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EPA's GLIMPSE project and an application exploring regional impacts of electric vehicles

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Foreword

- Objective of this presentation
  - Introduce the GLIMPSE project and demonstrate its use for an illustrative assessment of the impact of electric vehicles on emissions of carbon dioxide and air pollutants.
- Intended audience
  - The Global Change Assessment Model user community, including researchers and analysts
- Additional contributors
  - EPA ORD: Chris Nolte, Tai Wu, Carol Lenox
  - EPA OAR: Aaron Sobel, Michael Shell, Chris Ramig, Meredith Cleveland, Susan Burke, Ryan Sims
  - ORISE participants and fellows: Yang Ou, Wenjing Shi, Samaneh Babaee, and Troy Hottle
- Disclaimers
  - The views expressed in this presentation are those of the authors and do not necessarily represent the views or policies of the U.S. EPA or other author institutions.
  - Results are provided for illustrative purposes only

Abbreviations

- Emissions
  - CO_2 – carbon dioxide
  - GHG – Greenhouse gas
  - N - Nitrogen
  - NOx – nitrogen oxides
  - O_3 – ozone
  - PM – Particulate matter
  - $PM_{2.5}$ – PM with a diameter less than 2.5 microns, also called fine PM
  - SO_2 – sulfur dioxide
  - NEI – National Emissions Inventory
- Policies, regulations, and standards
  - CAFE – Corporate Average Fleet Efficiency standard
  - CSAPR – Cross-State Air Pollution Rule
  - NAAQS – National Ambient Air Quality Standard
  - NSPS – New Source Performance Standard
  - RPS – Renewable Portfolio Standard
  - RGGI – Regional Greenhouse Gas Initiative
  - ZEV – Zero emission vehicle
- Units
  - EJ – Exajoule
  - kT – Kiloton or kilotonne
  - MTC – Megatonnes carbon
- Modeling
  - GCAM – Global Change Assessment Model
  - GCAM-USA – GCAM with state-level resolution for the U.S.
  - GLIMPSE – GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator
  - MOVES – MObile Vehicle Emissions Simulator
  - IPM – Integrated Planning Model
  - NONROAD – Nonroad mobile source model
- Energy fuels, technologies, and control measures
  - CCS – Carbon capture and storage
  - CNG – Compressed natural gas
  - EV – Electric vehicle
  - EE – Energy efficiency
- Organizations
  - EPA – Environmental Protection Agency
  - ORD – Office of Research and Development
  - OAR – Office of Air and Radiation
- Other
  - AEO18 – 2018 Annual Energy Outlook report
  - ORISE – Oak Ridge Institute for Science and Education

Outline

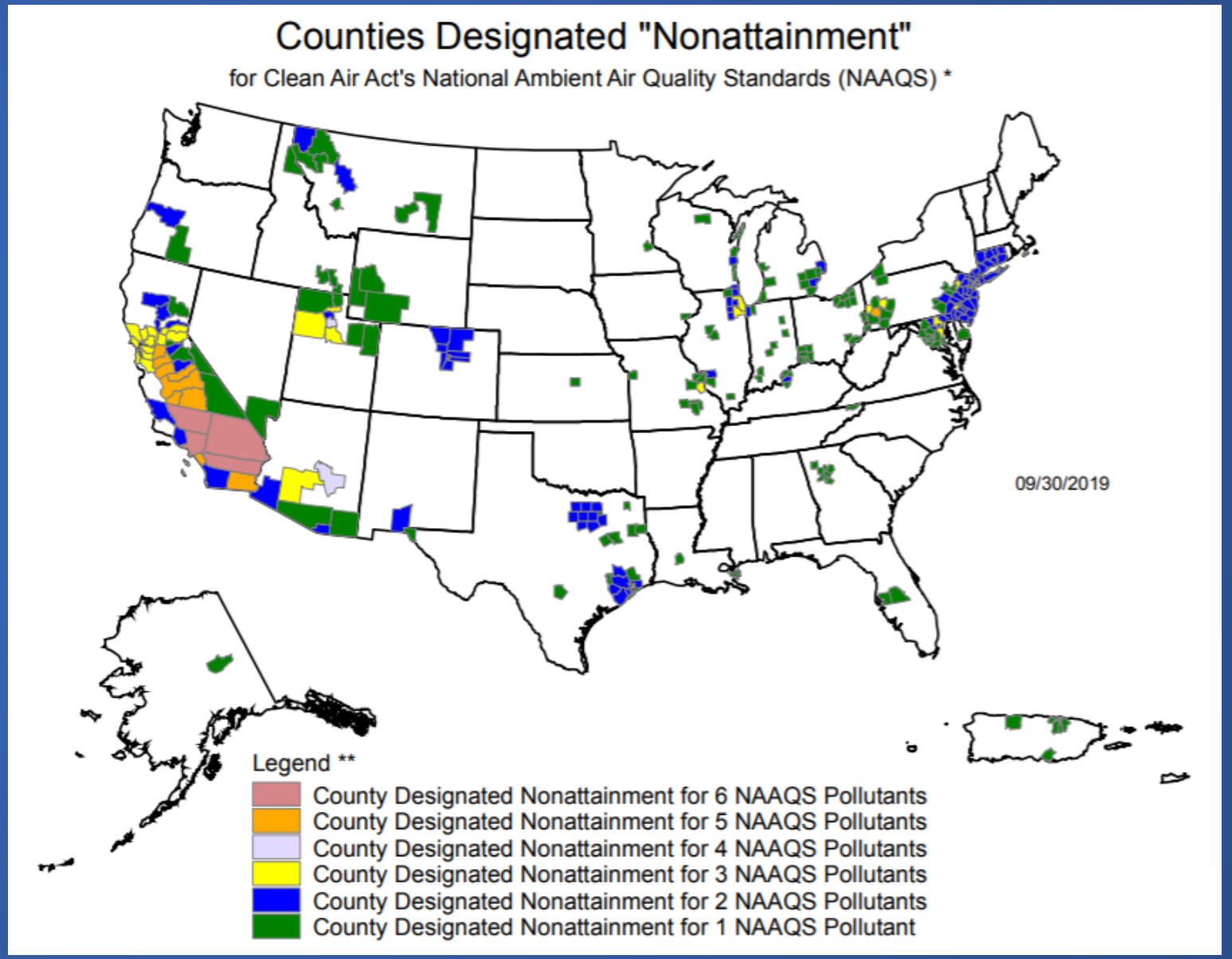
- Background
  - Air quality today
  - State and regional air quality planning
- GLIMPSE project
  - Objectives
  - Activities
- Illustrative application
  - Net emission impacts of electric vehicles
- Next steps

Air quality today

The Clean Air Act lays out procedures for setting and updating National Ambient Air Quality Standards (NAAQs).

Currently, approximately 140 million Americans live in counties that violate one or more of these standards.

States are responsible for developing plans to achieve and maintain attainment.



State and regional air quality planning

NAAQS:

How will factors such as population and economic growth, climate change, and new technologies challenge NAAQS attainment over the coming decades?

How do existing policies (e.g., RGGI, CSAPR, Tier 3, NSPSs, …) protect against these challenges?

What are new and/or emerging sources of pollution?

What additional measures may be necessary to attain/maintain attainment over a range of possible future scenarios?

State and regional air quality planning

Co-Benefits:

How do climate policies (e.g., RGGI, RPS, EE/RE, CAFE, ZEV mandate …) affect NAAQS attainment?

How do air quality policies (e.g., CSAPR, NSPS) affect GHG mitigation goals?

State and regional air quality planning

Management:

Are there cost-effective strategies for meeting both my air quality and climate goals?

What are the relative cost-effectiveness of end-of-pipe controls, renewable electricity, energy efficiency, mass transit, and vehicle and building electrification in meeting these goals?

If I have a limited amount of resources to invest, where are they best spent?

State and regional air quality planning

United States Environmental Protection Agency

Topics that arise:

What are the implications of PA and NJ joining RGGI?

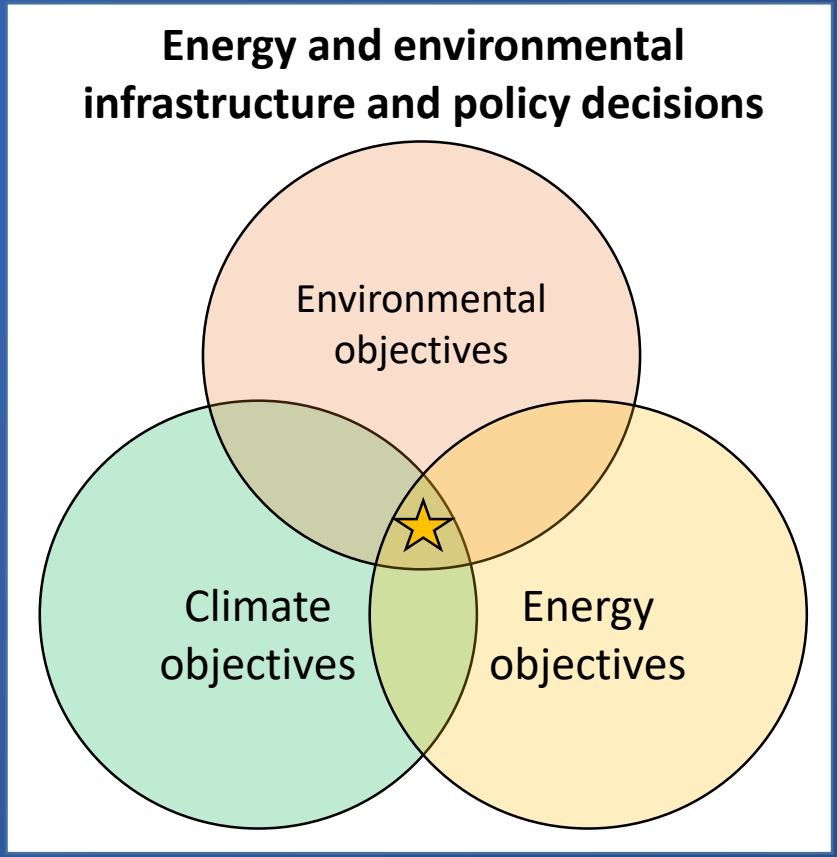
… the proposed transportation sector GHG cap and trade?

… more states adopting ZEV mandates?

How do the climate and air quality policies of my neighbors affect my state's climate and air quality goals (e.g., via spillover)?

GLIMPSE project objective

- Develop a model-based tool for long-term environmental and energy planning
  - Evaluate scenarios (exploring assumptions: technology, policy, socio-economic, …)
  - Understand tradeoffs among policy options
  - Identify cost-effective, robust management strategies
- Support decisions at various geo-political scales
  - National
  - Regional
  - State
- Desired attributes
  - Low-cost or free, open source
  - Easy to use
  - Executes on desktop computer
  - Relatively quick



GLIMPSE activities

Improvements to GCAM-USA

Added regulatory representations

- CSAPR, CAFE, NSPS, Tier 3

Updated emission factors from

- MOVES, IPM, NONROAD, GREET

Added electric sector and industrial "end-of-pipe" controls

Graphical interface for GCAM

Developed "Scenario Builder" to facilitate running the model and managing results

Adding "policy levers" to facilitate applications

Created "Enhanced ModelInterface", with improved graphics and filtering tools.

(see tomorrow's GCAM-USA breakout for a demo)

Applications

Health effects of alternative energy pathways

Net, state-level emission impacts of electric vehicles

Cost-effective strategies for achieving PM mortality reductions

Other activities

Comparing emission outputs with the NEI and EPA projections

Adding impact factors: PM mortality costs, O_3 damage to timber and crops, N deposition

Partnering with others

EPA program office beta-testers

Beginning collaboration with states in EPA Region 3 to explore how GLIMPSE can support state decision-making

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Illustrative application:

Net emission impacts of electric vehicles (EVs)

- Context
  - AEO18 passenger vehicle EV market share in 2050: ~11%
  - However, recent EV cost projections are much lower than in AEO18
- Research questions
  - What EV penetration is projected by GCAM-USA using updated EV costs?
  - What are the energy and emission impacts of greater EV penetration?
  - How do these impacts differ by U.S. region?
  - What drives regional differences?
- Methodology
  - Compare two scenarios with GCAM-USA:
    - Low-EV: calibrated to approximate AEO18
    - Higher-EV: projected using GCAM-USA using updated EV costs

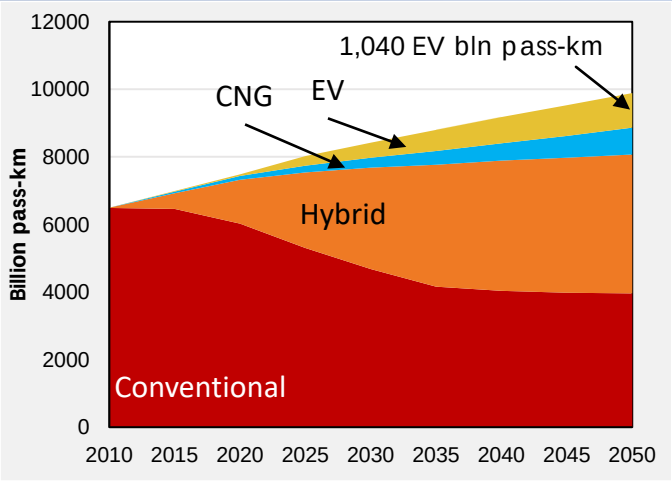
Results:

Light duty market penetration

How does EV market penetration differ between the Low-EV and Higher-EV scenarios?

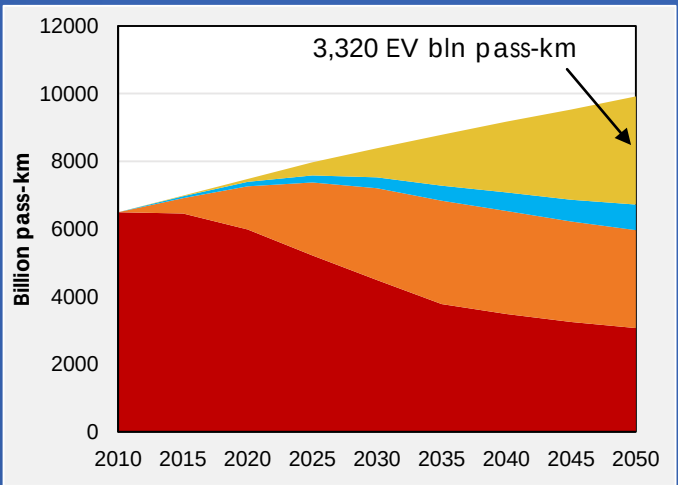
What technologies are being displaced by higher EV penetration?

Low-EV



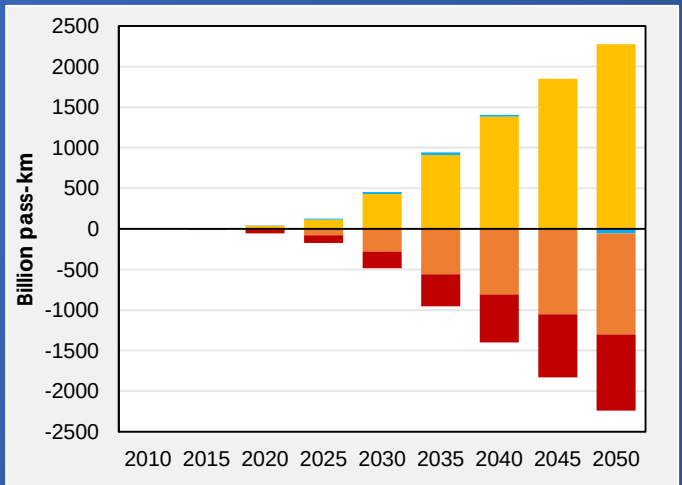
Light duty travel met by EVS, 2050: 11%

Higher-EV



Light duty travel met by EVs, 2050: 31%

Higher-EV minus Low-EV



About 60% of offset travel demand is from hybrid cars and trucks.

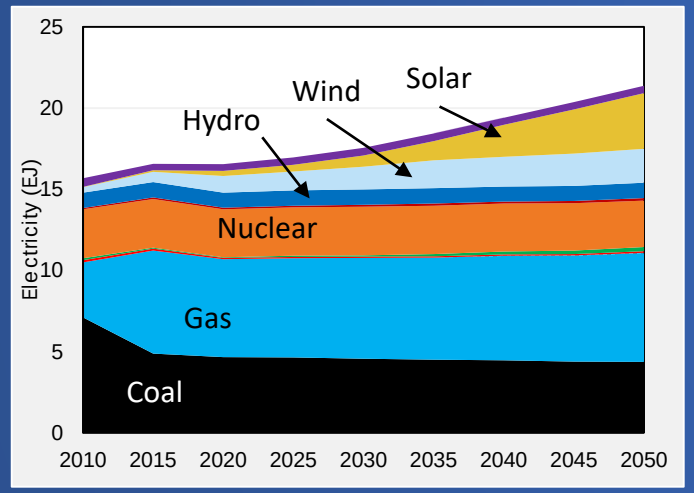
Results:

Electricity production

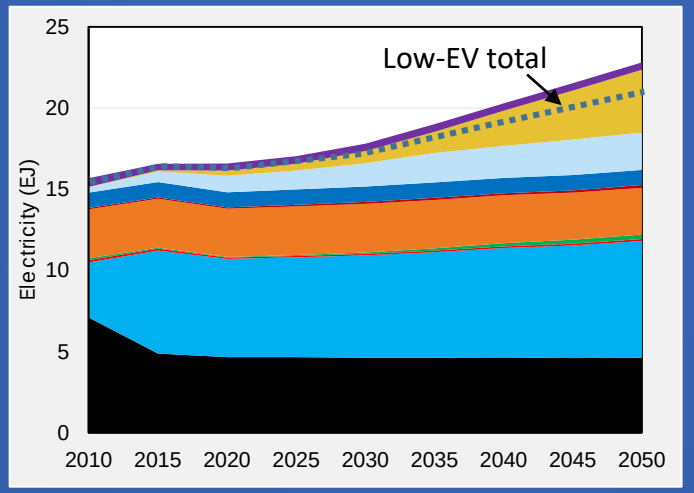
How much additional electricity must be produced in the Higher-EV scenario?

What mix of technologies are used to meet the additional electricity demands?

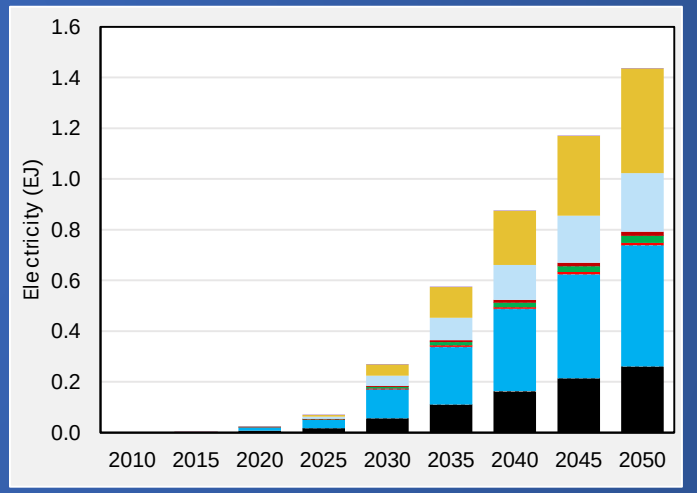
Low-EV

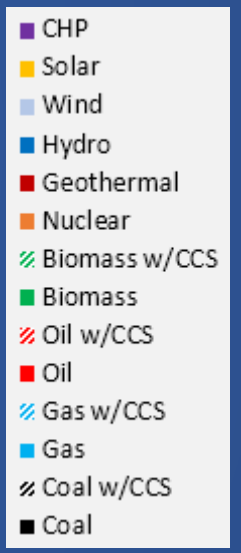


Higher-EV



Higher-EV minus Low-EV





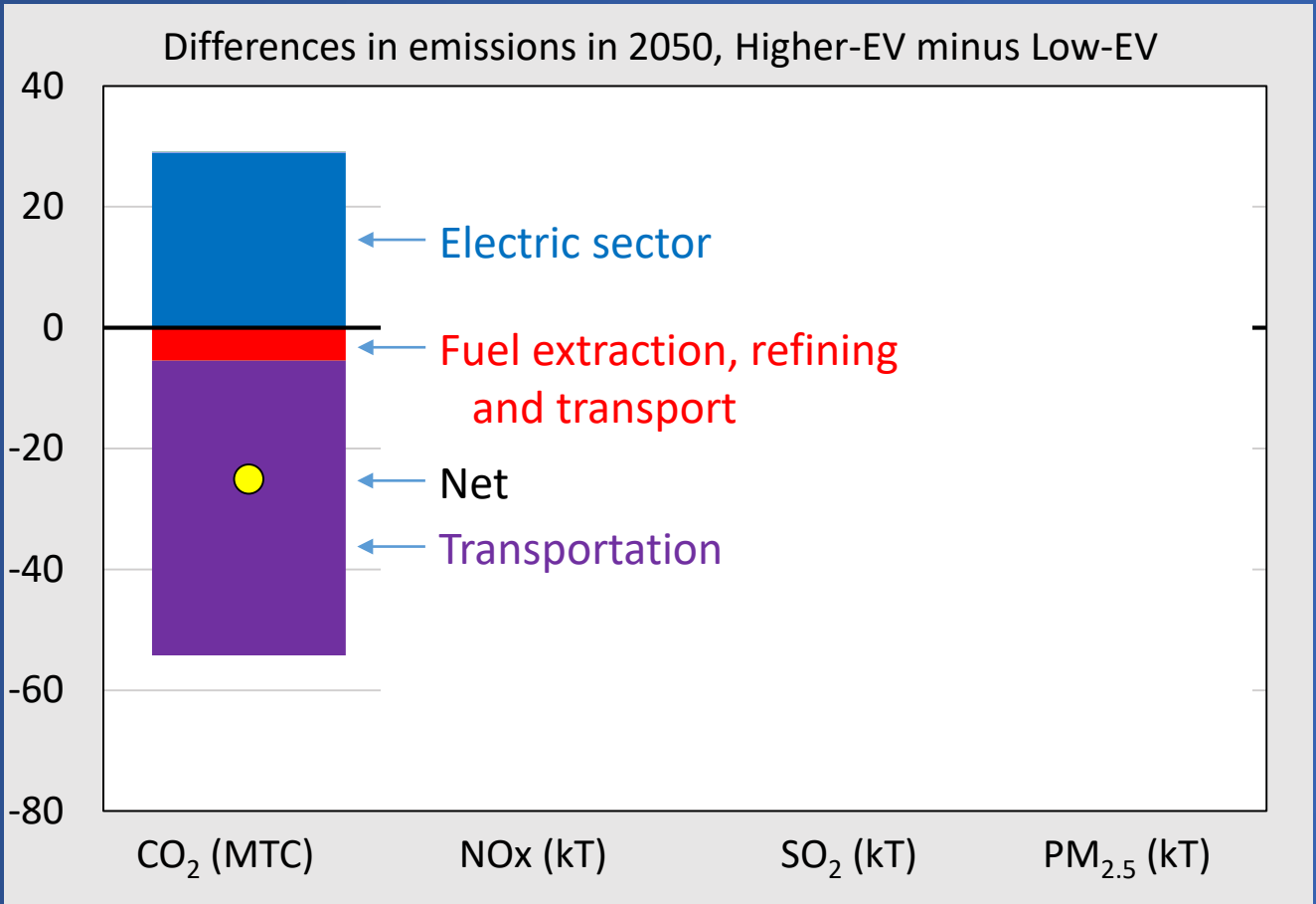
After 2020, wind and solar make up a large portion of new generation

By 2050, electricity production has increased by 7% relative to Low-EV

Some coal that would retire under the Low-EV scenario instead stays in use. Natural gas, wind, and solar comprise most of the additional generation.

Results:

System-wide emissions response at the national level



Categories:

(1) Primary:
Avoided tailpipe emissions (purple)
(2) Secondary:
Avoided refinery emissions (red)
Electricity production emissions (blue)
(3) Tertiary:
Price-induced fuel-switching (light purple, green, and orange)

There is a net reduction in CO_2, NOx, and SO_2. $PM_{2.5}$ increases, driven by the electric sector.

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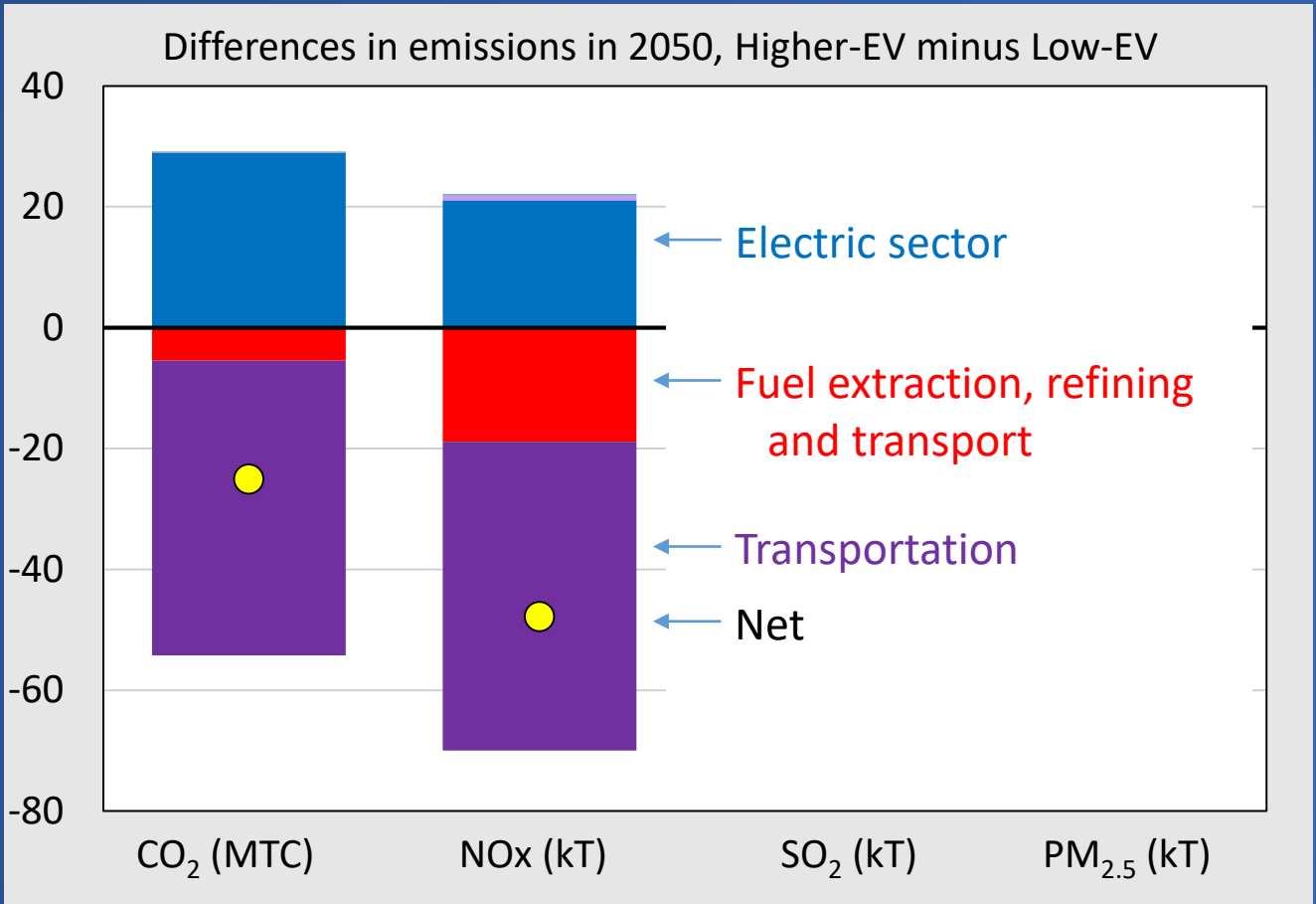

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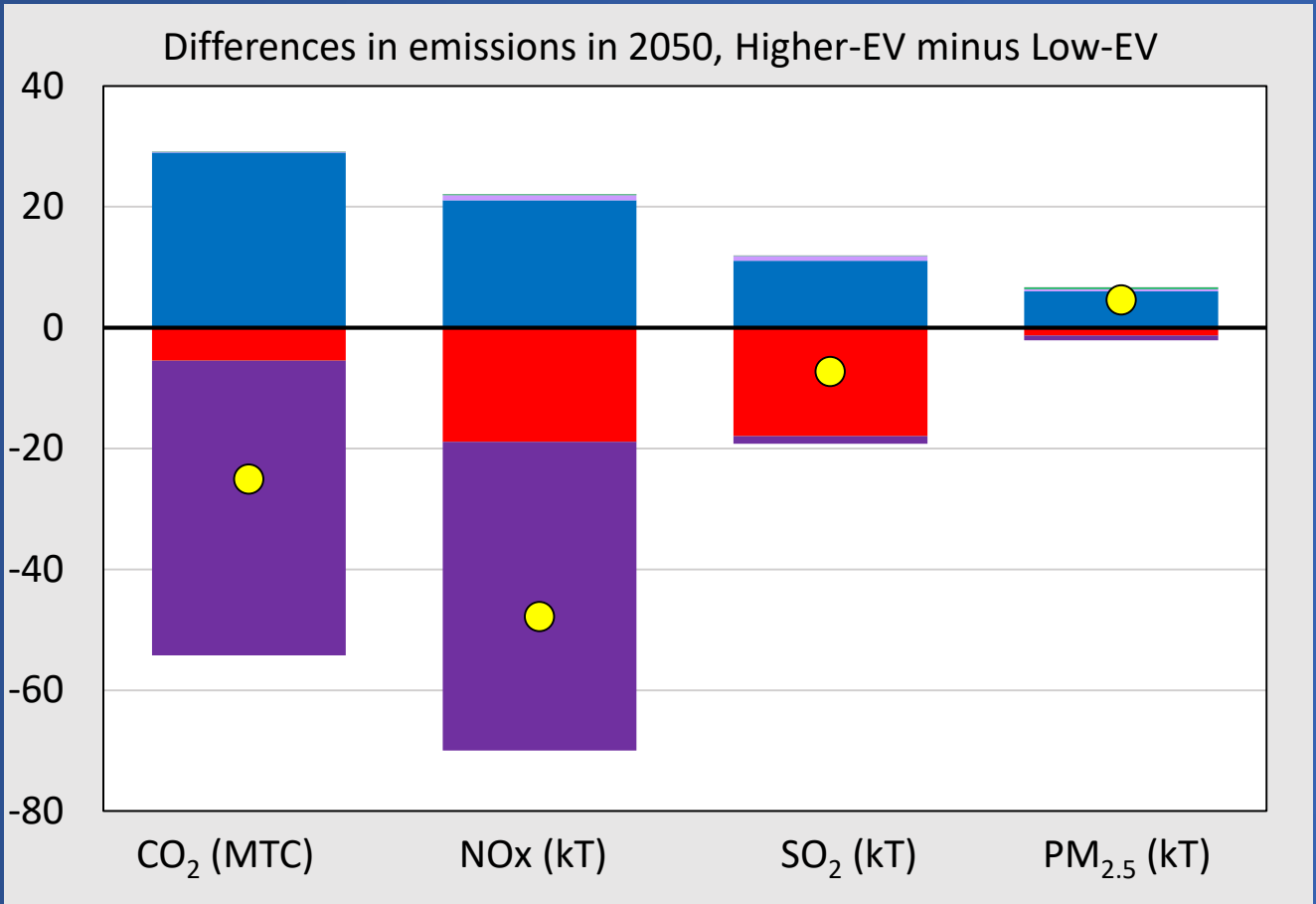

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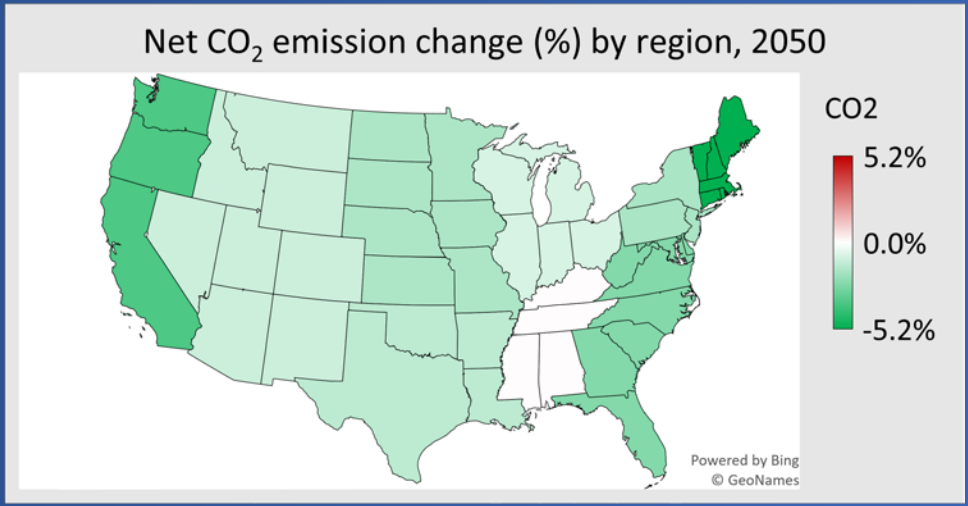
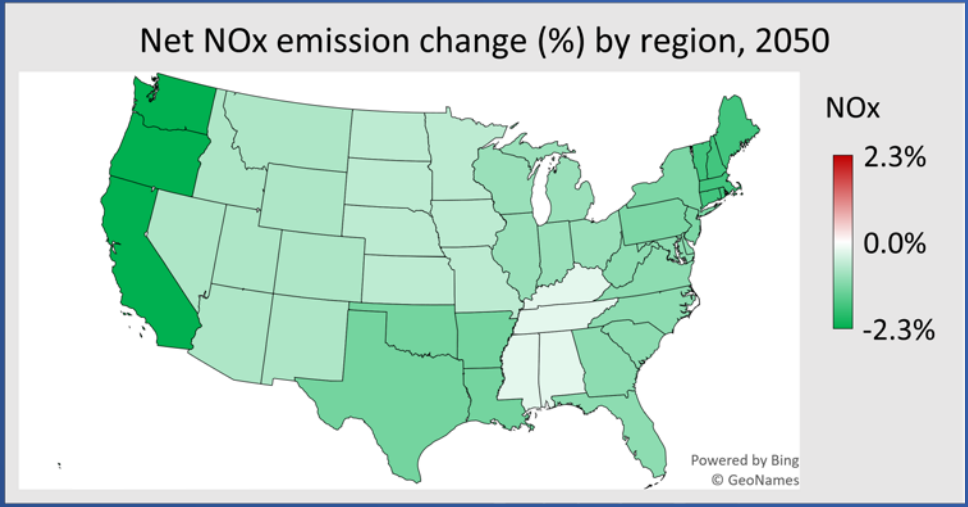
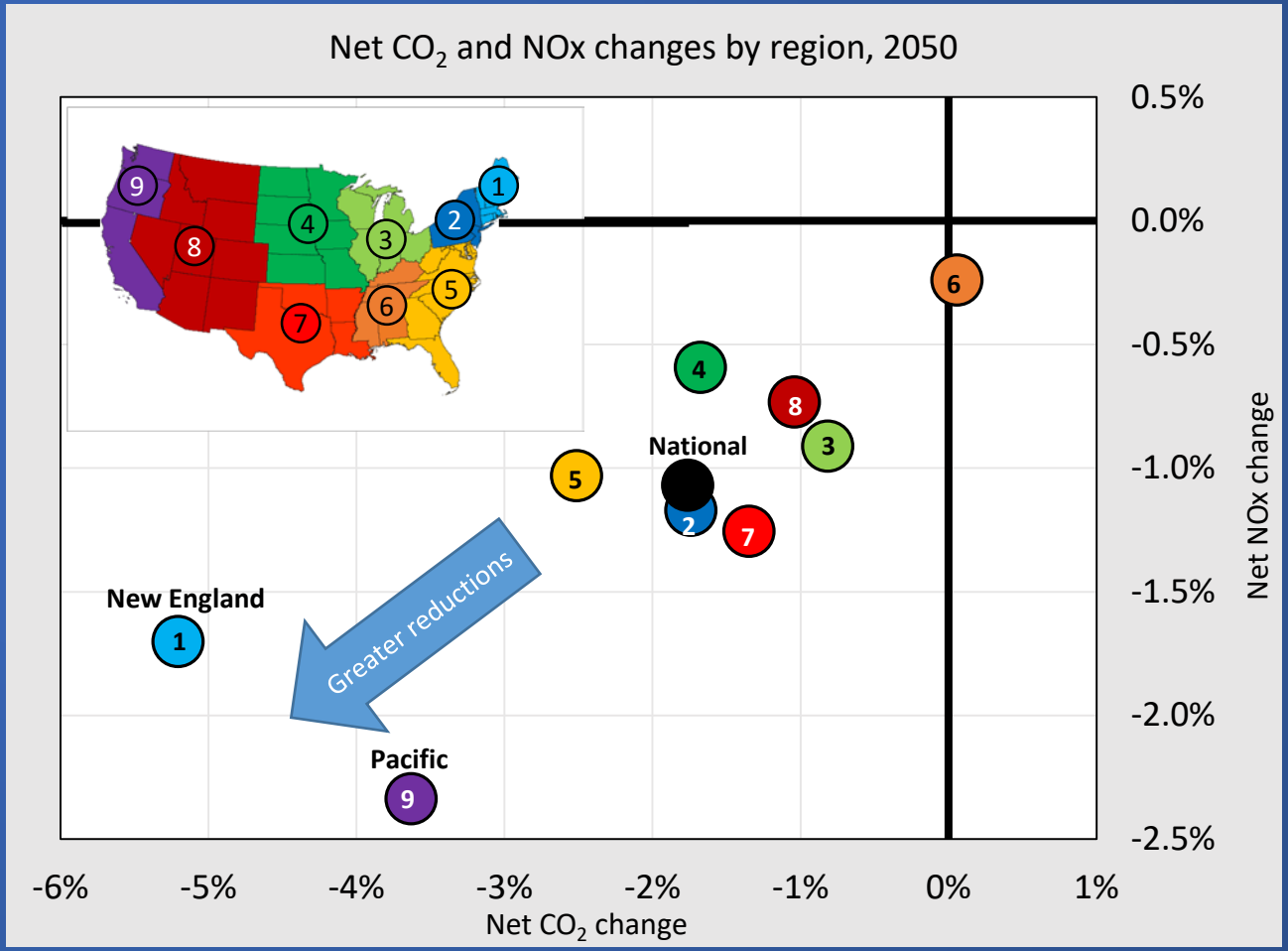
Results:

Comparison of regional emission responses

How do the regional net emission changes compare?





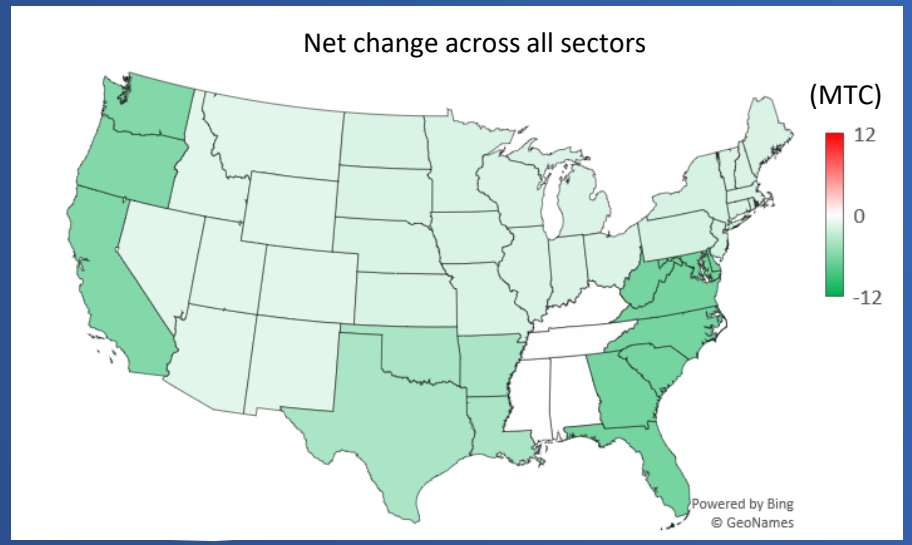


Hawaii and Alaska are not included in Region 9 values shown

Results:

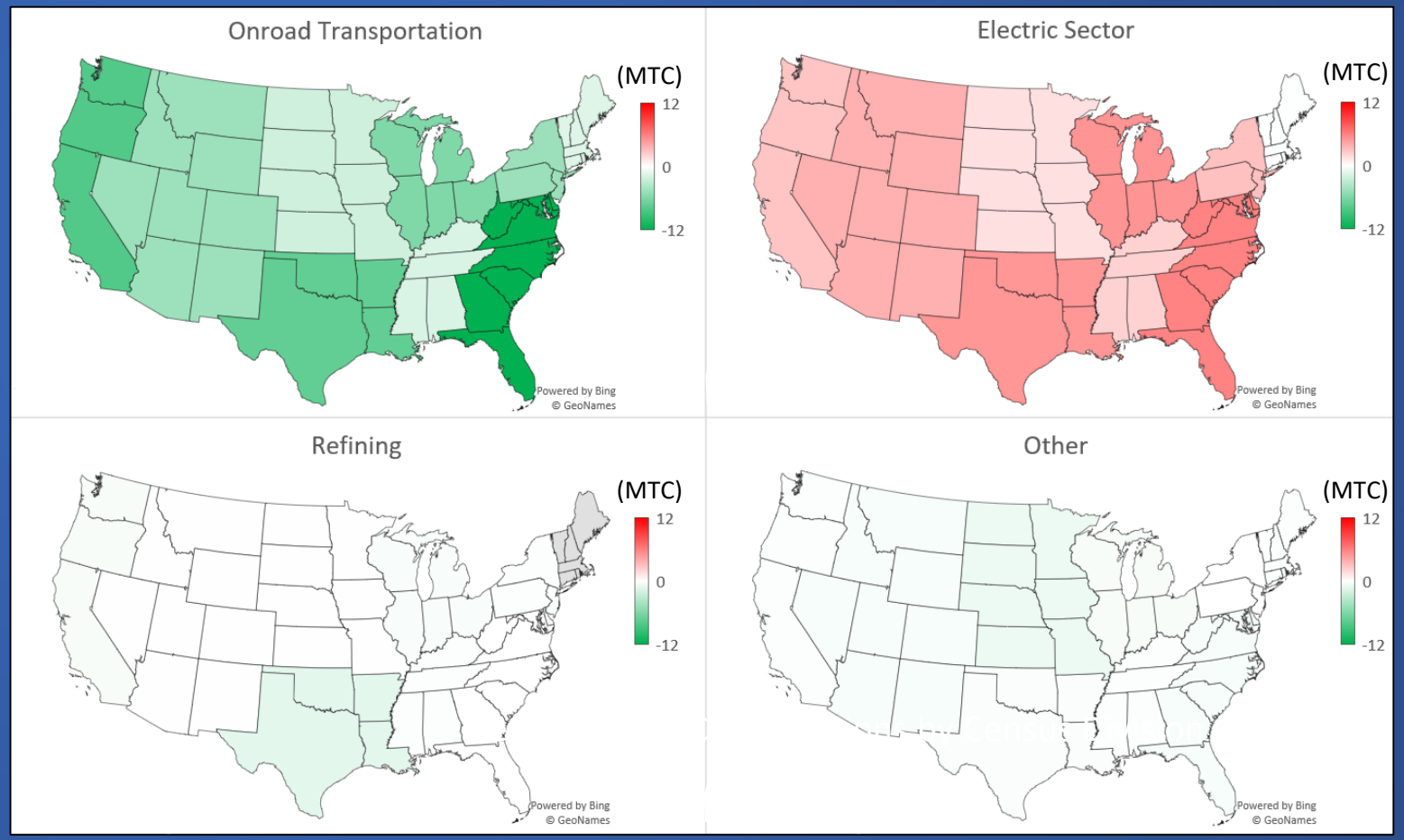
Differences in regional CO_2 emissions

Differences in 2050 CO_2 by Census Division and sector, Higher-EV minus Low-EV



Largest decrease: Region 5, Southeast, -6.5 MTC

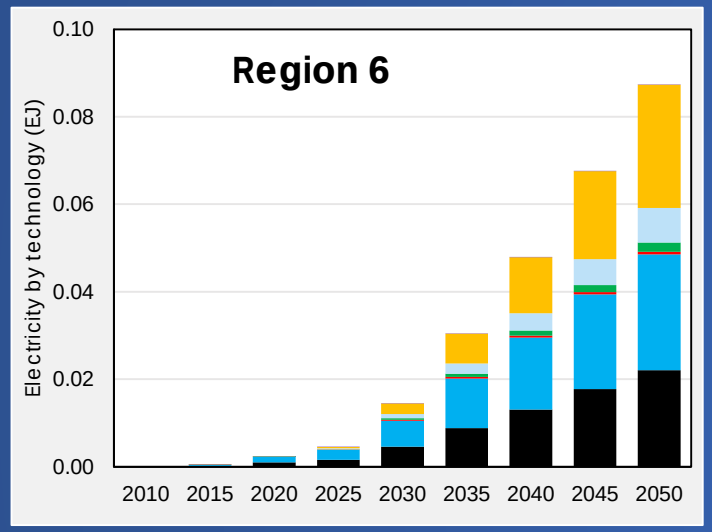
Sectoral

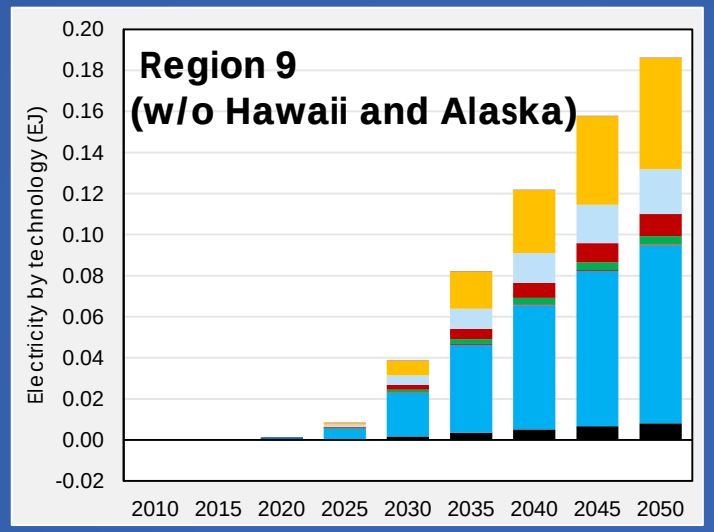


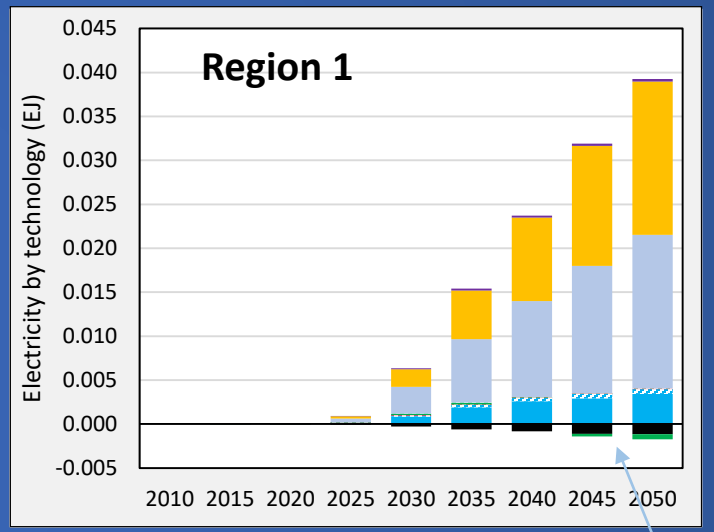
Results:

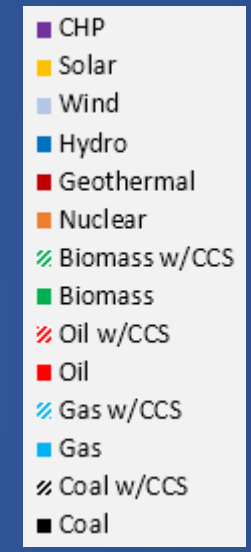
Factors driving regional differences

The technologies used to meet additional electricity demands differ by region









Emission intensity, 2050:

CO_2: 24 MTC/EJ
NOx: 21 kT/EJ

Emission intensity of additional electricity in 2050:
CO_2: 19 MTC/EJ
NOx: 7.8 kT/EJ

Emission intensity of additional electricity in 2050:
CO_2: -1.9 MTC/EJ
NOx: -0.004 kT/EJ

The Region 1 response to EVs reflects RGGI

Intensity calculation: $\frac{\text{Change in regional electric sector emissions}}{\text{Change in regional electricity production}}$ (Higher-EV minus Low-EV)

Results:

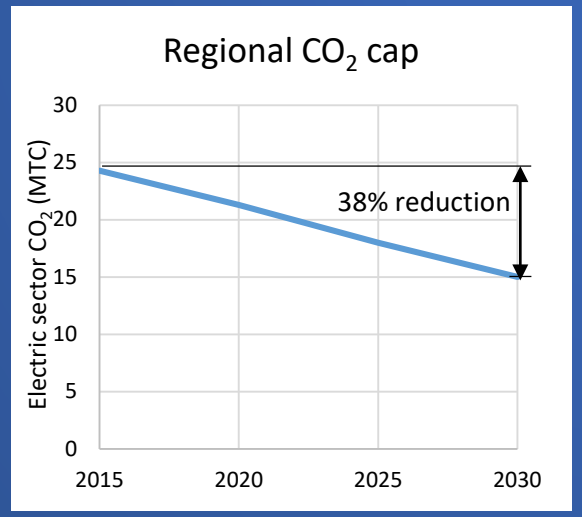
Regional policy influence

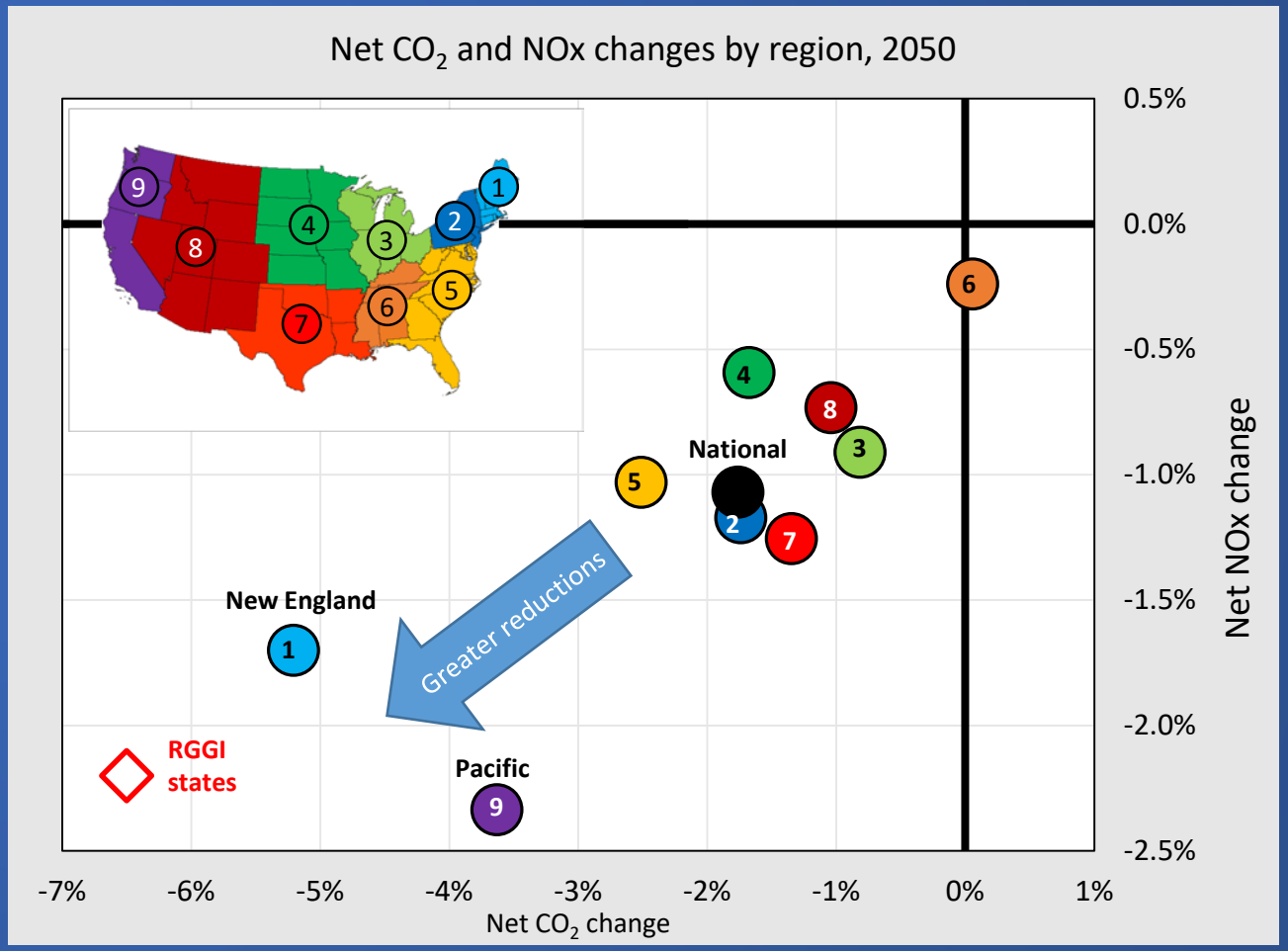
Regional Greenhouse Gas Initiative (RGGI)

Prior to 2019, 9 RGGI states had agreed to cap on electric sector CO_2 emissions

RGGI states:

Region 1 (New England), plus Maryland and Delaware (total population of 40 million in 2010)





Regional Greenhouse Gas Initiative (RGGI) states are those in Region 1, plus Maryland and Delaware.

Summary and next steps

- GCAM-USA can be applied to examine the long-term energy and emission impacts of EVs, including primary, secondary, and tertiary impacts
- These impacts are different by region, affected by existing technology stock and its turnover, fuel prices, access to renewables, and national regulations and state policies
  - RGGI is shown to enhance the benefits of EVs in member states
- Next steps
  - Examine high market penetration scenarios
  - Re-evaluate using the new version of GCAM-USA with enhanced electric sector detail
  - Link GCAM-USA with IPM to provide a more detailed exploration of electric sector response to EVs, including under alternative charging scenarios

GLIMPSE project directions

- Make the Enhanced ModelInterface available through GitHUB
- Work toward a late 2020 release of GLIMPSE to the public
  - Updates
    - Incorporate GCAMv5.2 with EPA modifications (emission factors, policies, controls)
    - Finalize and adopt the new industrial sector representation
    - Continue to implement existing state and regional policies
  - Improvements
    - Modify GLIMPSE to include easy-to-use “Policy levers”, e.g., pollutant taxes and caps, technology and fuel taxes and subsidies, Renewable Portfolio Standards, efficiency standards
  - Documentation
    - Documented case study applications
    - Users’ guide
- Explore adding a reduced-form air quality model that would translate emissions to pollutant concentrations

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Questions?

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