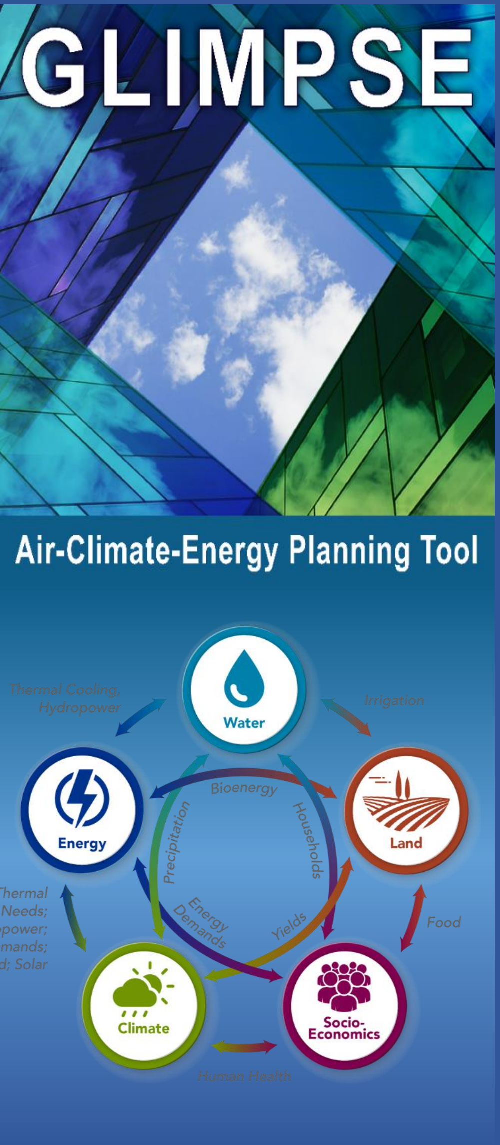
United States
Environmental
Protection Agency



GCAM-USA State Application Community of Practice Meeting

Developing State-Specific Insights about GHG Mitigation Opportunities Using a GLIMPSE/GCAM-USA Model

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U.S. EPA Office of Research and Development

December 5, 2024

Background

- State and local governments play a significant role in implementing climate mitigation actions.

- The Carbon Pollution Reduction Grants (CPRG) under the Inflation Reduction Act of 2022 (IRA) offers an unprecedented opportunity by providing funding specifically for states to develop carbon reduction strategies.

- Many states, municipalities, Tribes and territories submitted a Priority Climate Action Plan (PCAP) in March 2024 that outlines near-term actions and have now started to develop longer-term Comprehensive Climate Action Plans (CCAPs), which are due by the summer of 2025.

- CCAPs require an approach that involves steps such as:
    - Developing a greenhouse gas (GHG) inventory,
    - Projecting that inventory into the future,
    - Assessing the impacts of specific GHG reduction measures, and
    - Estimating associated reductions in co-emitted air pollutants.
    - Anticipating impacts on low income and disadvantaged communities

Challenge

- With limited resources available, states will need to prioritize their approaches that are effective and efficient.
- Heterogeneity of the United States results in “one size does not fit all” in the development of decarbonization strategies.
- Taking into account each state’s conditions is important for developing decarbonization strategies that are cost-effective and robust.

Research Questions

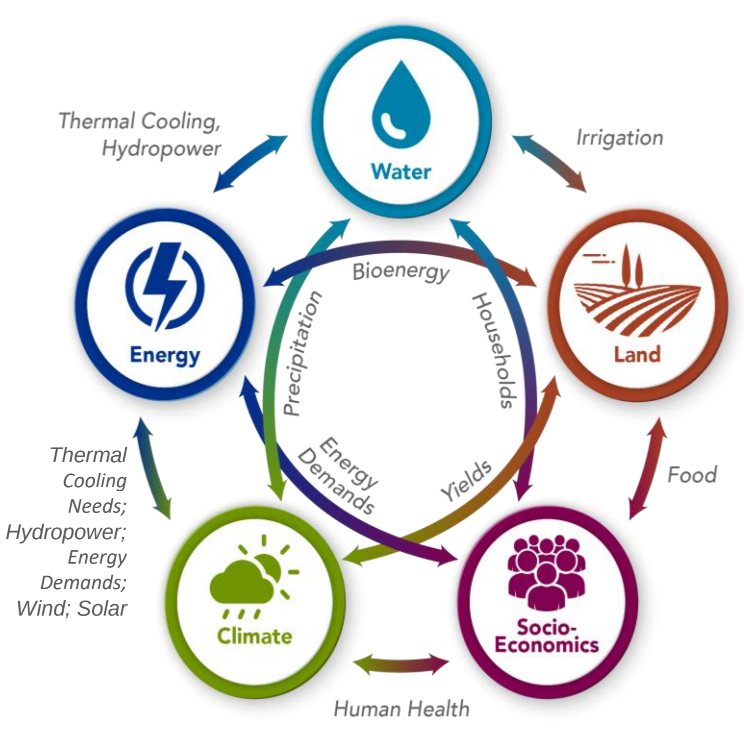
- Decomposition analysis helps us address the following questions:
    - What are the factors driving of GHG emissions for each state?
    - Can we develop insights into the most effective state-specific emission reduction strategies?

Approach

- The **Global Change Analysis Model (GCAM-USA)** allows users to:
    - specify GHG emission reduction targets
    - identify cost-effective strategies for achieving emission reduction targets

- Application of decomposition approaches, theoretically rooted in the Kaya Identity (Kaya & Keiichi, 1997), can then:
    - identify state-specific factors driving emissions
    - provide insights into the most cost-effective emission reduction measures

Human-Earth systems in GCAM



(Source: PNNL)

Methodology

Step 1
Scenario Design

Reference : No climate action
Decarbonization : Net-zero CO_2 emission constraint by 2050 (from the EMF37 study)

Step 2
GCAM Modeling

GCAM-USA simulates the scenarios.
From the results, we extract the following state-level data from 2020 to 2050 as below:

(a) CO2 emissions by technology,
(b) Inputs by technology,
(c) Outputs by technology,
(d) Population by state,
(e) GDP per capita by state

Step 3
Kaya Identity Analysis

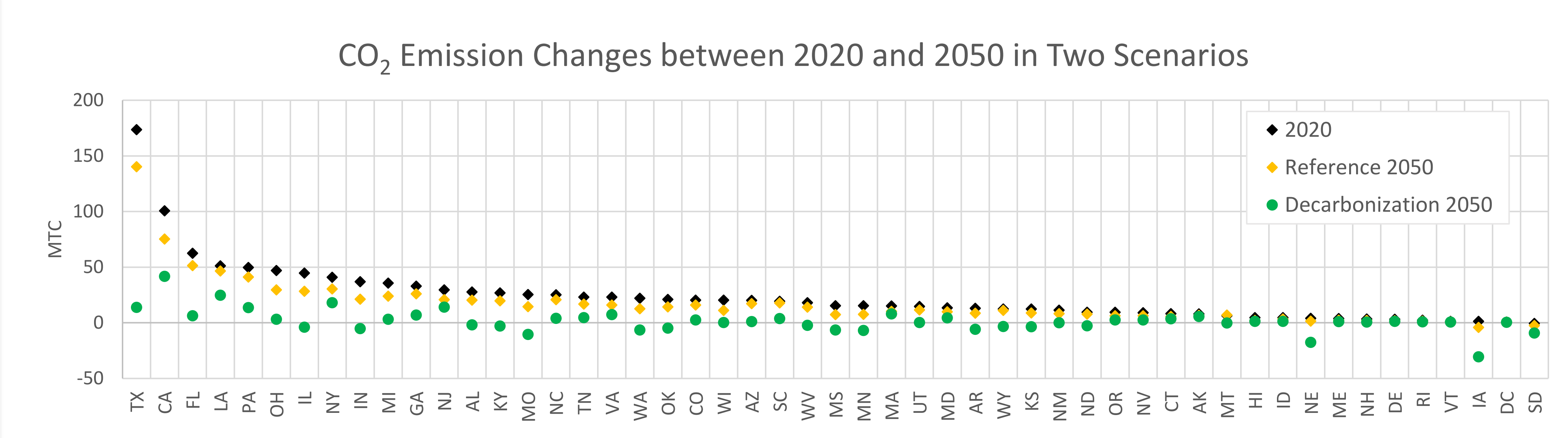
Decomposition analysis breaks down the factors of CO_2 emissions

$$C^t = \sum_{i}^{n} \overbrace{P^t}^{\text{Population}} * \underbrace{\frac{G^t}{P^t}}_{\text{GDP per capita}} * \overbrace{\frac{E_i^t}{G^t}}^{\text{Energy Intensity}} * \underbrace{\frac{E_o^t}{E_i^t}}_{\text{Energy Efficiency}} * \overbrace{\frac{C_i^t}{E_o^t}}^{\text{Carbon Intensity}}$$

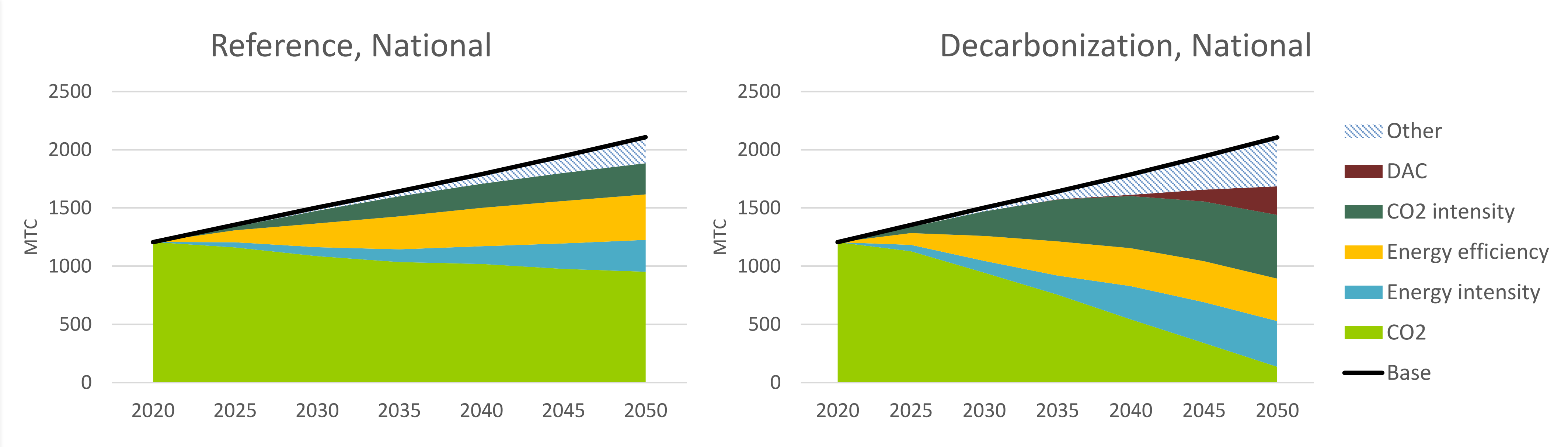
C^t: total CO2 emissions in a particular year, *t*
P^t: total population in the *t* year
G^t: GDP by state in the t year
E_i^t: energy consumption of energy technology *i* in the *t* year
E_o^t: energy service outputs of energy technology *i* in the t year
C_i^t: carbon emissions of energy technology *i* in the *t* year

Results

Projecting CO_2 inventory into the future by scenario

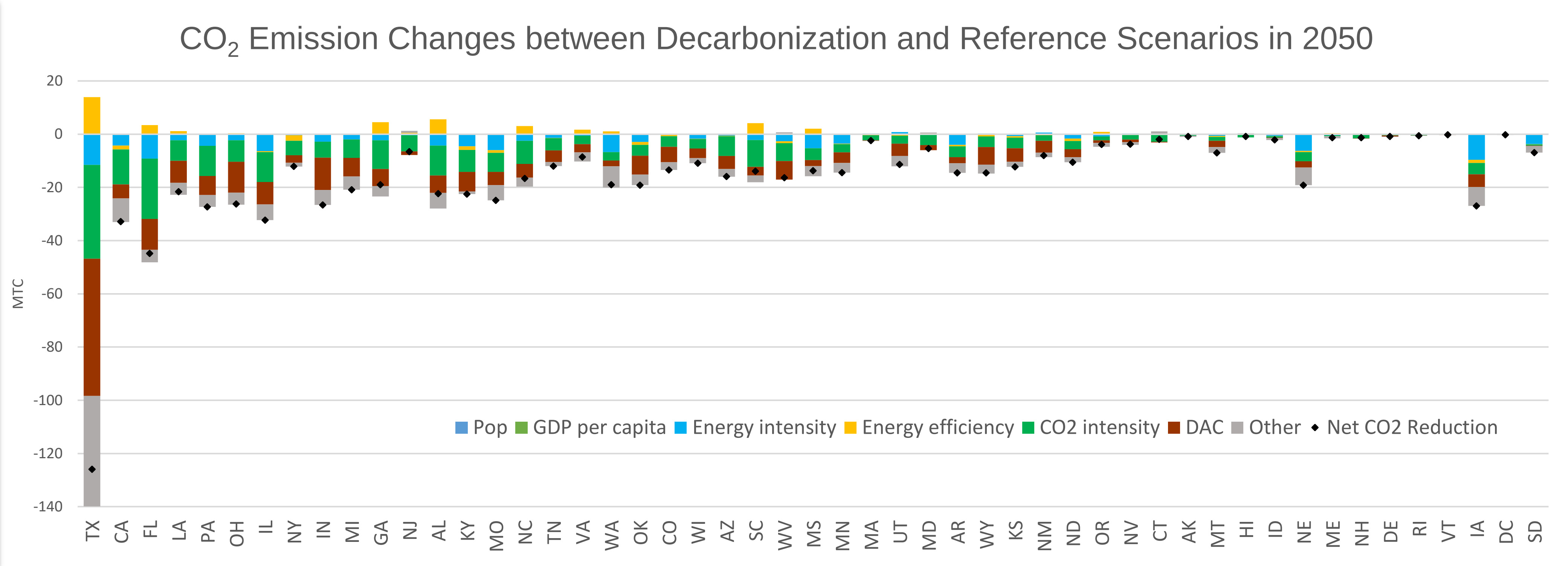


Characterizing CO_2 emission reduction wedges over time



Results

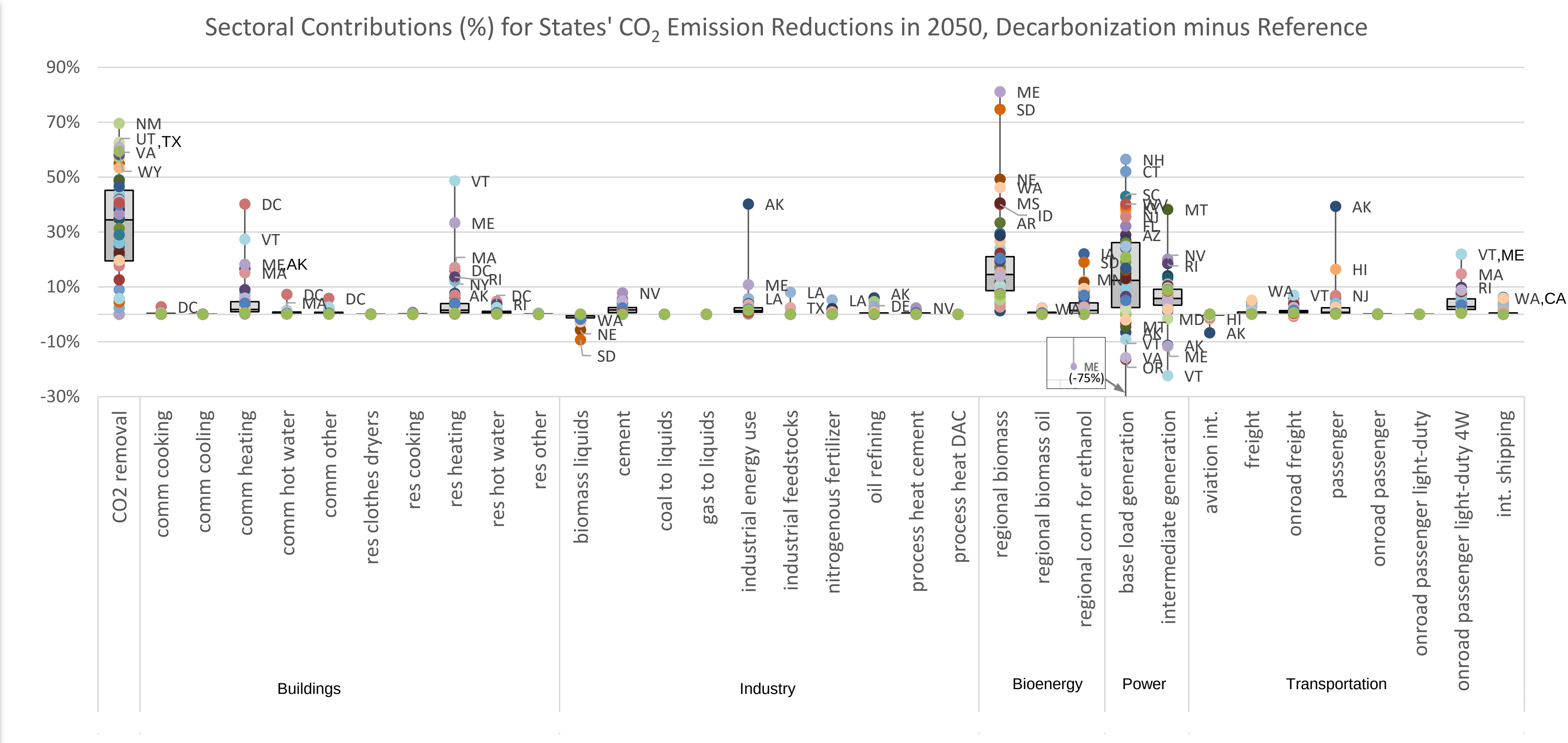
Comparing similarities and differences of CO_2 reduction strategies across states



- Some states (e.g. TX, FL) would have relatively greater potential for CO_2 reduction, due to improved CO_2 intensity and energy intensity and the use of DAC.
- States (e.g. NE, IA) with biomass resources would have greater potential for CO_2 reduction.

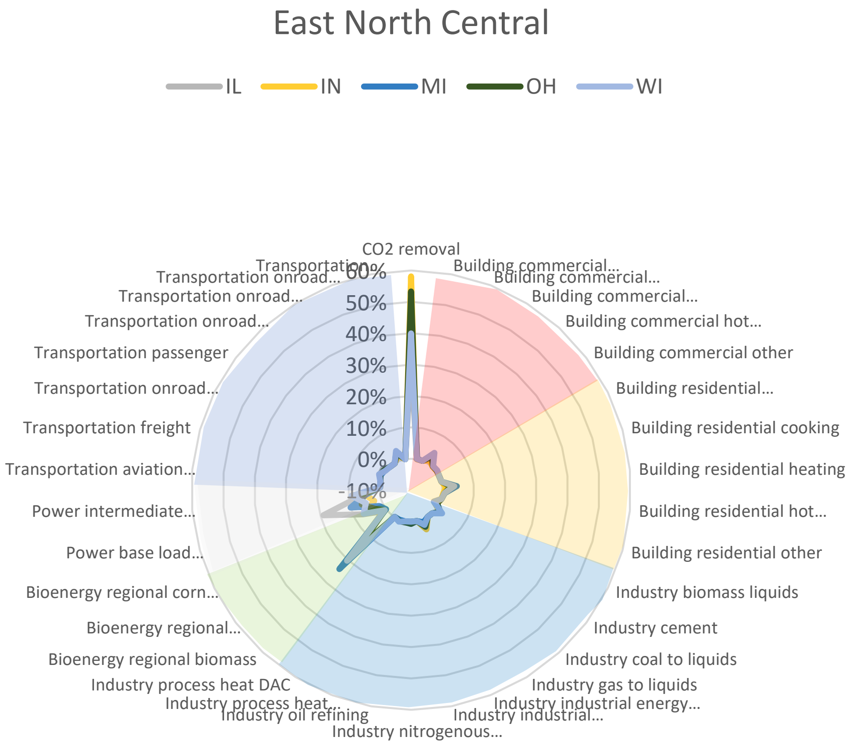
Results

Identifying mitigation contributors by end-use sector



- Outlier states can establish effective and efficient CO_2 reduction strategies from the sectors.
- Despite the net-zero constraints, the power sector, biomass liquids industry, and international aviation industry in some states are still expected to increase in CO_2 emissions.

Results


East North Central
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Industry nitrogenous...
Industry oil refining
Industry process heat...
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Bioenergy regional biomass
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Bioenergy regional corn...
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Power intermediate...
Transportation aviation...
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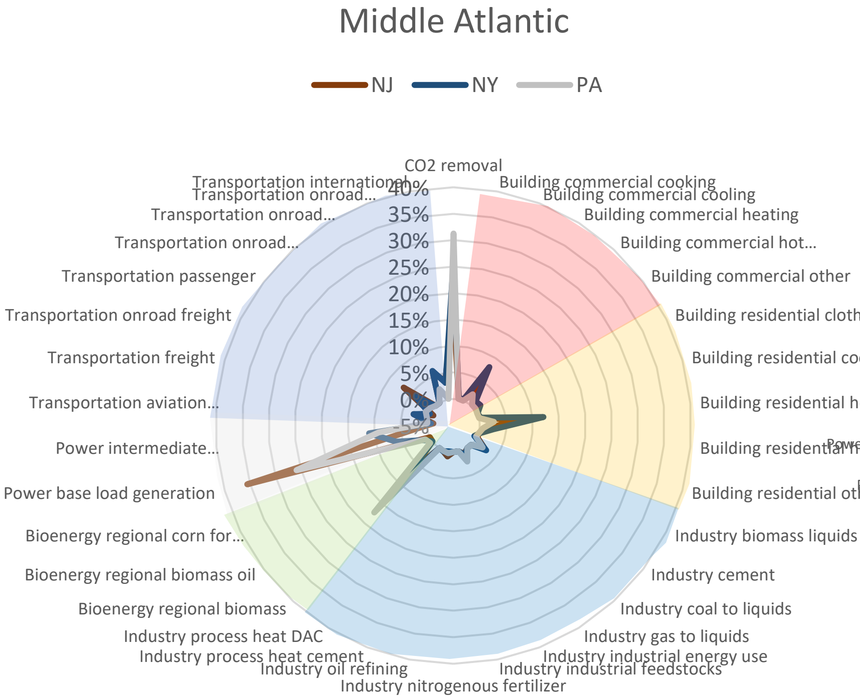
Middle Atlantic
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CO2 removal
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Industry industrial energy use
Industry industrial feedstocks
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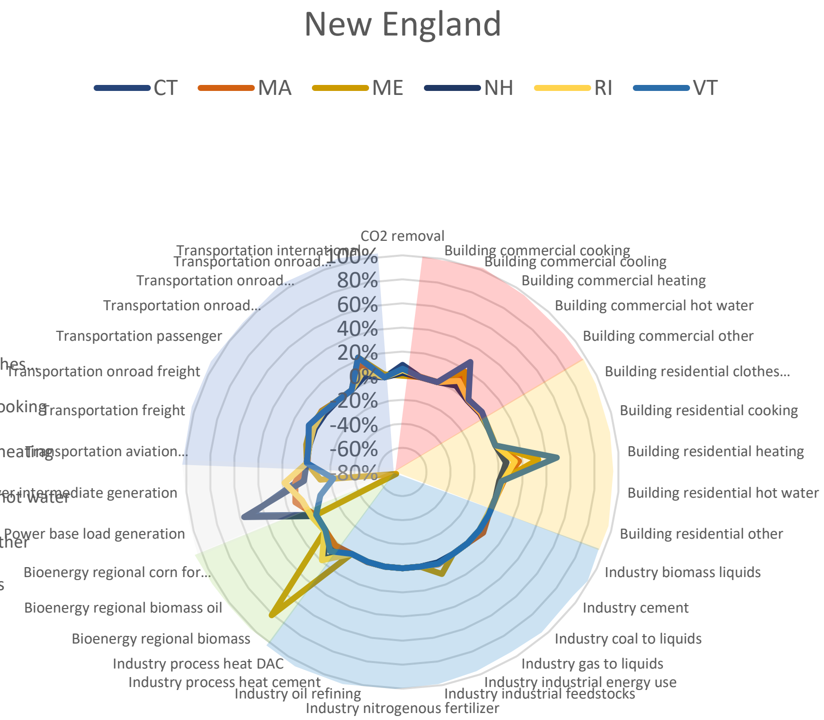
New England
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Bioenergy regional biomass
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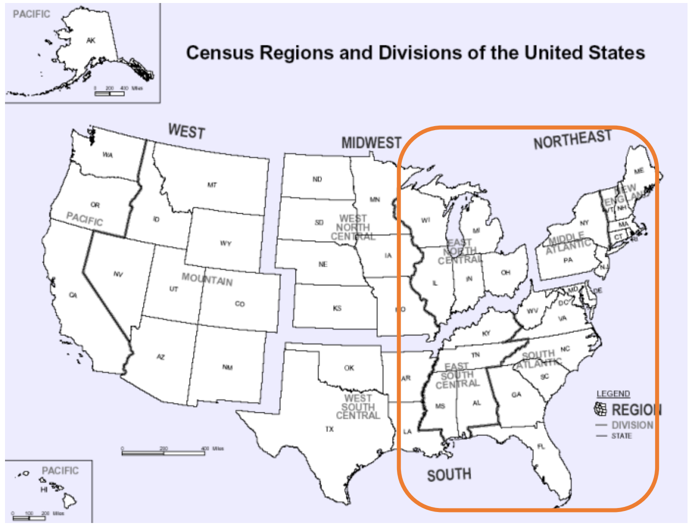
Census Regions and Divisions of the United States
PACIFIC
WEST
MIDWEST
NORTHEAST
SOUTH
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MOUNTAIN
WEST NORTH CENTRAL
EAST NORTH CENTRAL
MIDDLE ATLANTIC
NEW ENGLAND
WEST SOUTH CENTRAL
EAST SOUTH CENTRAL
SOUTH ATLANTIC
LEGEND
REGION
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OR
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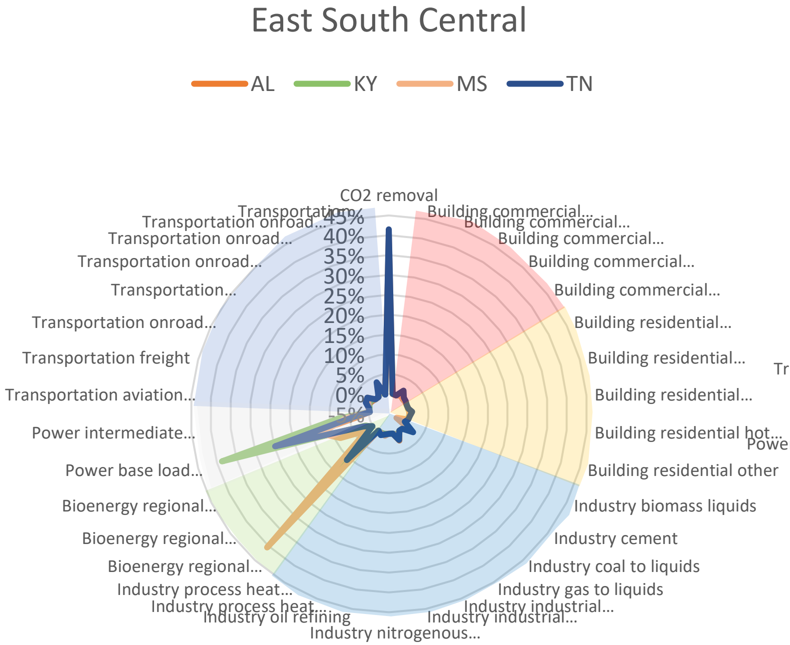
East South Central
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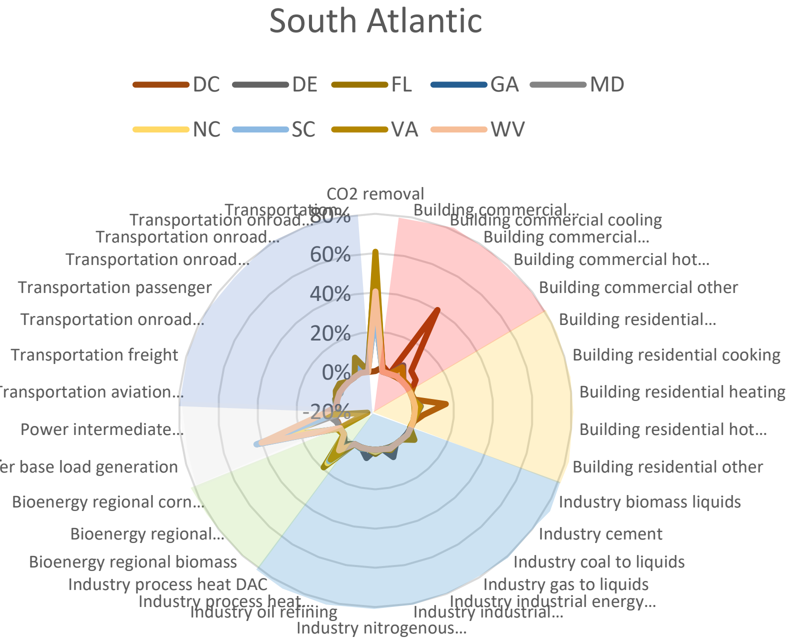
South Atlantic
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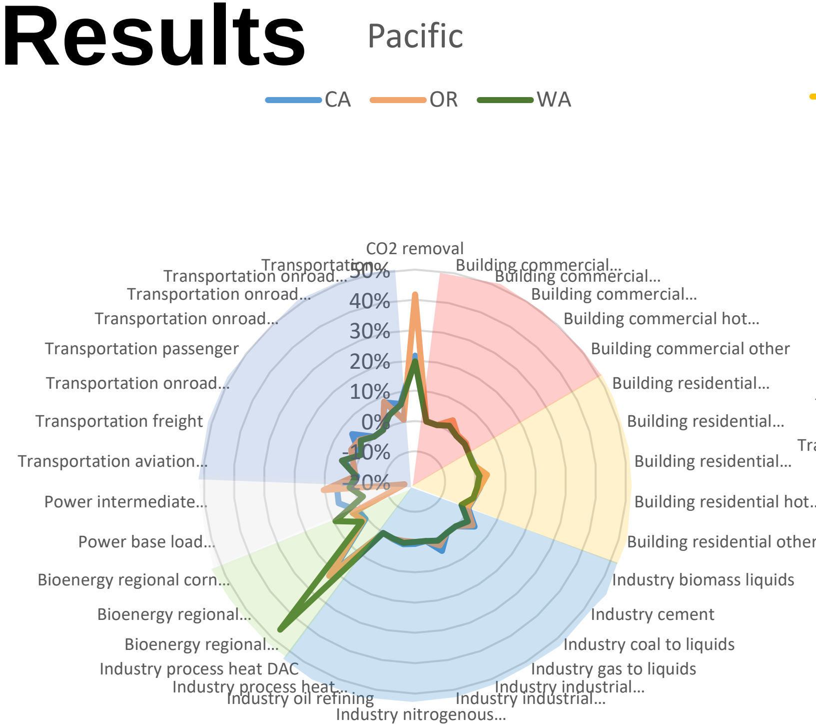
Results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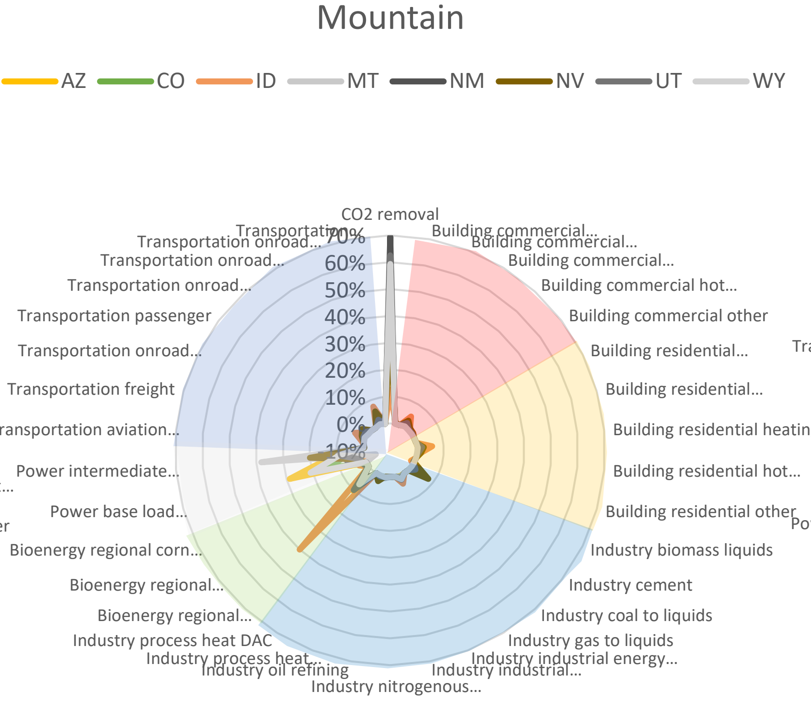
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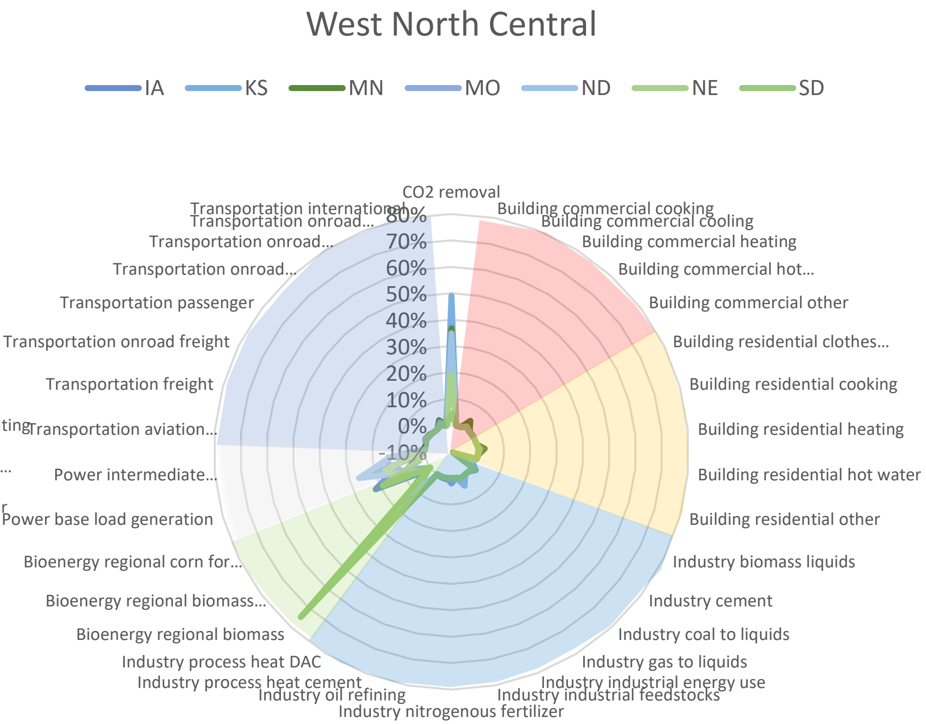
West North Central
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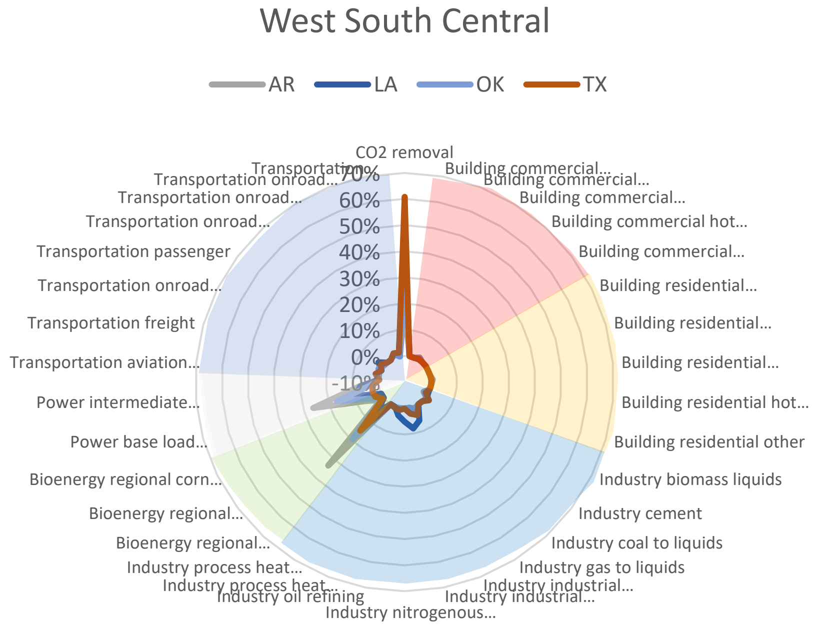
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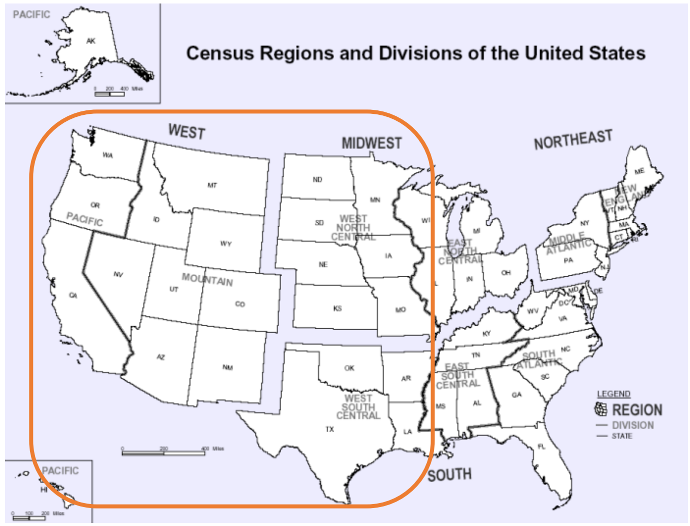
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WEST NORTH CENTRAL
EAST NORTH CENTRAL
WEST SOUTH CENTRAL
EAST SOUTH CENTRAL
SOUTH ATLANTIC
MIDDLE ATLANTIC
NEW ENGLAND
LEGEND
REGION
DIVISION
STATE

Conclusions

- GCAM-USA selected a unique mix of measures in each state, although there were regional similarities.

- Each of 50 states would establish different mitigation strategies based on their existing economic and industrial foundations, as well as their energy production and demand structures.

- Strategic similarities to achieve decarbonization are observed among states based on geographic, natural, and industrial conditions. For example, Pacific states such as CA and WA would likely to reduce CO2 emissions from CO2 removal, regional biomass and transportation sector while New England states such as MA and VT would likely to reduce from commercial and residential buildings and power sector.

- Some measures were adopted in nearly all states, including decarbonization of electricity and application of CO_2 removal technologies.

Thank you!

Contact: Joyce Kim, Kim.joyce@epa.gov

Disclaimer: The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the U.S. EPA.

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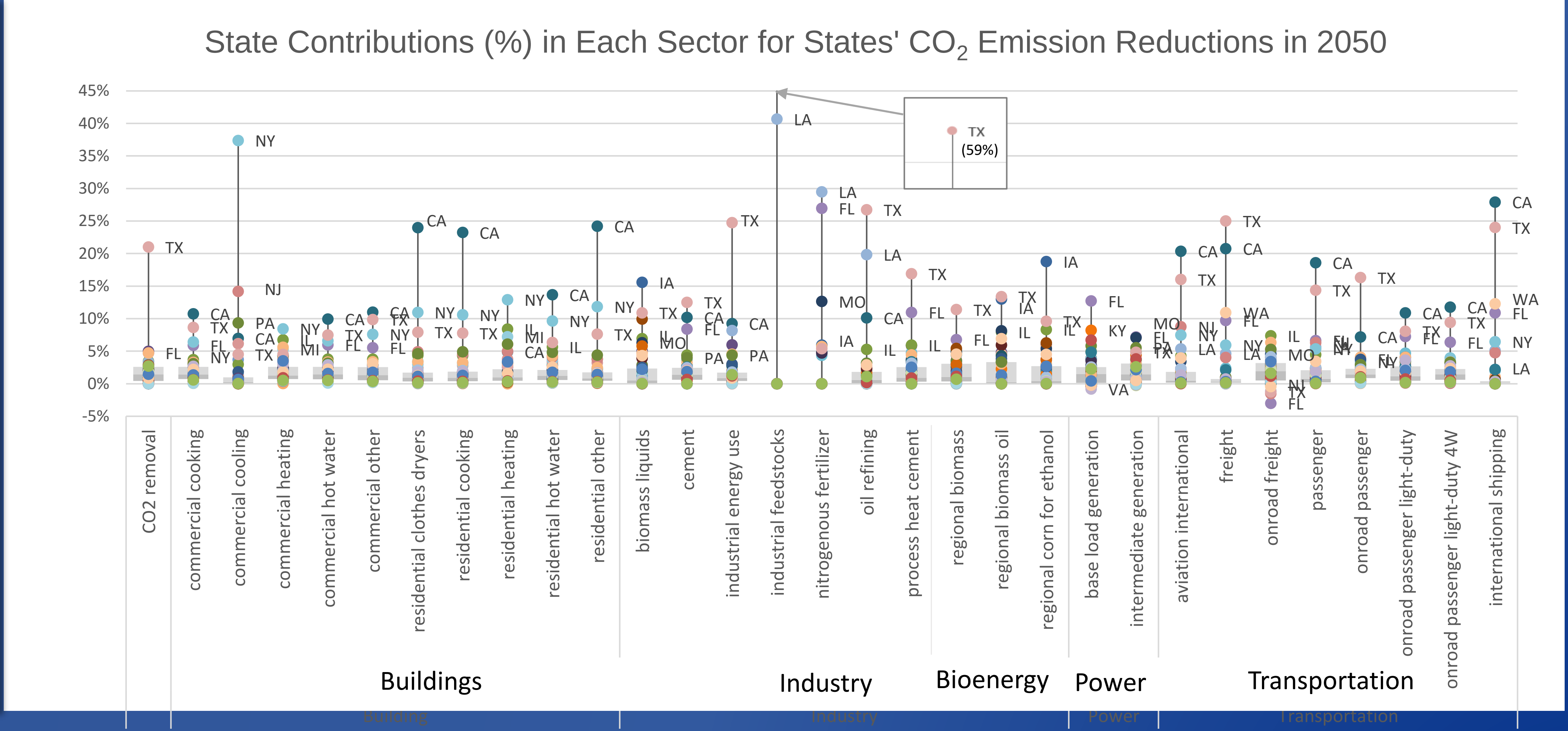
Results

Identifying mitigation contributors by end-use sector


State Contributions (%) in Each Sector for States' CO_2 Emission Reductions in 2050