicle miles traveled (VMT):** Two VMT scenarios are developed to reflect a range of possible behavioral responses to the pandemic, primarily relating to changes in public transit use, telecommuting and working from home.

	COVID High	COVID Low-1	COVID Low-2
Macroeconomic	Recession	Recession	Recession
Oil Prices	AEO 2018 Low	AEO 2018 Low	AEO 2018 Reference
Personal LDV VMT	High	Low	Low

COVID-19 Macroeconomic Assumptions



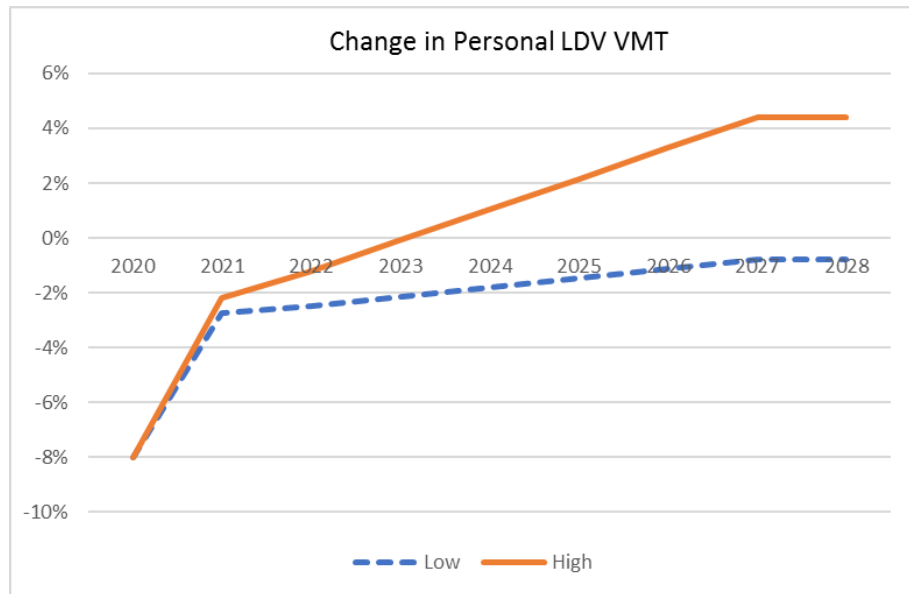
- Personal income, employment, vehicles sales (LDV and HDV), and industrial production were modified to reflect the May IHS Markit projections that include the recessionary impacts of the pandemic.
 - The IHS growth rates were applied starting in 2019 to account for slight differences between historical data used by IHS & NEMS.



Personal LDV VMT Adjustments

- The trajectory for the personal light duty vehicle (LDV) LDV vehicle miles traveled (VMT) adjustment for the high and low COVID scenarios are below.
 - The 2020 VMT adjustment is based on EIA's short-term forecast for gasoline consumption

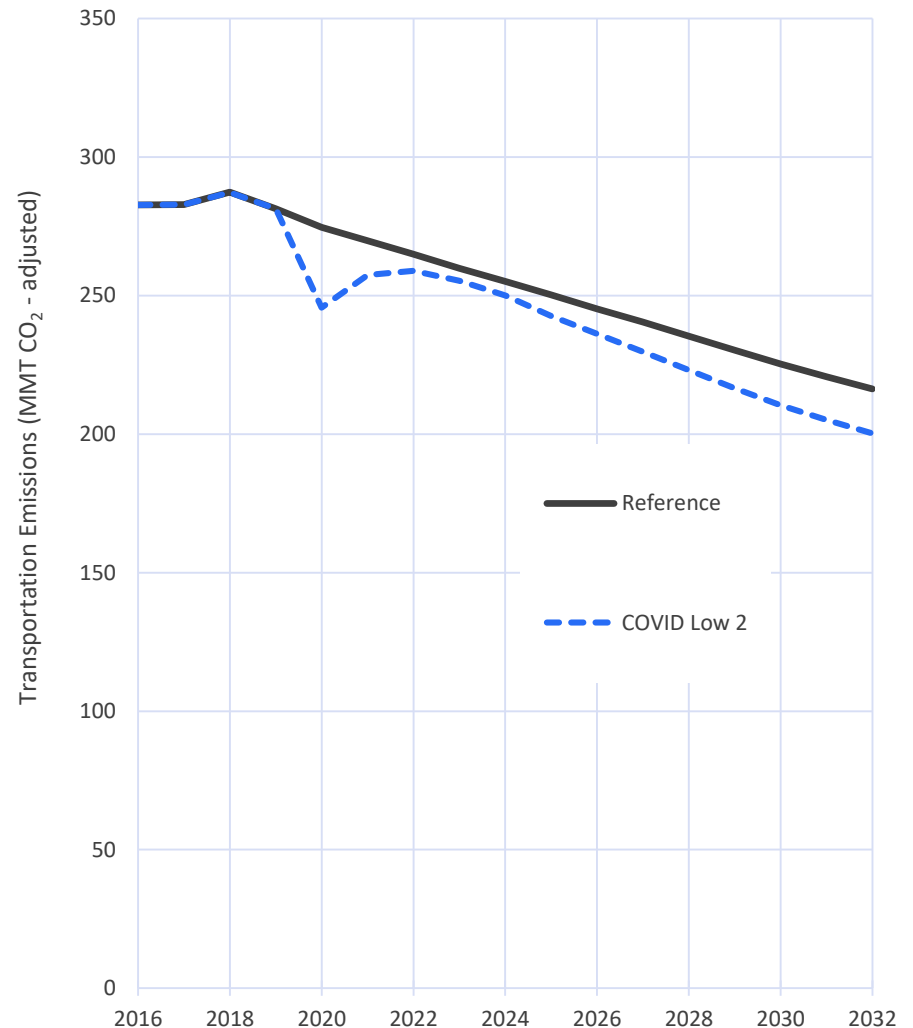
	2020	2021	2022	2023	2024	2025	2026	2027	2028
Low	-8%	-2.7%	-2.5%	-2.2%	-1.8%	-1.5%	-1.1%	-0.8%	-0.8%
High	-8%	-2.2%	-1.2%	-0.1%	1.0%	2.2%	3.3%	4.4%	4.4%



COVID-19 Sensitivity Results – Macroeconomic and VMT

- The macroeconomic effect of the COVID-19 recession and the Low VMT scenario assumptions contribute to persistent low emissions
- Both cases include the same oil prices (AEO 2018 Reference case)

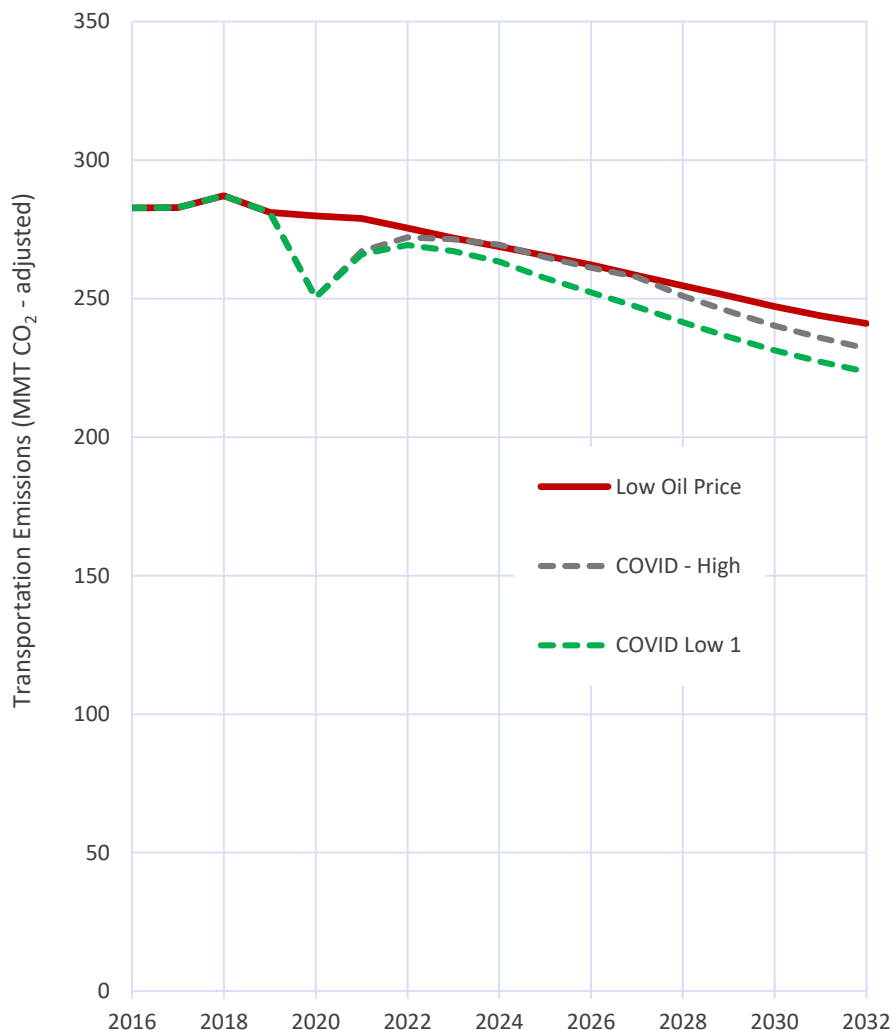
Projected CO₂ Emissions from TCI Region - No Policy



COVID-19 Sensitivity Results – VMT Scenarios and Low Oil Prices

- The macroeconomic effect puts long-term downward pressure on emissions.
- Personal VMT assumptions affect the projected emissions either up or down, depending on the scenario.
- All three scenarios include the same, low oil prices (AEO 2018 low oil price side case)

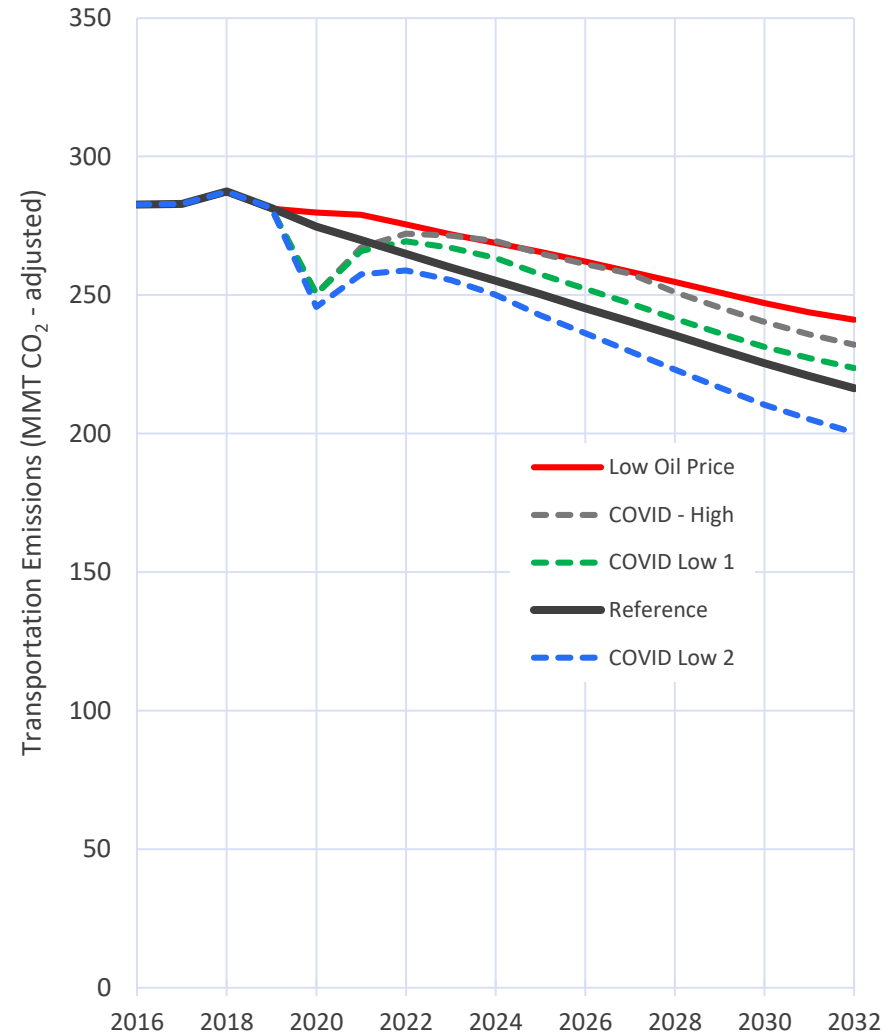
Projected CO₂ Emissions from TCI Region - No Policy



COVID-19 Sensitivity Results - Combined

- In the absence of new policy, the pandemic could lead to a range of future transportation emissions, depending on:
 - How individuals change their travel behavior, including with respect to telecommuting and transit ridership
 - How long oil prices remain low
 - How quickly the economy recovers

Projected CO₂ Emissions from TCI Region - No Policy

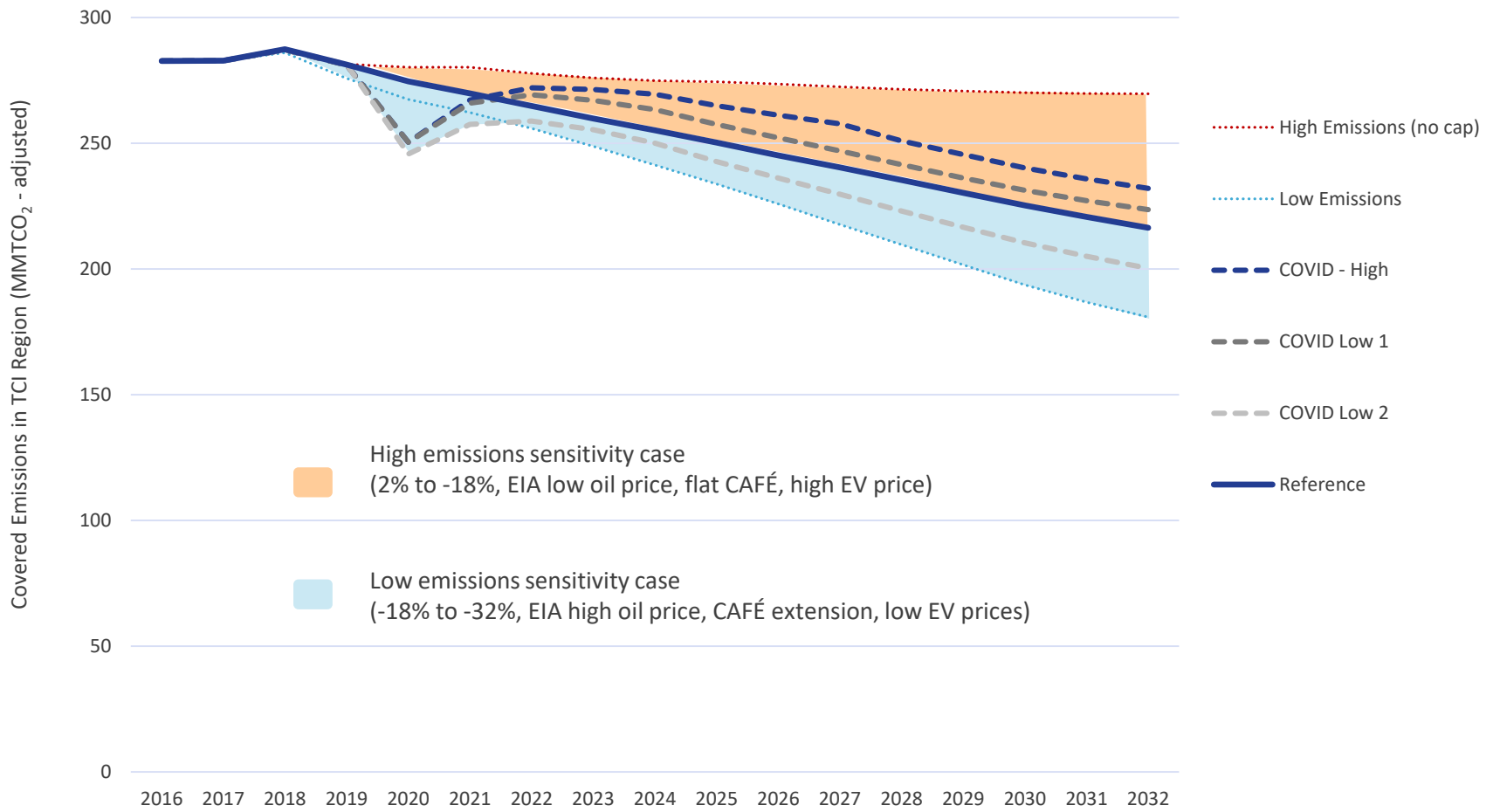




Chris Hoagland
Climate Change Program Manager
Maryland Department of the Environment

Designing the Program to Manage Uncertainty

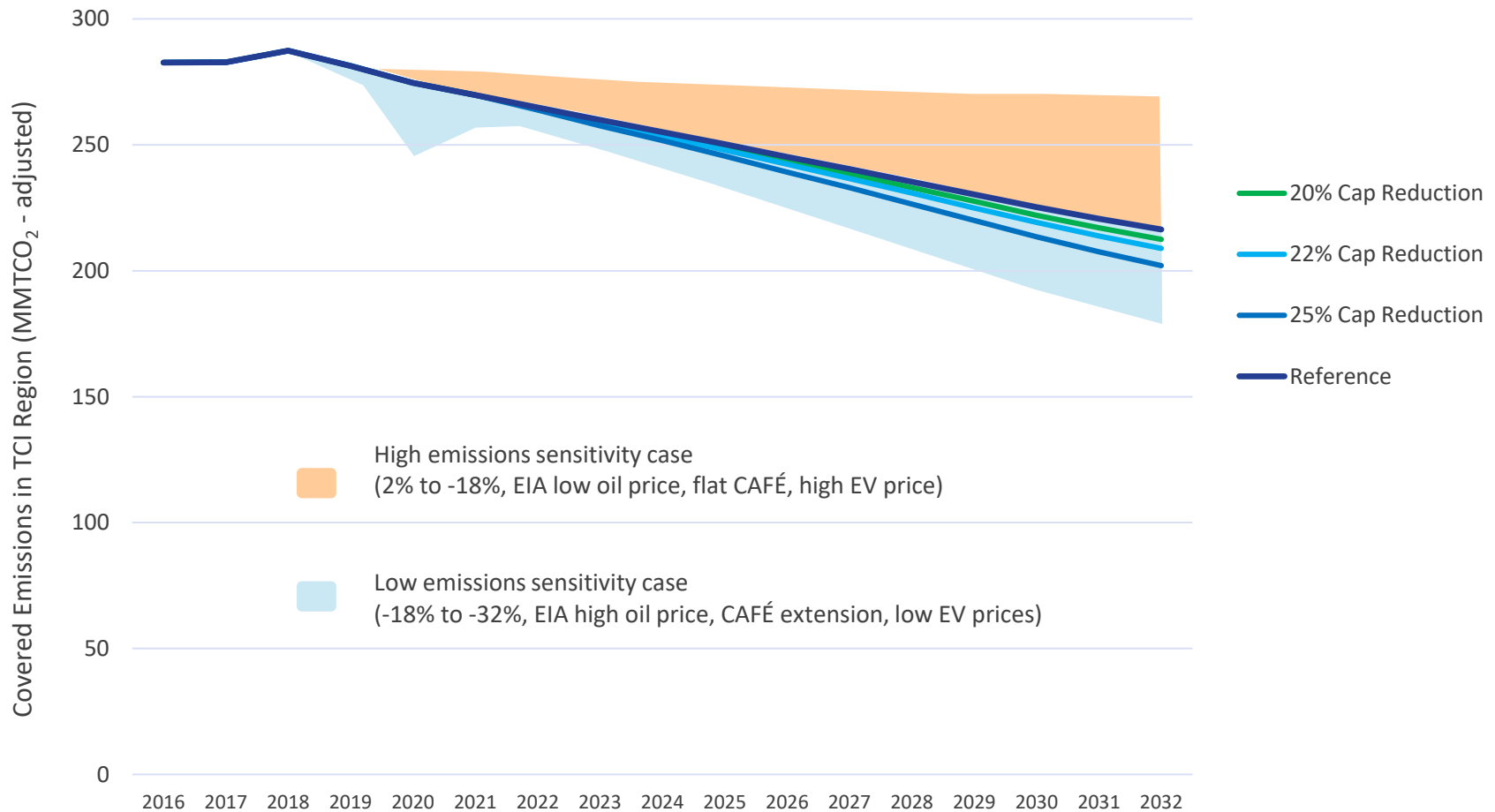
Projected Transportation CO₂ Emissions – Range of sensitivity analysis, with no policy



Observation:

- COVID recession scenarios are generally within the range of uncertainty that we had previously modeled

Emissions Cap Scenarios: Projected Transportation CO₂ Emissions



Observations:

- More stringent caps result in greater emissions cuts and more proceeds for investments.
- Initial annual proceeds range from \$1.4 billion at start in the 20% case up to \$5.6 billion in the 25% case.

Stability Mechanisms

- These mechanisms respond to uncertainty to:
 - Ensure the program achieves what we want
 - Keep impacts within an acceptable range (especially price impacts)
- These mechanisms are in place for RGGI
- Proposed mechanisms:
 1. Cost Containment Reserve: mitigate price increases
(does this by releasing additional allowances & increasing cap if prices are high)
 2. Emissions Containment Reserve: take advantage of low costs to get more reductions
(does this by diverting allowances & tightening cap if prices are low)
 3. Auction Reserve Price: prevent prices from going to zero

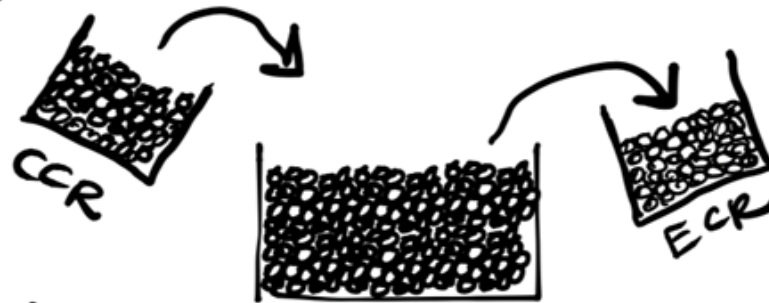
Managing Uncertainty

IF THE UNEXPECTED HAPPENS
(OR "MANAGING PRICE RISK")

COST
CONTAINMENT
RESERVE
(CCR)

EMISSIONS
CONTAINMENT
RESERVE
(ECR)

+



If allowance prices higher than expected, CCR adds allowances

EMISSIONS
"BUDGET"
(each year)

If allowance prices are lower than expected, ECR removes allowances

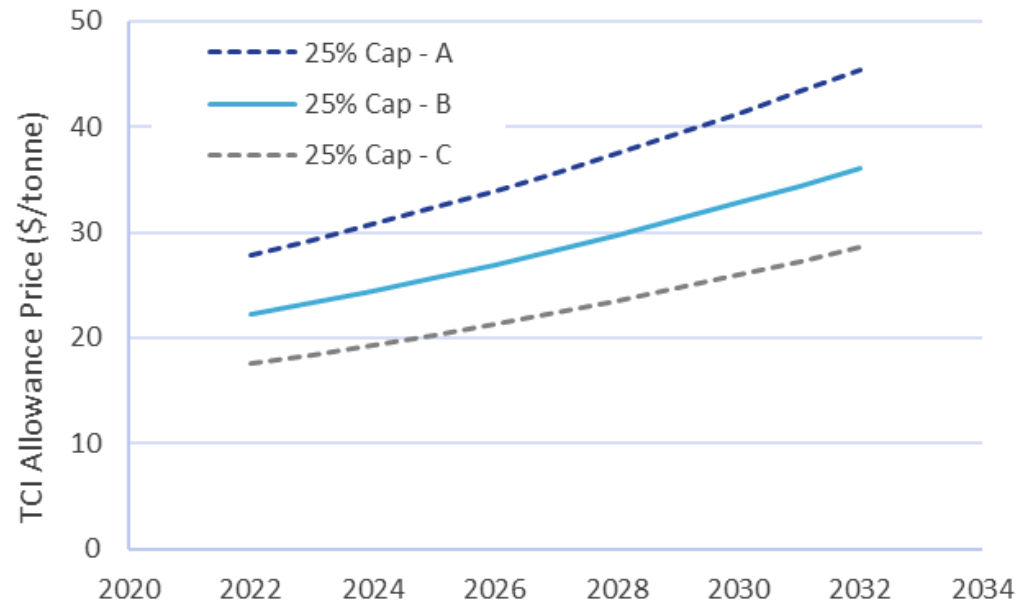
CCR & ECR Design Questions

1. What is the “**trigger price**” (\$/ton) for the mechanism?
 - CCR: price point where additional allowances are released, to mitigate allowance price increases
 - ECR: price point where fewer allowances are released, to secure low-cost reductions
2. What is the “**reserve size**” (millions of tons) for the mechanism?
 - CCR: How many additional allowances (additional tons of allowed CO₂) will we deploy to mitigate price growth?
 - ECR: How many fewer allowances (fewer tons of allowed CO₂ / additional reductions) will we deploy to secure low-cost reductions?

How Does Modeling Inform These Decisions?

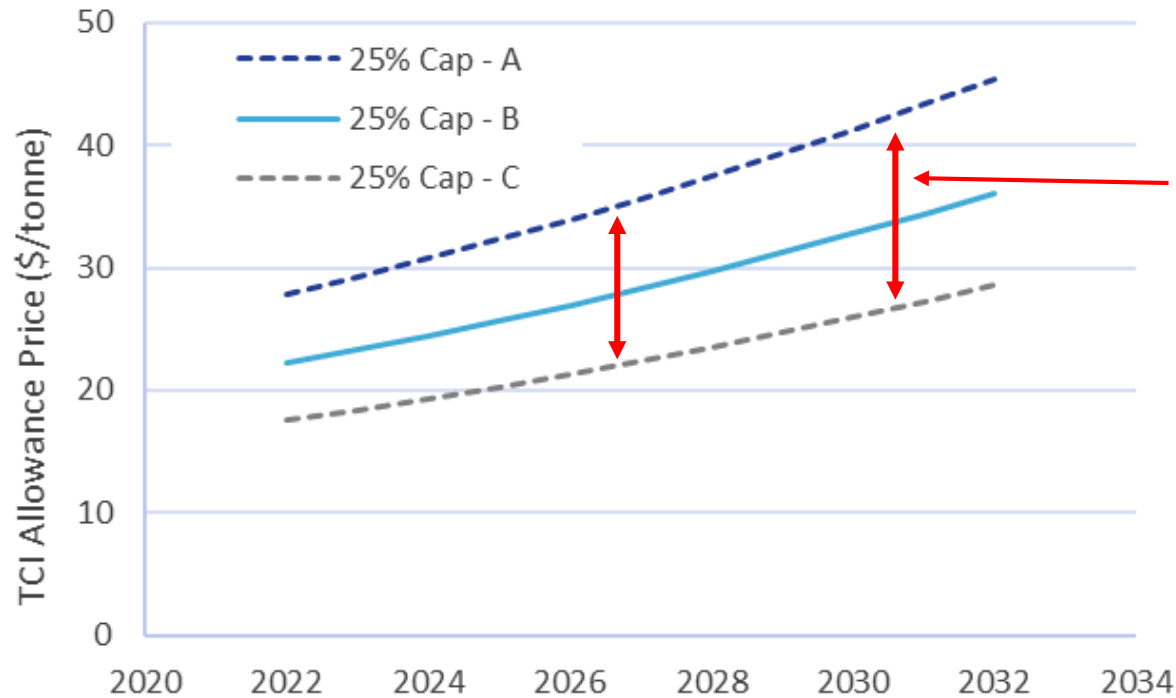
Example Investment Impacts: CO₂ Allowance Prices in 25% Cap Reduction Scenario

- Allowance prices reflect the combined effect of the cap and the investments.
- How the proceeds are invested affects the allowance price.
 - Investments in more cost-effective CO₂ reductions lower allowance prices.
 - Investments in clean transportation projects with other important benefits but less CO₂ reduction result in higher allowance prices.



Sources of Uncertainty:

What STATES DO CONTROL: Investments of proceeds



Variation from state investment decisions

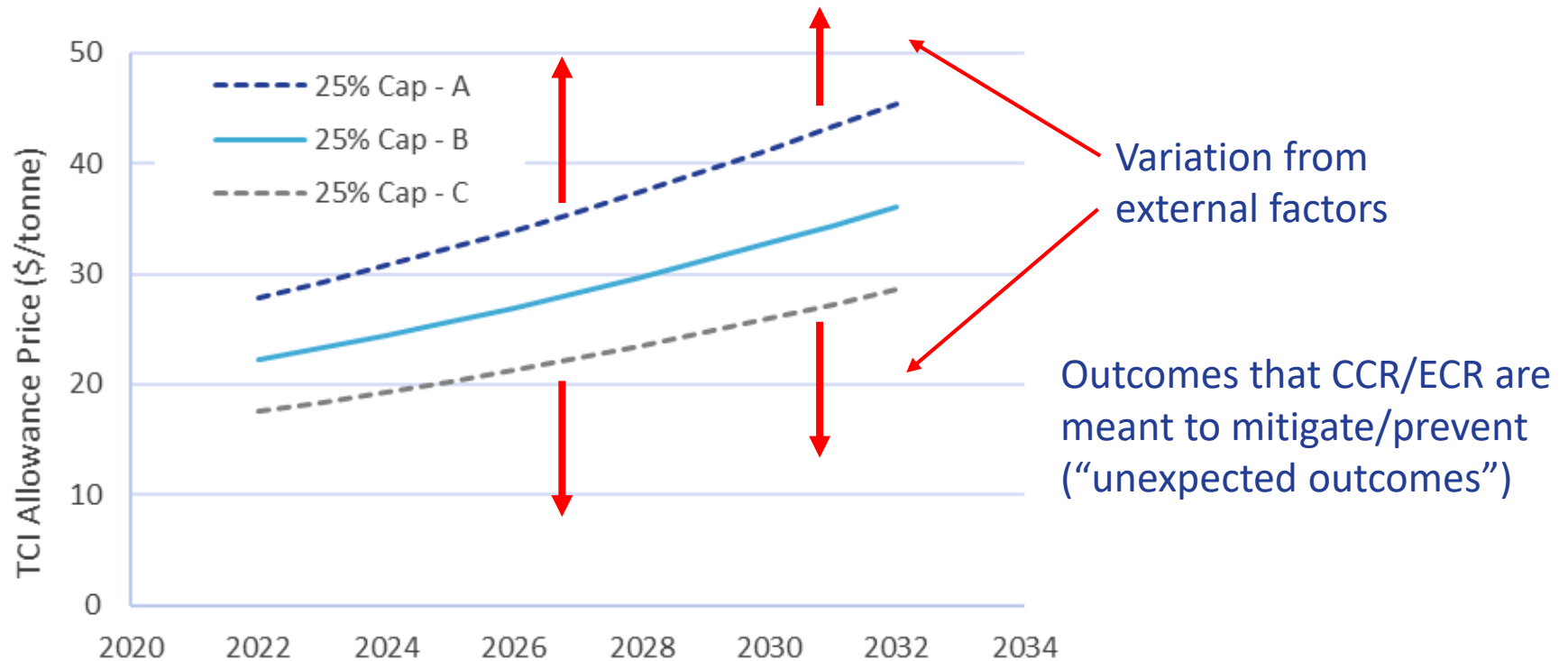
Can be *starting point* for trigger price conversations (range of outcomes if program implemented “as expected”)

EXAMPLE: Allowance prices under 25% cap and 3 investment scenarios.

Sources of Uncertainty:

What STATES DO NOT CONTROL:

External factors (oil price, federal policy, EV costs, etc.)



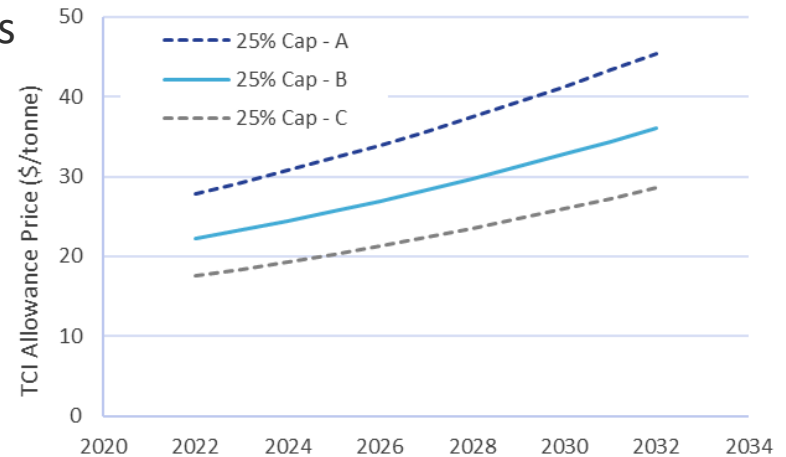
EXAMPLE: Allowance prices under 25% cap and 3 investment scenarios.

Modeling Approach to CCR & ECR Design

Steps:

1. Run a cap under three investment portfolios

- Starting points for trigger price conversations
 - CCR – Investment scenario A (higher allowance prices)
 - ECR – Investment scenario C (lower allowance prices)



2. Run sensitivity cases with CCR/ECR price triggers in place to explore emissions outcomes & price stabilization

- For CCR: Combined High Emissions Scenario
- For ECR: Combined Low Emissions Scenario
- Amount of emissions variation compared to cap informs size of ECR/CCR that would contain prices at triggers

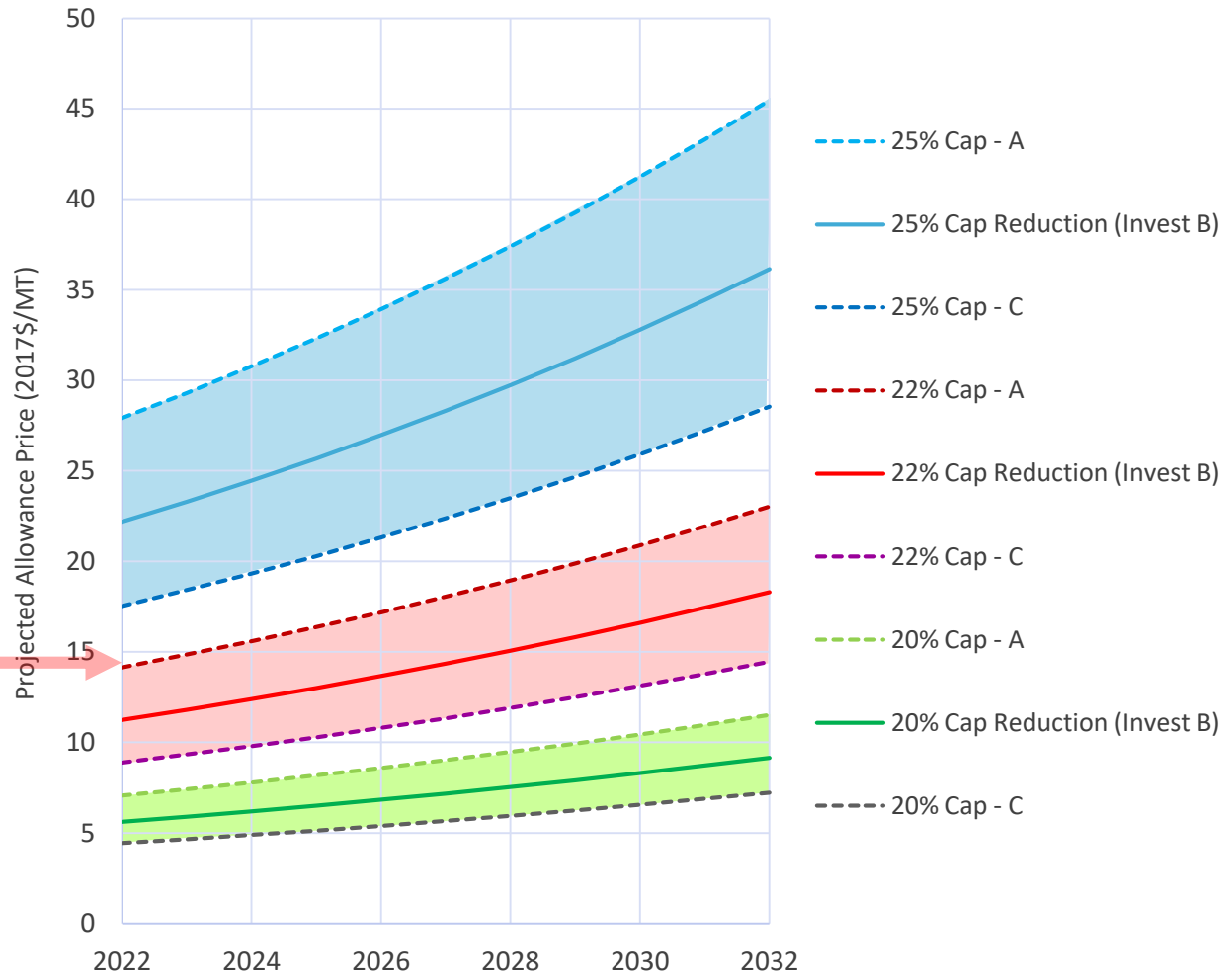
CCR and ECR Analysis – Modeled Trigger Prices

- Each cap has different trigger prices
- Modeling approach established triggers to analyze
- Analyzed triggers are starting points for design decision

E.g.:

For a 22% cap scenario

*CO₂ allowance prices for the CCR begin at \$14 (2017\$) per metric ton in 2022 and rise at 5% real to \$23 (2017\$) in 2032**



**Price triggers in the final model rule would account for inflation*

TCI Cap reduction scenarios with three investment portfolios

	Investment portfolio A	Investment Portfolio B	Investment Portfolio C
20% cap reduction	✓	✓	✓
22% cap reduction	✓	✓	✓
25% cap reduction	✓	✓	✓

TCI policy case sensitivity runs to inform ECR & CCR Decisions

Description	Investments
CCR & ECR Policy Cases – estimating the size of a cost containment reserve and emission containment reserve to ensure that allowance prices stay within a specified price range	
20% cap reduction, high emission sensitivity, price cap on CO ₂ allowances	B
22% cap reduction, high emission sensitivity, price cap on CO ₂ allowances	B
25% cap reduction, high emission sensitivity, price cap on CO ₂ allowances	B
20% cap reduction, low emission sensitivity, price cap on CO ₂ allowances	B
22% cap reduction, low emission sensitivity, price cap on CO ₂ allowances	B
25% cap reduction, low emission sensitivity, price cap on CO ₂ allowances	B

Modeling to Estimate Appropriate Reserve Sizes

- Cumulative emissions from the ECR case are 9% below the 22% cap, by 2032
- Cumulative emissions from the CCR case are 12% above the 22% cap, by 2032

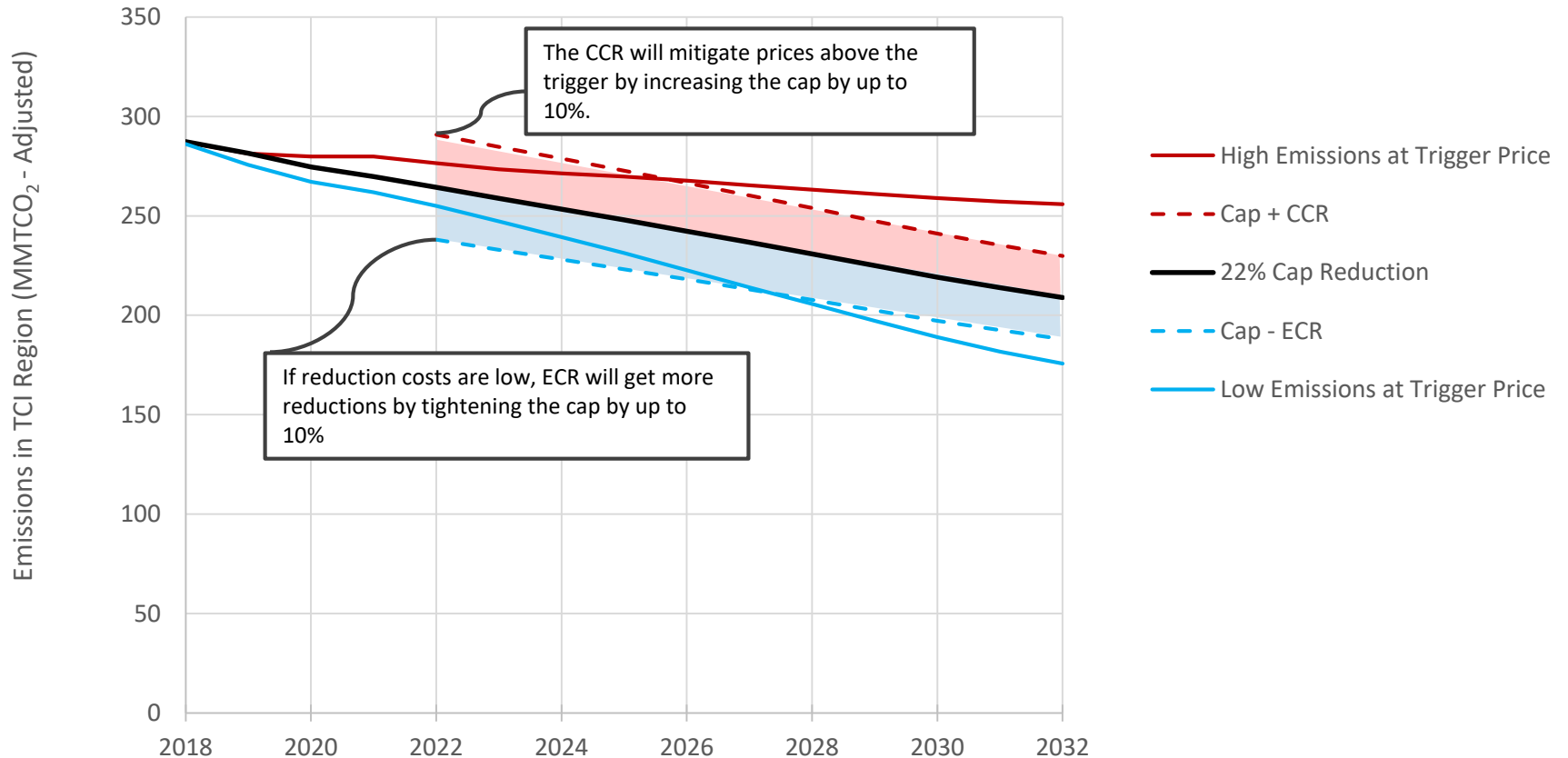
TCI-NEMS Results: 22% Cap Reduction with ECR & CCR High emission sensitivity case with CCR & ECR triggered each year					
Year	22% Cap Reduction (MMT CO ₂)	22% ECR (MMT CO ₂)	ECR as % of cap	22% CCR (MMT CO ₂)	CCR as % of cap
2022	264	255	4%	276	5%
2023	259	247	4%	273	6%
2024	253	239	6%	271	7%
2025	248	231	7%	270	9%
2026	242	223	8%	268	10%
2027	237	214	10%	265	12%
2028	231	206	11%	263	14%
2029	225	197	12%	261	16%
2030	219	189	14%	259	18%
2031	214	182	15%	257	20%
2032	209	176	16%	256	22%
Cumulative	2,601	2,359	9%	2,920	12%

Same conclusion for all three caps:

*To reduce the potential for carbon prices outside of the trigger price range, both ECR and CCR could have reserves equal to **10% of the cap each year.***

Comparing Projected Emissions with 10% Annual CCR & ECR: 22% Cap Reduction Scenario Example

Projected CO₂ Emissions from Covered Sources –
22% Cap Reduction, CCR & ECR scenarios w/ 10% reserves



The model results graphed above include the banking of allowances.

Market Stability Mechanisms Recap

- Stability Mechanisms will automatically adjust the cap to manage uncertainty.
- Modeling indicates starting points for designing trigger prices and reserve sizes.
 - *To reduce the potential for carbon prices outside of the modeled trigger price range, both ECR and CCR could have reserves equal to **10% of the cap each year.***

Request for input:

- Building on these modeling results, how should the program be designed to ensure reductions and other program benefits amid uncertainty?
- How else should the program be designed to manage uncertainty?

Inventory of Materials Being Released: Inputs, Outputs, & Scenarios.

- Webinar recording & slides
- Spreadsheet files
 - Reference Case and Reference Case sensitivity scenarios
 - Reference Case (input assumptions and outputs)
 - High emissions sensitivity cases (low oil prices, federal roll backs & high EV costs)
 - Low emissions sensitivity cases (high oil prices, federal standard extensions & low EV costs)
 - “COVID-19 recession” sensitivity cases
 - Policy Cases
 - All nine cap reduction scenarios, including 20%, 22% & 25% caps and all three investment scenarios
 - All three cost containment reserve cases
 - All three emissions containment reserve cases
- Written summary of investment strategy tool and related TCI modeling methods and assumptions

“Clean Up”

- Final “Clean Up” scenario reflecting design decisions.
 - Also addressing “punch list” of model updates or improvements, such as:
 - Improving how emissions adjustments are incorporated into modeling
 - Refining estimates of reductions from electric trucks and buses
 - Other updates as needed
 - Test runs of adjustments and electric truck/bus corrections indicate minor positive impact on estimated program cost-effectiveness.



Martin Suuberg
Commissioner
Massachusetts Department of
Environmental Protection

Next Steps

- A final MOU, model rule, and program implementation
- September 29: TCI webinar on ensuring environmental justice and equity in a regional low-carbon transportation program
- Inviting public input on webinar content and related published materials.
 - *Public input on this webinar and related content is most useful if provided through the TCI input portal by Wednesday, September 30, 2020.*
- Final modeling will be released along with the final MOU

Questions?

Respondents for Q&A



Comm. Martin Suuberg
Massachusetts Department
of Environmental Protection



James Bradbury
Georgetown Climate Center



Joe Kruger
Georgetown Climate Center



Chris Hoagland
Maryland Department
of the Environment



Chris Porter
Cambridge Systematics



Frances Wood
OnLocation, Inc.

Thank you!



Next Webinar:

Tuesday, September 29, 2020, 4 - 6 PM

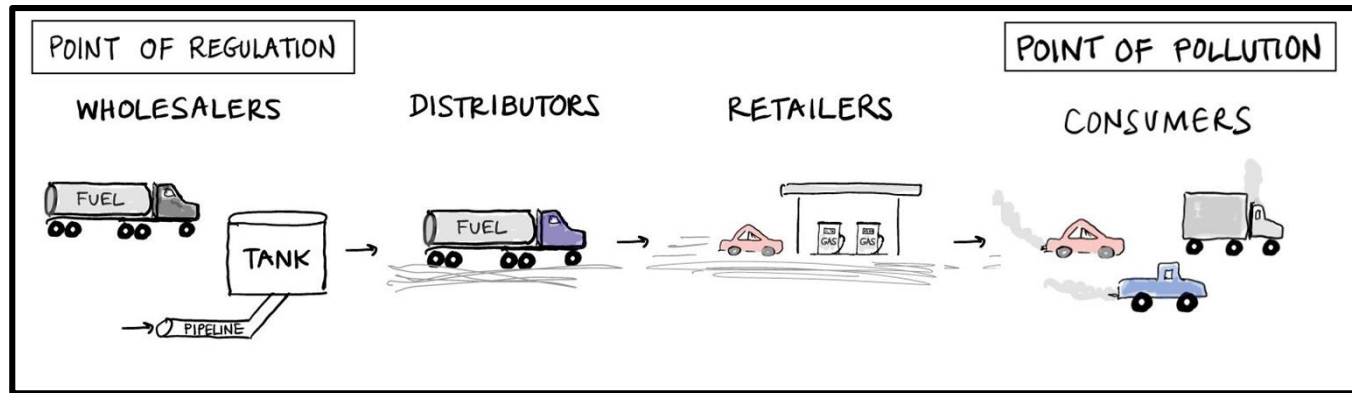
**“Ensuring environmental justice and equity
in a regional low-carbon transportation program”**

More Information at TransportationAndClimate.org

Contact us: climate@georgetown.edu

Appendix

How Would a CO₂ Cap Work in TCI?



State Fuel Suppliers (i.e. wholesalers) would comply with a regulation by holding enough allowances to cover the CO₂ from combustion of fuel sold.

Gas stations and consumers would not have any regulatory obligation.

Modeling Business as Usual, or the TCI Reference Case

- ✓ The TCI analysis process began with the Reference Case, which projects future emissions, fuel use, and other aspects of the transportation system **in the absence of any TCI "cap and invest" program** (from present through 2032).
- ✓ The TCI jurisdictions proposed assumptions for the Reference Case via webinar on May 23, and incorporated input received.
- ✓ The first Reference Case was analyzed in July and presented on a public webinar on August 8.
- ✓ Non-battery electric vehicle (EV) cost assumption was revisited in September and a new TCI Reference Case was established in October.

Key Assumptions in TCI Reference Case

- **Electricity Sector**

- National Renewable Energy Lab (NREL) 2018 Annual Technology Baseline costs for wind, utility solar photovoltaics (PV), and residential solar PV
- Annual Energy Outlook (AEO*) 2018 High Efficiency case for building energy demand
- Updated offshore wind and battery storage mandates
- Updated planned capacity additions and retirements in Regional Greenhouse Gas Initiative (RGGI) states

- **Electric Vehicles**

- Battery costs trajectories were revised downward based on Bloomberg New Energy Finance (BNEF) and the New York State Energy Research and Development Authority (NYSERDA) cost estimates
- Non-battery EV costs were revised downward, based on NYSERDA and International Council on Clean Transportation estimates
- Electric vehicle introduction years were accelerated for several light-duty vehicle (LDV) categories based on market analysis

- **Federal Corporate Average Fuel Economy (CAFE) / Vehicle Emissions Standards**

- Vehicle standards are based on current regulations and remain flat after 2025

- **Federal Electric Vehicle (EV) Tax Credit**

- Phase-out of the tax credit is based on OnLocation analysis and phases out somewhat more slowly than AEO 2018

- **Vehicle Miles Traveled (VMT)**

- Calibrated projected vehicle miles traveled (VMT) estimates to be consistent with TCI state estimates

- **State EV policies**

- Estimated regional impact of state policies on EV prices is incorporated into TCI Reference Case
- State zero-emission vehicle (ZEV) regulation is already accounted for in AEO 2018

- **Regional Greenhouse Gas Initiative (RGGI)**

- New Jersey and Virginia are included as participants in the RGGI program

Modeling Investments in Clean Transportation Strategies

- TCI is using an Investment Modeling Tool, in conjunction with TCI-NEMS, to estimate the reductions in CO₂ emissions (and other benefits) for different amounts of potential allowance proceeds and clean transportation investments.
- The Investment Tool generates rough estimates for specific investment types, recognizing that there is substantial variability in the real world when comparing the impacts of investments across places and project types.
- This investment modeling is directional and illustrative, and *does not take the place of each jurisdiction's discretion to invest using strategies that support the goals of the overall program within their jurisdiction.*

CAP

TCI-NEMS

- Energy system model
- Effect of cap & other policies on transportation energy use & GHGs
- Interactions with other sectors (e.g. electricity)

OnLocation

Allowance
Proceeds

Investment
Impacts

INVEST

Investment Strategy Tool

- VMT changes due to certain low-carbon transportation investment strategies

Cambridge Systematics

Capital Costs,
Fuel Savings,
etc.

Co-Pollutant
Emissions

Active
Transportation

Other
Costs

REMI

- Net impacts on GDP, income, jobs

Cambridge Systematics

Health Impacts Model

- Health co-benefits of air pollution reductions

TRECH

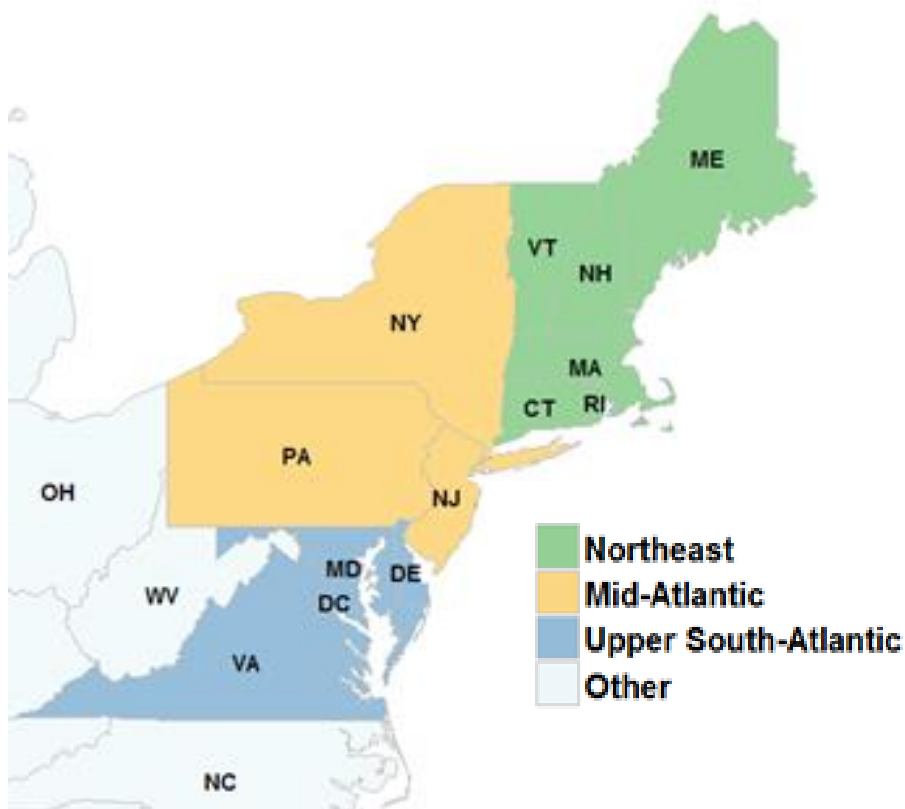
Incidence Model

- Distribution of costs & benefits to different populations/ groups

Resources For the Future

Emissions, Economic & Public Health Impacts, and How Distributed

“TCI-NEMS” Energy System Model

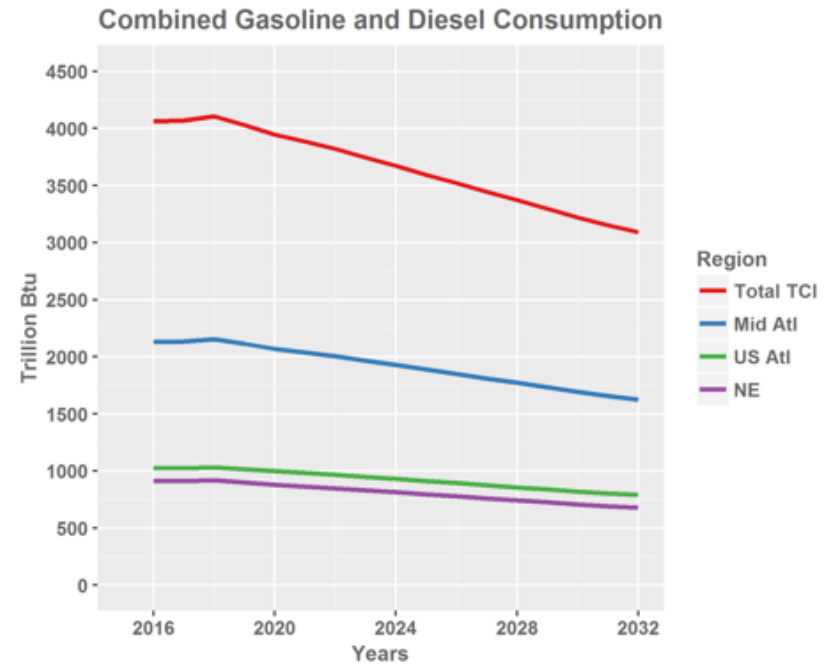
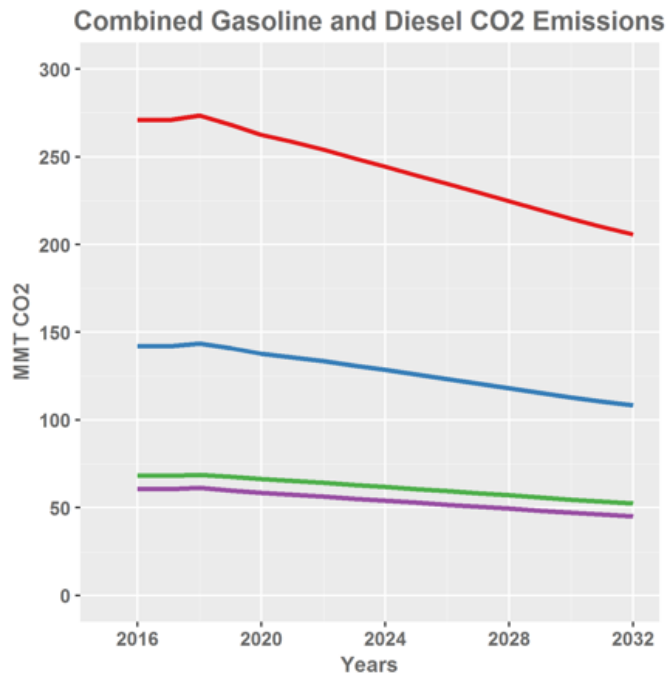


- In the TCI-NEMS model run to inform the TCI policy development process, the region is represented by three subregions:
 - Northeast,
 - Mid-Atlantic and
 - Upper South-Atlantic*

** For this analysis, we have split the South Atlantic Census Division into 2 subregions and renamed the model TCI-NEMS*

Reference Case: Motor Gasoline and On-Road Diesel Consumption and CO₂ Emissions

- Total gasoline and diesel consumption and CO₂ emissions both fall by roughly 19% from 2022 through 2032 as a result of increased fuel economy in light and heavy-duty vehicles and increased LDV EV shares.



Personal LDV VMT Adjustment Assumptions in COVID-19 Sensitivities

Two time horizons for the VMT bounding scenarios, both represent changes from pre-COVID-19:

- In the short term (by 2022): above-normal levels of working from home and telecommuting but also below normal use of public transit.
- In the longer term (by 2027), above-normal levels of working from home and telecommuting but also a greater “rebound” effect – which increases VMT as a result of associated changes in residential land-use and other factors. There is also expected to be a return to normal, or near-normal, levels of public transit use.

The two bounding scenarios are

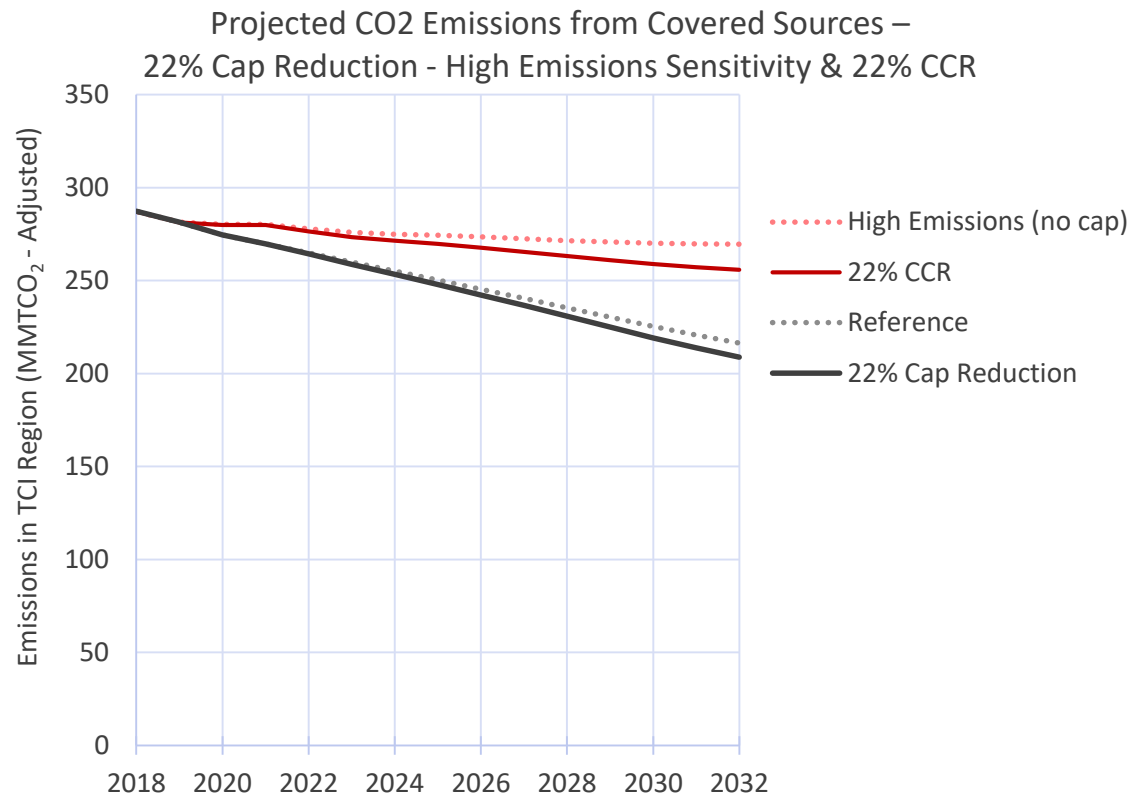
- a “low” scenario representing the maximum VMT reduction likely to be seen, and
- a “high” scenario representing the minimum VMT reduction (or maximum increase) likely to be seen.

The analytical basis for the low and high scenarios are as follows:

- Low, 2022 (-2.5%): High increase in telecommuting and working from home, with low short-term rebound effect and high mode shift away from public transportation.
- High, 2022 (-1.2%): Moderate increase in telecommuting and working from home (the same short-term rebound effect and reduced transit use are assumed in both scenarios in the near term).
- Low, 2027 (-0.8%): High increase in telecommuting and working from home with moderate long-term rebound effect and return to normal use of public transport.
- High, 2027 (+4.4%): High increase in telecommuting and working from home with higher long-term rebound effect and maximum long-term mode shift away from public transportation.

CCR Implications - Incremental CO₂ Emission Reductions

- In the High Emissions sensitivity case (i.e., no cap), emissions in 2032 are roughly 2% above the 2022 level projected in the Reference case.
- Relative to their respective No Policy cases in 2032
 - The original 22% cap case achieves a 3.4% reduction
 - The 22% CCR case achieves a 5.1% reduction relative to the High Emissions sensitivity case



Electricity Sector Analysis

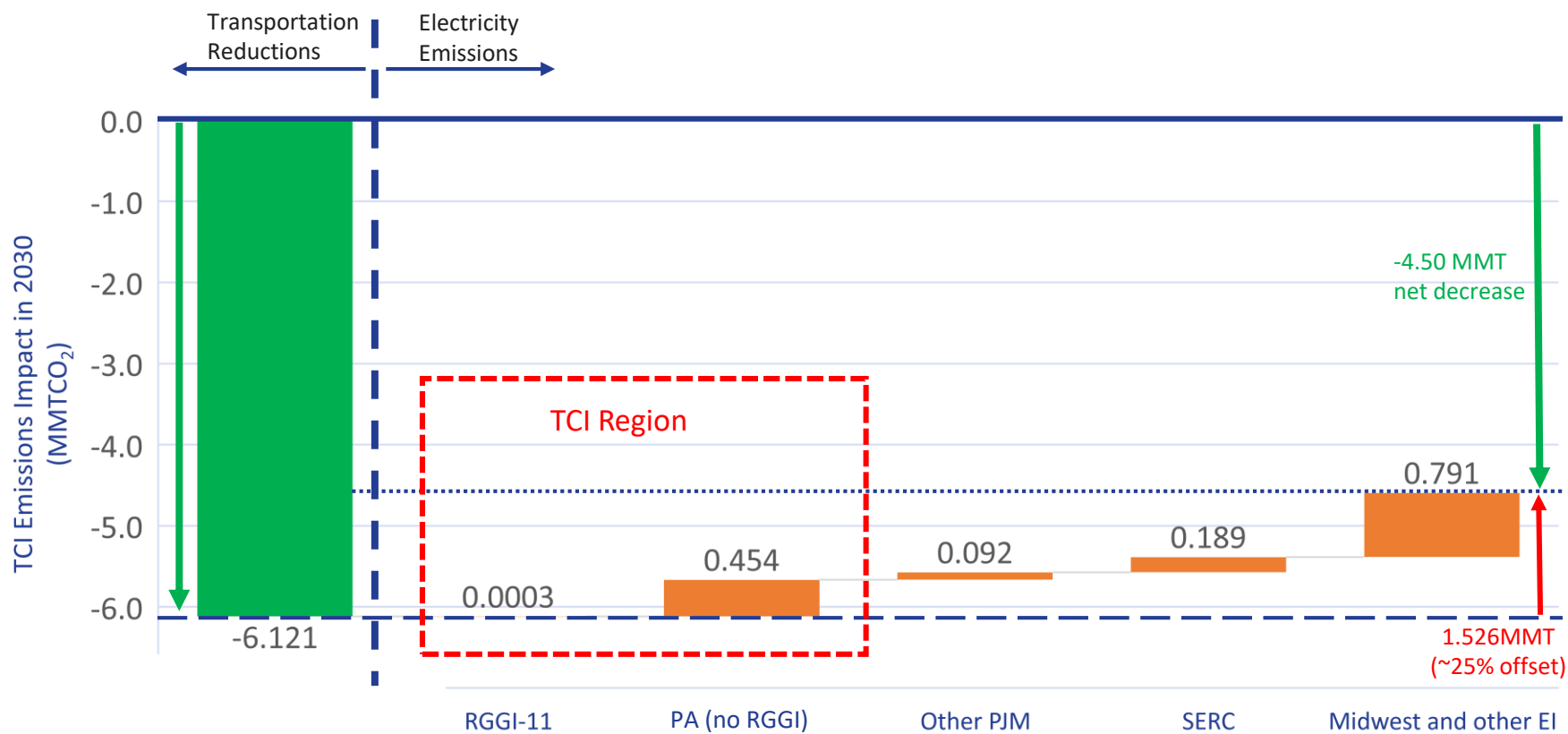
- Electrification reduces transportation emissions, but increases electricity emissions
- Our **NEMS** modeling accounts for electricity impacts, but the model's geography does not work as well for state-level analysis
- We turned to **IPM** for a second opinion, as it is better at “seeing” state borders
 - IPM is the “model of record” for RGGI
- The IPM results evaluate the electricity sector impact from the incremental electricity demand in TCI policy cases due to greater electric vehicle deployment
- Results available for:
 - TCI 22% case with no RGGI participation in Pennsylvania
 - TCI 25% case with no RGGI participation in Pennsylvania
 - TCI 25% case with RGGI participation in Pennsylvania

} All run under investment portfolio B

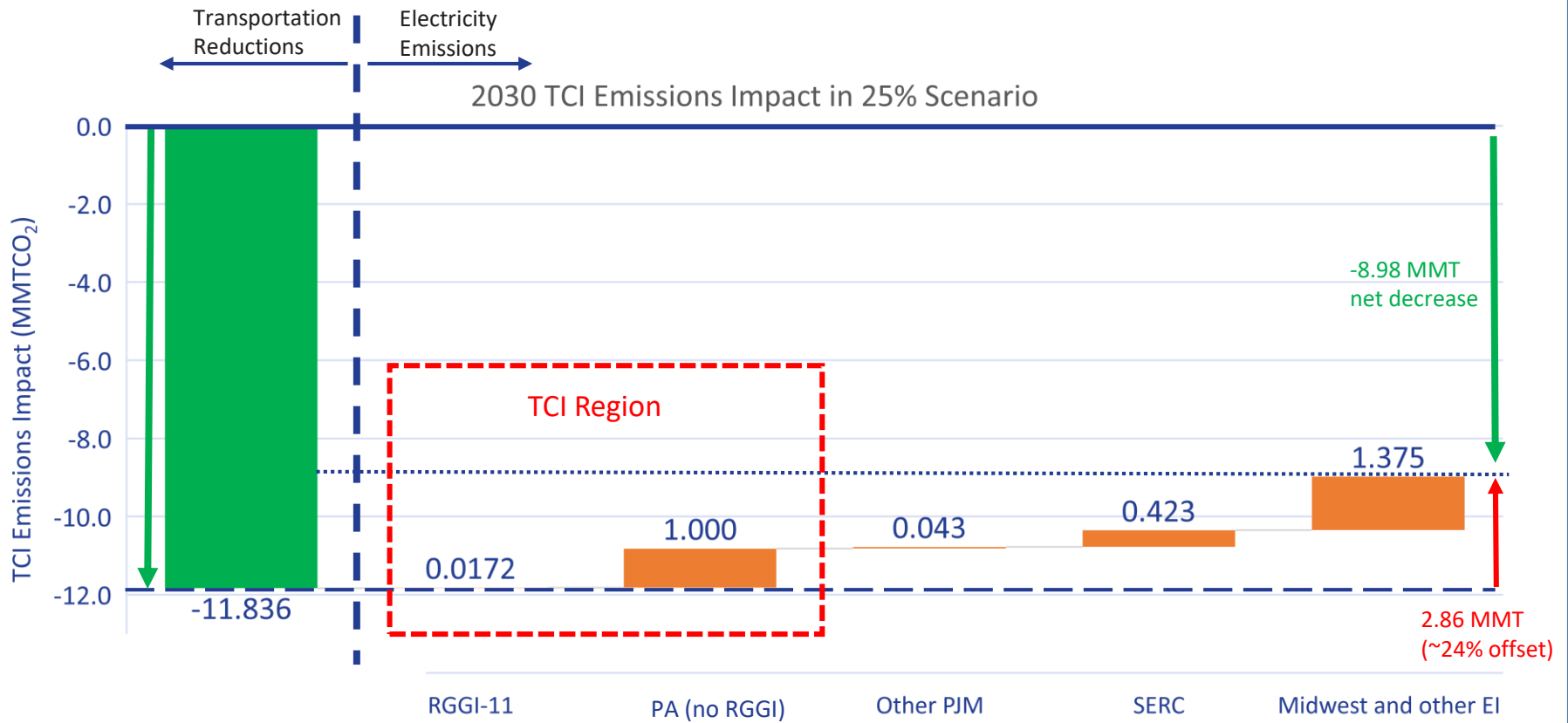
NEMS Electricity Module Regions



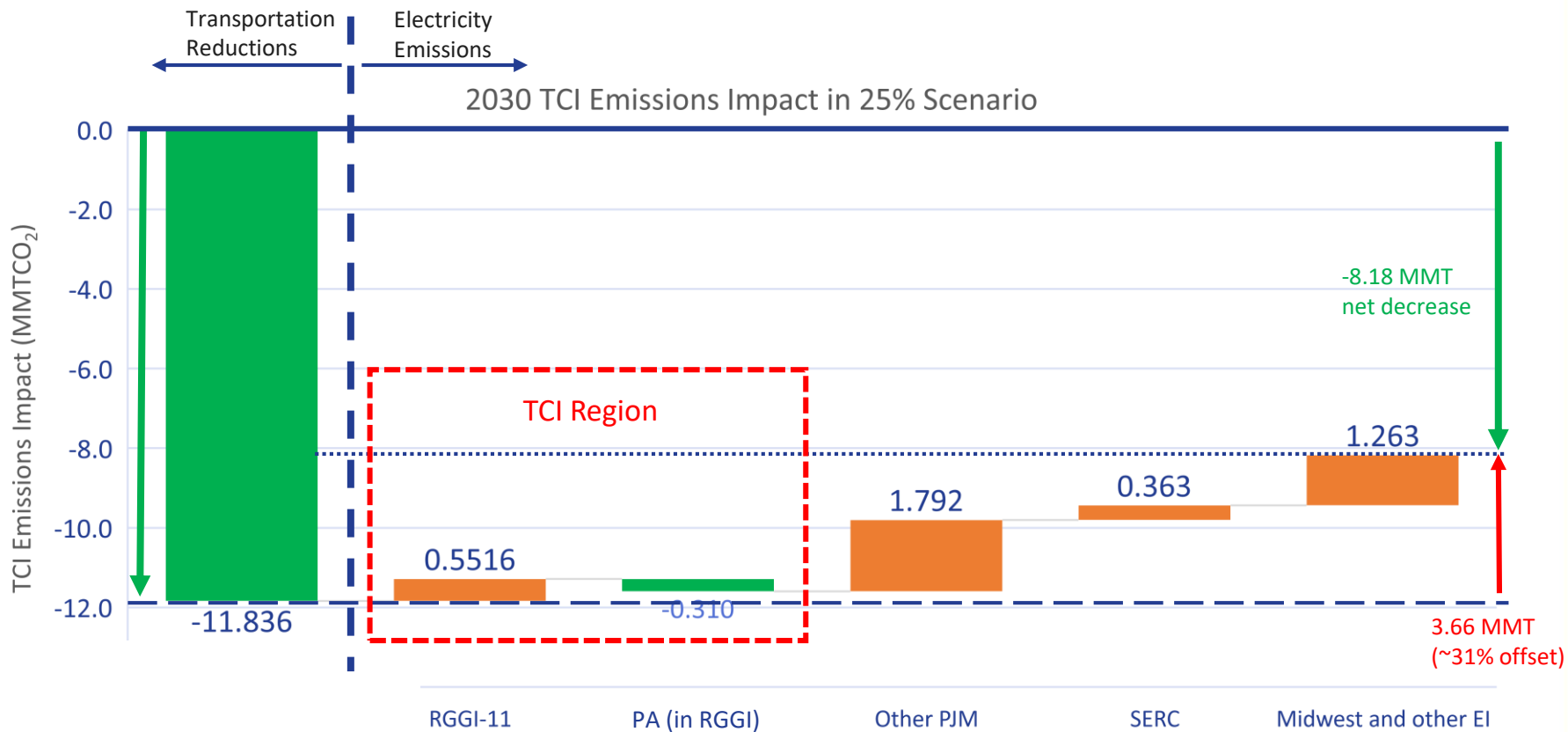
2030 CO₂ Impacts in 22% TCI Cap Scenario (ICF Electricity Analysis)



2030 CO₂ Impacts in 25% TCI Cap Scenario (ICF Electricity Analysis)



2030 CO₂ Impacts in 25% TCI Cap Scenario w/ PA in RGGI (ICF Electricity Analysis)

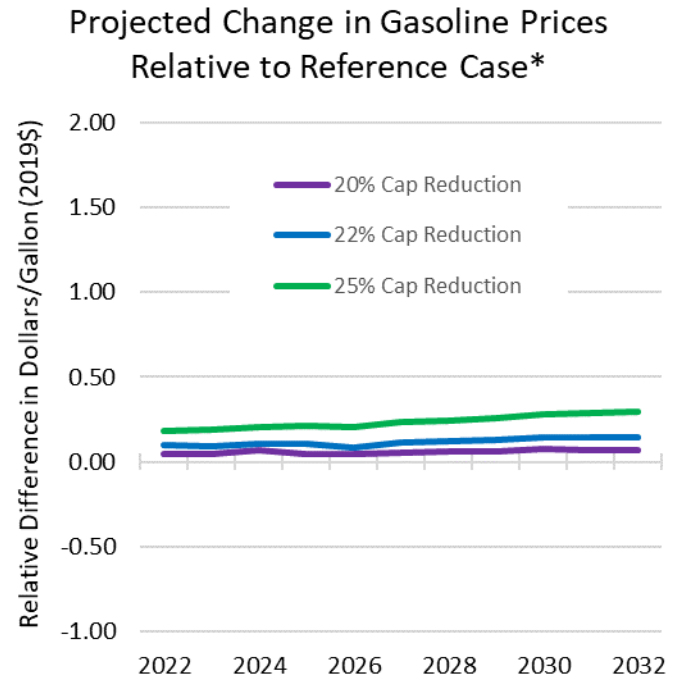
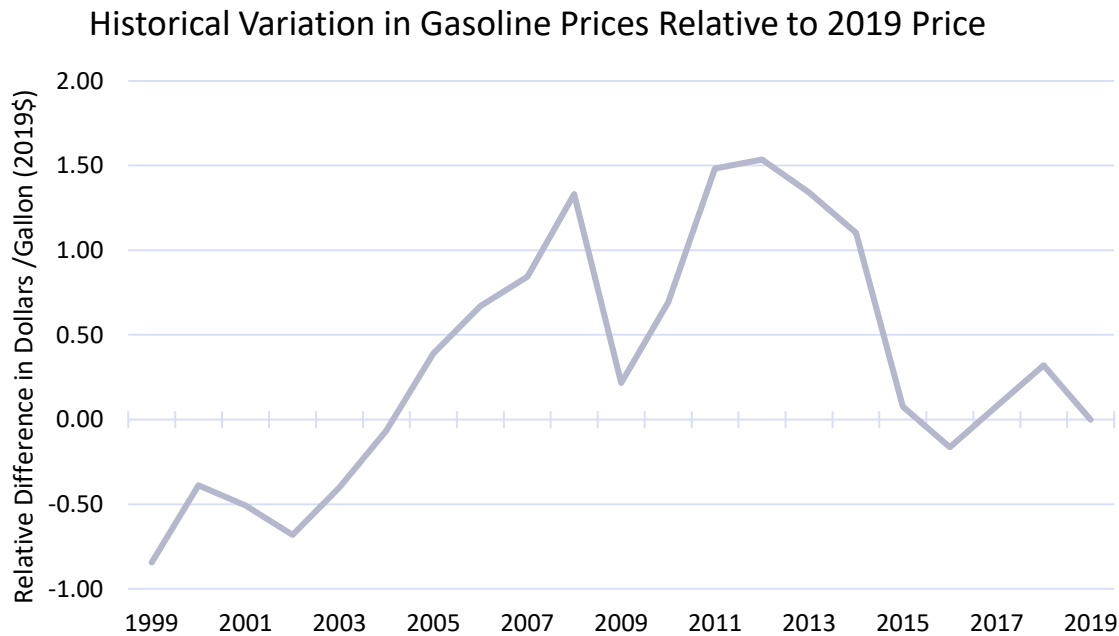


Key Takeaways from Electricity Analysis

- Electrification causes some electricity emissions increase
- Electricity CO₂ Increases are modest compared to TCI reductions
 - Extremely uncertain, depending on future market and policy drivers for electricity
 - Changes in modeling are very small, so model uncertainty is especially high
- In IPM modeling of 22 & 25% cases, electricity CO₂ increases are
 - Equal to ~7.2 to 8.6% of TCI reductions in TCI region (with no PA RGGI);
 - Equal to 2% of reductions in the TCI region with PA in RGGI
 - Equal to up to ~24 to 31% of TCI reductions across entire Eastern Interconnection (EI)
 - Most increases occur far outside of TCI and RGGI, in states without robust clean energy programs
 - ***These estimates assume no improvement in national clean energy policy or state/regional programs outside of TCI***

Modeled Gasoline Prices in Policy Scenarios

Compared with historical variations



*If fuel companies decide to pass on allowance costs it could mean an incremental price increase in 2022 of \$0.05, \$0.09 or \$0.17 / gallon in the 20%, 22% and 25% Cap Reduction Scenarios, respectively. This is not a prediction of gasoline prices in the future. Several factors affect future gas prices, including policy and market forces.