# Foreword

- Acronyms
  - GCAM-USA: Global Change Analysis Model with state-level resolution
  - GLIMPSE: GCAM Long-term Interactive Multi-Pollutant Scenario Evaluator
- Intended audience
  - Air quality integrated assessment modeling community
- Disclaimers
  - The views expressed in this presentation are those of the authors and do not necessarily reflect the views or policies of the US EPA.
  - Any mention of trade names, products, or services does not imply an endorsement by the US Government or EPA. EPA does not endorse any commercial products, services, or enterprises.

# U.S. EPA Office of Research and Development Air Quality IAM Research Activities

- Objective
  - Develop a decision support tool for:
    - Projecting Greenhouse Gas (GHG) and air pollutant emissions for specific scenarios
    - Estimating the impacts of potential federal, regional, and state policies
    - Designing holistic policies that account for "upstream" and "downstream" emissions
    - Identifying cost-effective strategies for meeting air, climate, and energy objectives
    - Assessing the impacts of new and emerging technologies

- Potential users:
  - EPA regulatory offices
  - Regional Planning Organizations (RPOs)
  - State environmental, climate, and energy planners
  - University researchers

# U.S. EPA Office of Research and Development Air Quality IAM Research Activities

- Requirements
  - Generally consistent with EPA inventories and technology projections
  - Technology-rich, particularly in energy supply and demand
  - Able to capture multi-sector, multi-pollutant dynamics
  - State-level resolution, global context
  - Policy-relevant levers
  - Low-to-zero cost (software and computing)
  - Transparent/open source
  - Easy to use

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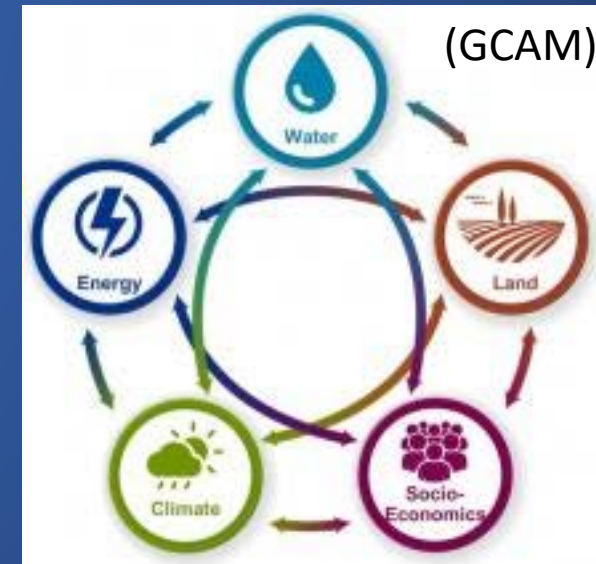  - Transparent/open source
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Global Change Analysis Model

(GCAM)



Pacific Northwest National Laboratory (PNNL)'s GCAM-USA met most of these requirements

https://github.com/JGCRI/gcam-core

# Addressing consistency: PNNL activities

- The Community Emissions Data System (CEDS)
  - Development led by Steve Smith of PNNL
  - Calculates emission factors (EFs) used in GCAM-USA

$$EF_{s,c,p} = \frac{Emissions_{s,c,p}}{Activity_{s,c}}$$

← U.S. EPA National Emissions Inventory

← U.S. EIA fuel use or service data

Where:

    S is the state

    c is the source category

    p is the pollutant

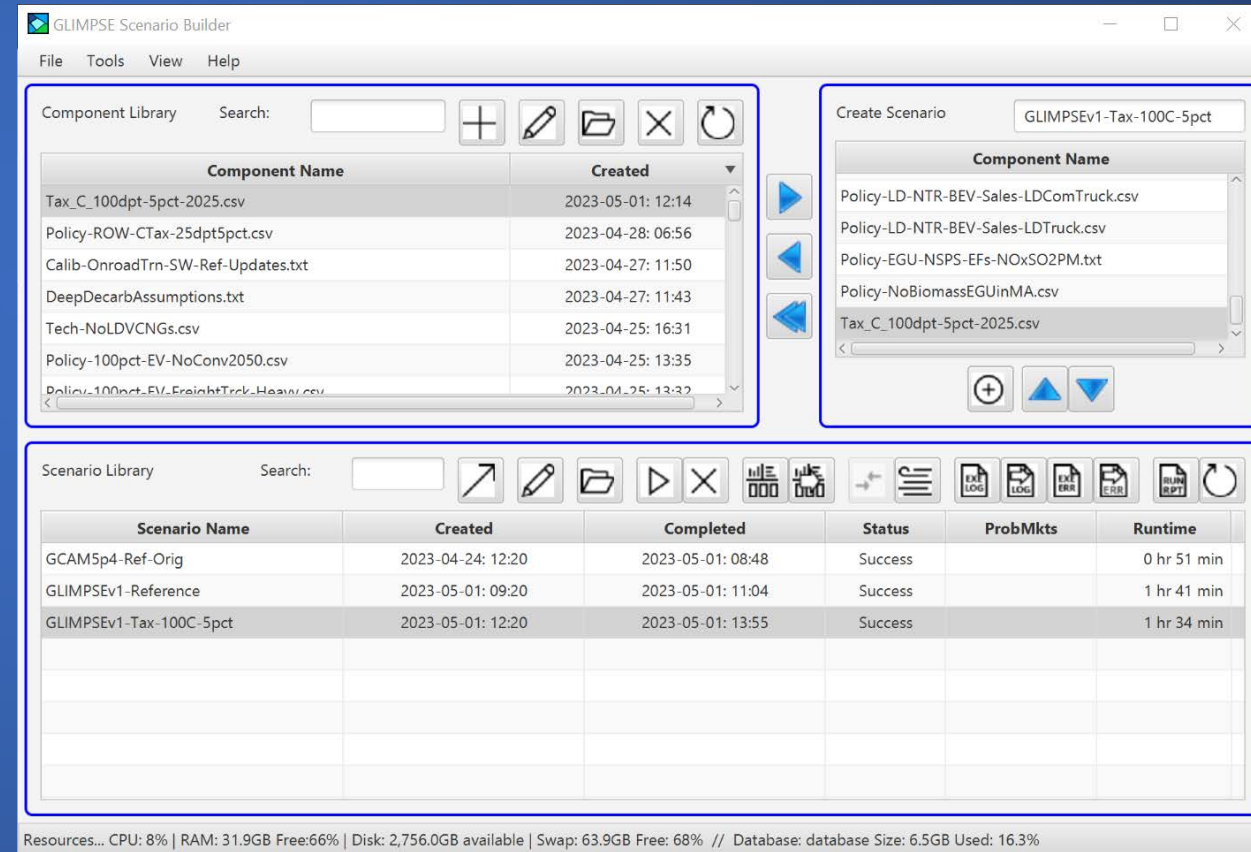EIA is the Energy Information Administration

# Addressing consistency: EPA activities

- Improving future-year EFs:
  - Emission standards for various source categories
  - Electric sector EFs from the Integrated Planning Model (IPM)
  - Onroad mobile EFs developed from EPA's Motor Vehicle Emissions Simulator (MOVES) model

- Other modifications:
  - Regional Greenhouse Gas Initiative in the Northeast U.S.
  - Electric vehicle (EV) market share estimates from finalized EPA regulatory actions
  - Inclusion of state-level policies
    - GHG mitigation targets
    - Renewable Portfolio Standards updates
    - Onroad EV targets

- **Supporting modeling**
  - Easily construct policies
    - RPSs, EV targets, caps, taxes, and subsidies
  - Combine to create scenarios
  - Manage and monitor runs
  - Assist with Quality Assurance
    - Creates metadata
    - Checks inputs for conflicts
    - Monitors resources
    - Assists with debugging
    - Manages files
    - Creates archives for storage and repeatability

**GLIMPSE Scenario Builder**

# Addressing usability: EPA activities

- **Supporting analysis**
  - On-demand graphing
  - Filtering and sorting
  - Identify major differences
  - On the horizon
    - Sankey diagrams
    - Maps
    - Customizable units
    - Favorites
      - Queries
      - Regional groupings

GLIMPSE Model Interface
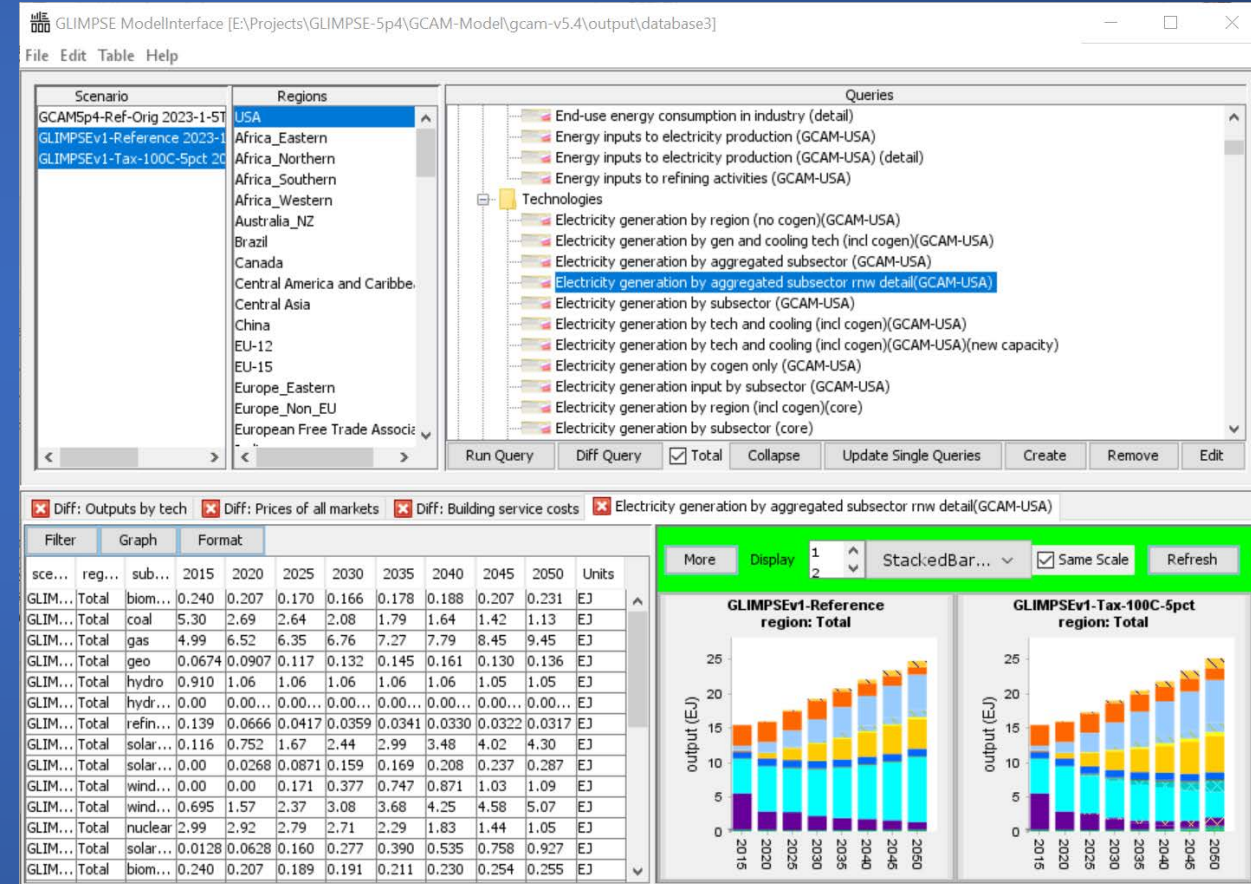


*Derived from PNNL's Model Interface*

# Air pollution-related activities

Development of state-specific Marginal Abatement Curves (MACs) for NOx



State-level MACs for NOx in 2030
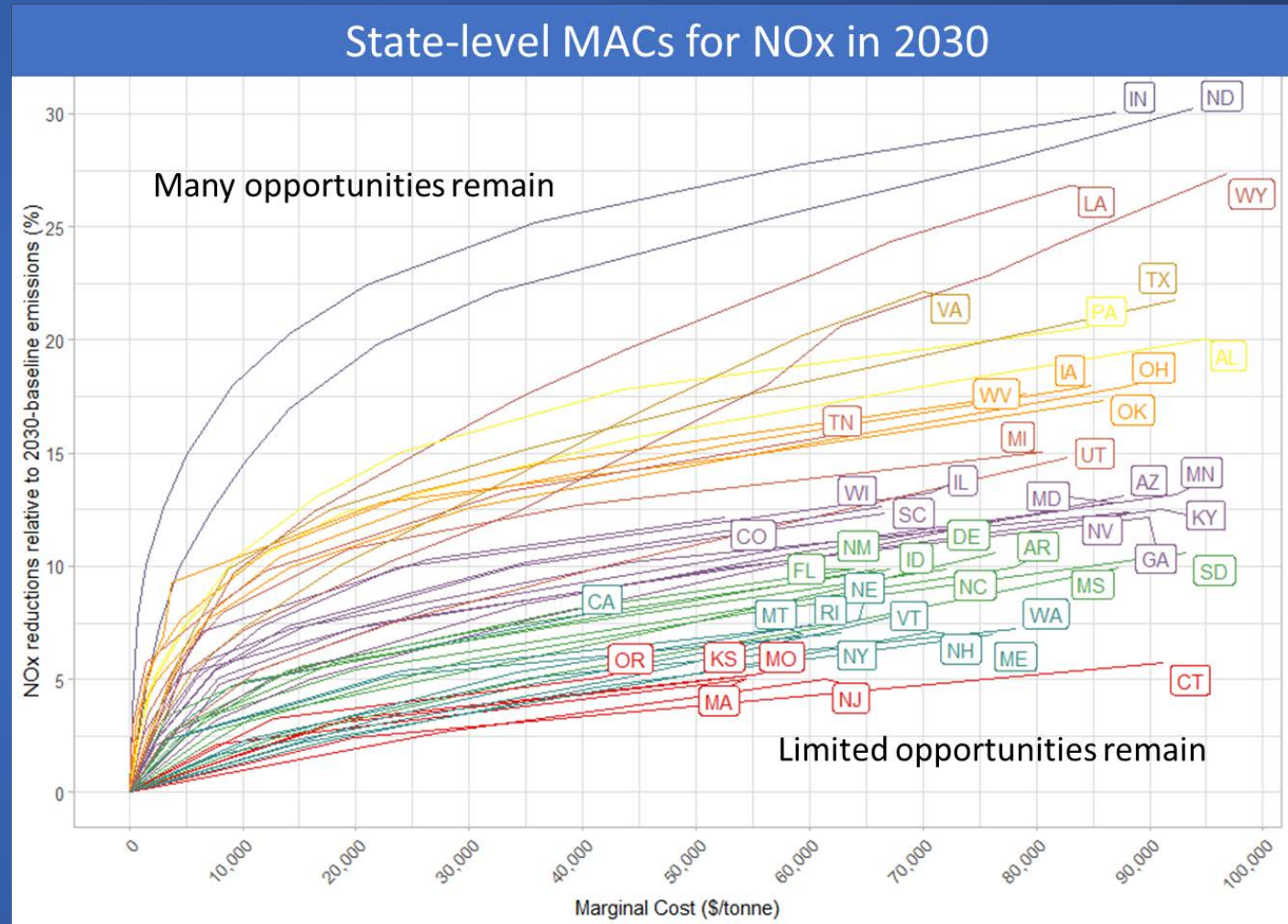
Jia, F., S. Smith, A. Macpherson, D. Bielen, C. Nolte, and D. Loughlin. Using Marginal Abatement Cost Curves to Identify Optimal Control Strategies for Meeting State-level NOx Abatement Targets. 19th Annual CMAS Conference, Chapel Hill, North Carolina, October 26 - 30, 2020.

# Air pollution-related activities

Decomposition of the MACs via the Kaya Identity to understand sectoral opportunities by state
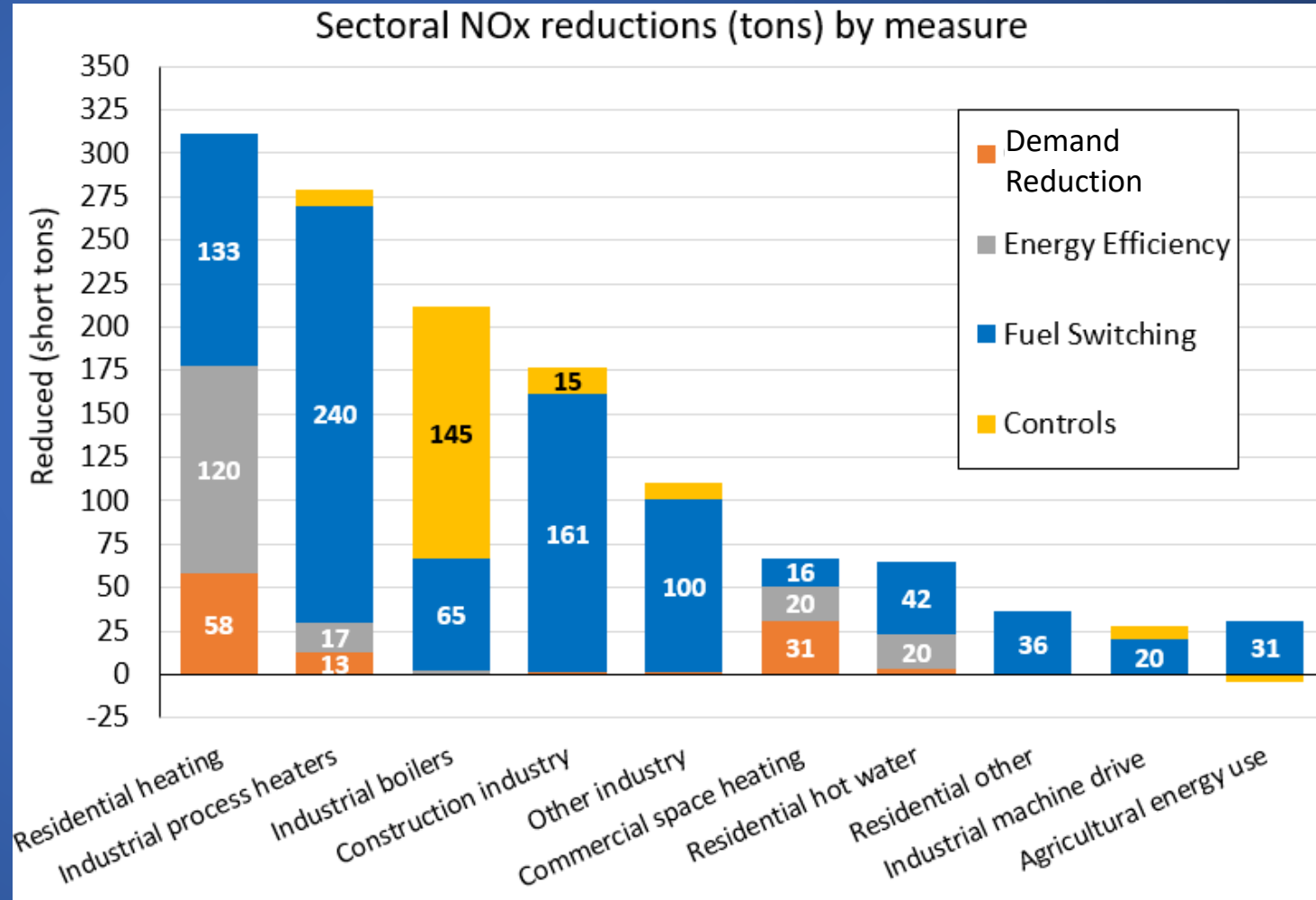
# Air pollution-related activities

Exploring incorporation of "upstream emissions" into holistic policy designs

**Extraction**      **Transport**      **Generation**

Coal Mines      Freight Rail      Coal Plant

Gas Wells      Gas Pipelines      Gas Turbine

Renewables

Power sector policy

Holistic policy design

Babaee, S., Loughlin, D.H., and P.O. Kaplan (2020). Incorporating upstream emissions into electric sector nitrogen oxide reduction targets. Cleaner Engineering and Technology, https://doi.org/10.1016/j.clet.2020.100017.
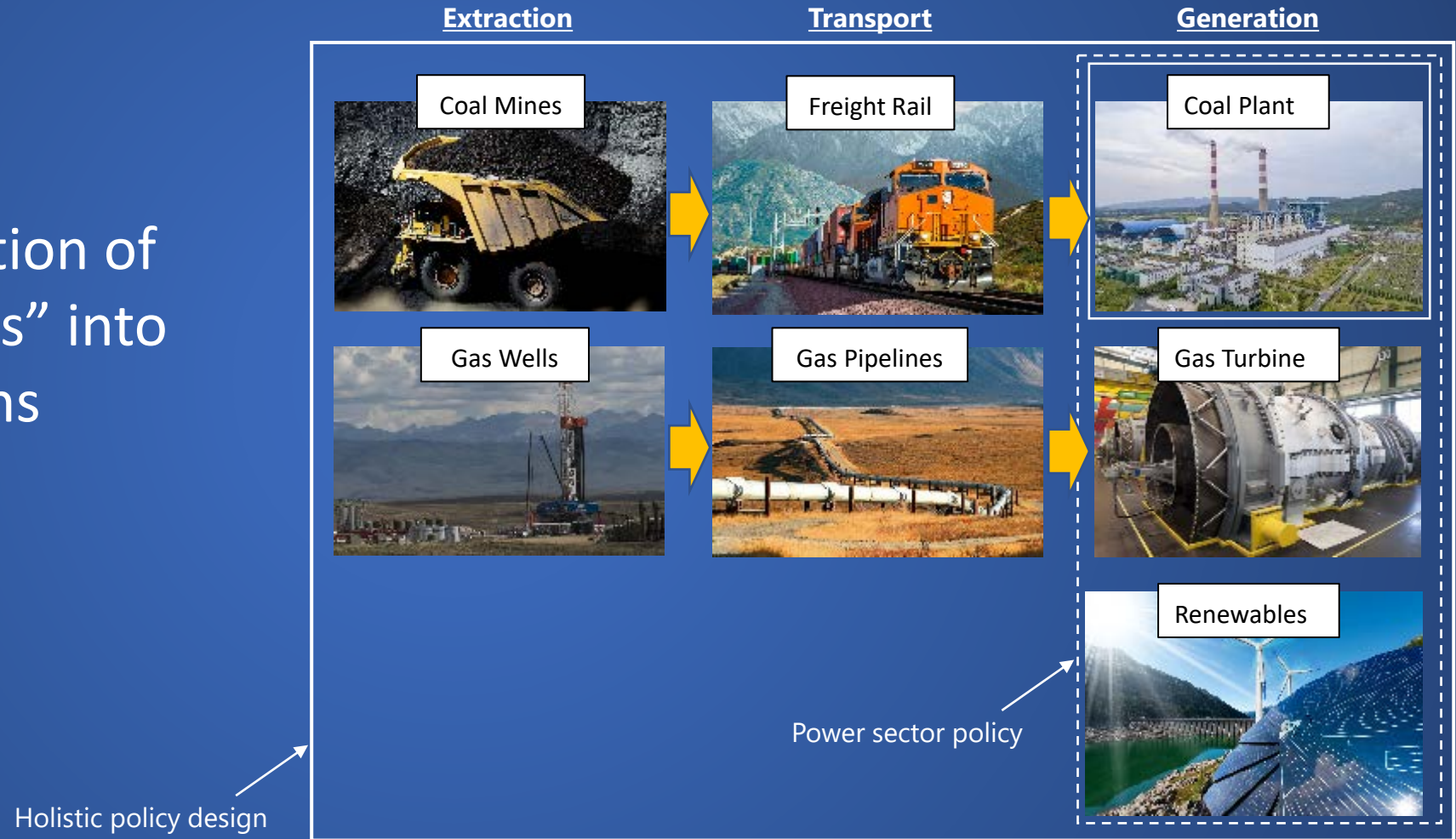
# Air pollution-related activities

## Linkage of GCAM-USA to full-scale air quality models to assess air pollution and health impacts

Decarbonization
Scenario

→ GLIMPSE
Air-Climate-Energy Planning Tool

→ DESID* CMAQ
Community Multiscale Air Quality Modeling System

CMAQ Chemical
Transport Model

→ Ozone co-reductions (ppb) in 2050

\* DESID is the "Detailed Emission Scaling, Isolation, and Diagnostic" module

Shankar, U., K. Brown, B. Murphy, G. Pouliot, K. Foley, D. Loughlin, and C. Nolte. Modeling the Air Quality Impacts of Future Energy Scenarios. CMAS Conference (presentation), Virtual, NC, November 01 - 05, 2021.

# Air pollution-related activities
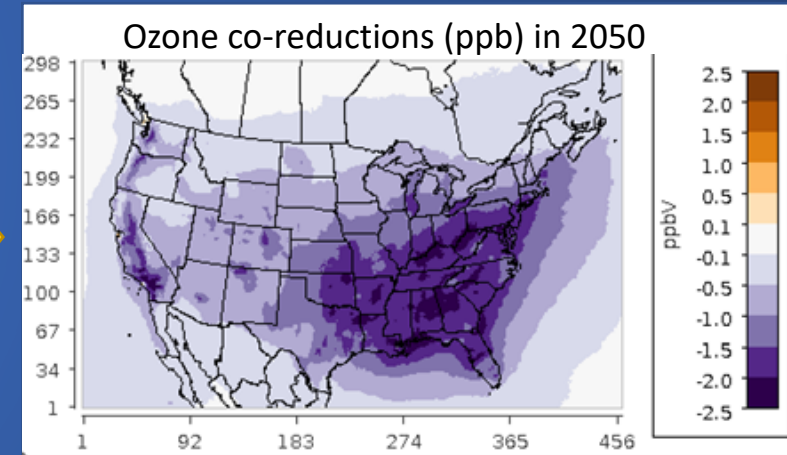
Linkage of GCAM-USA to reduced-form models
to assess air pollution and health impacts

Decarbonization
Scenario

**GLIMPSE**
Air-Climate-Energy Planning Tool

**COBRA**

EPA Co-Benefits Risk
Assessment tool

PM2.5 co-reductions (µg/m3), 2050

Delta PM 2.5
3.59
0.00

Powered by Bing
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Health benefits

Dong, D. "Assessing the air quality and health impacts of decarbonization strategies in Connecticut" Masters Thesis, Rollins School of Public Health, Emory University, Atlanta, Georgia, May 2023.
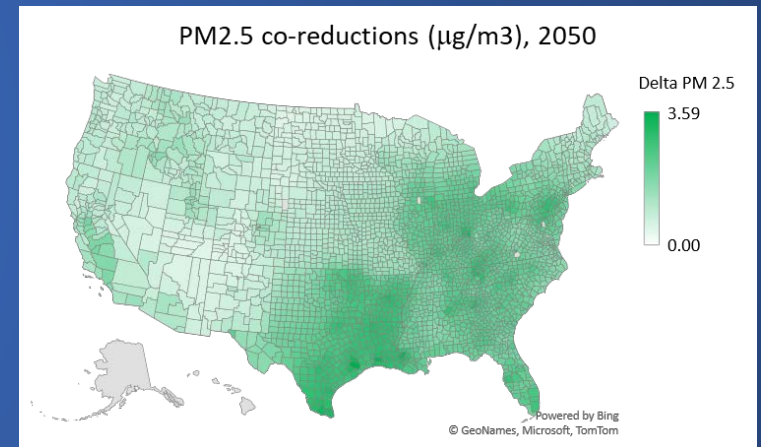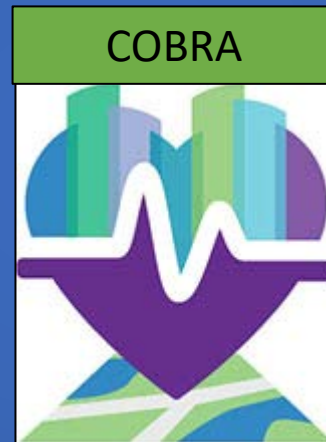
# Air pollution-related activities

Incorporation of health impact factors directly into GCAM to explore health-focused management strategies

Policy targets →

**GLIMPSE**
Air-Climate-Energy Planning Tool

→ State-specific management strategies for achieving health benefits

↑ State-, pollutant-, category-specific health impact factors

Ou Y., West, J.J., Smith, S.J., Nolte, C.G., and D.H. Loughlin (2020). Air pollution control strategies directly limiting national health damages in the US. *Nature Communications*, (2020)11:957, https://doi.org/10.1038/s41467-020-14783-2.
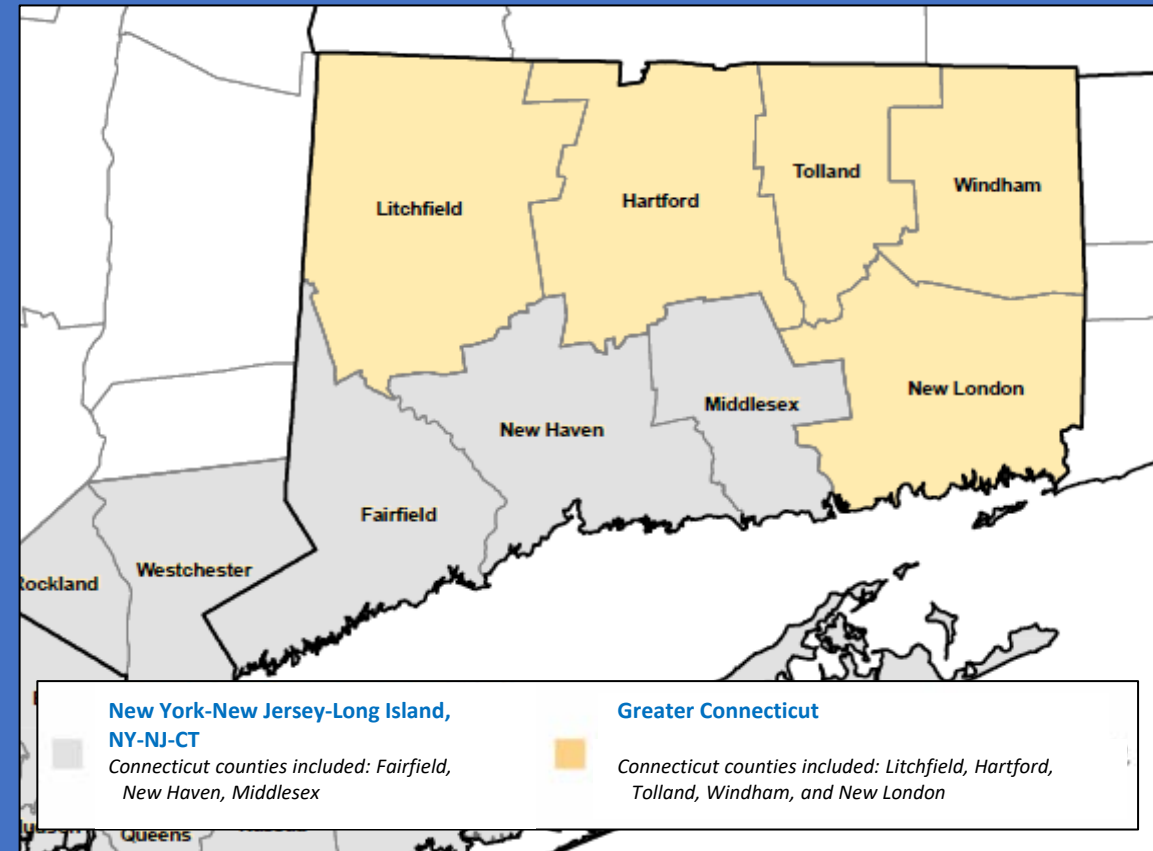
# Air pollution-related activities

## Multi-pollutant planning with Connecticut (CT)

- CT does not meet ozone ($O_3$) standards
- Most of CT ozone is attributable to emissions upwind states
- Most of these states have GHG reduction goals
- What impact may these targets have on CT $O_3$ attainment?

All CT counties designated in "nonattainment" of the 2015 $O_3$ NAAQS as of Feb. 2022

**New York-New Jersey-Long Island, NY-NJ-CT**
*Connecticut counties included: Fairfield, New Haven, Middlesex*

**Greater Connecticut**
*Connecticut counties included: Litchfield, Hartford, Tolland, Windham, and New London*
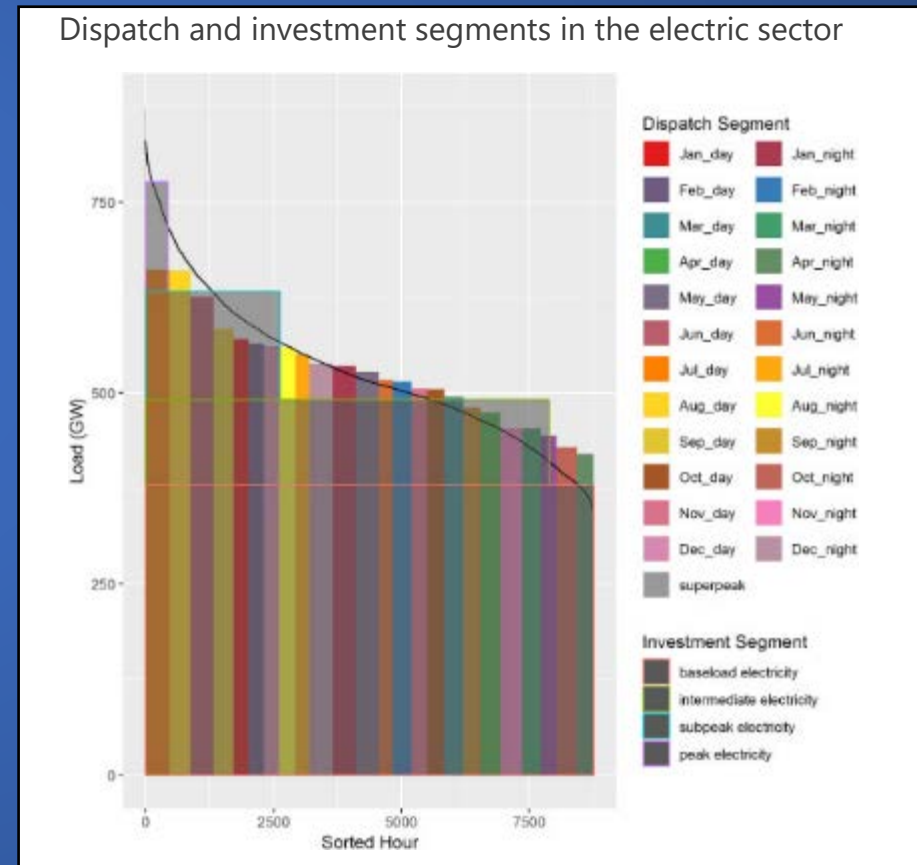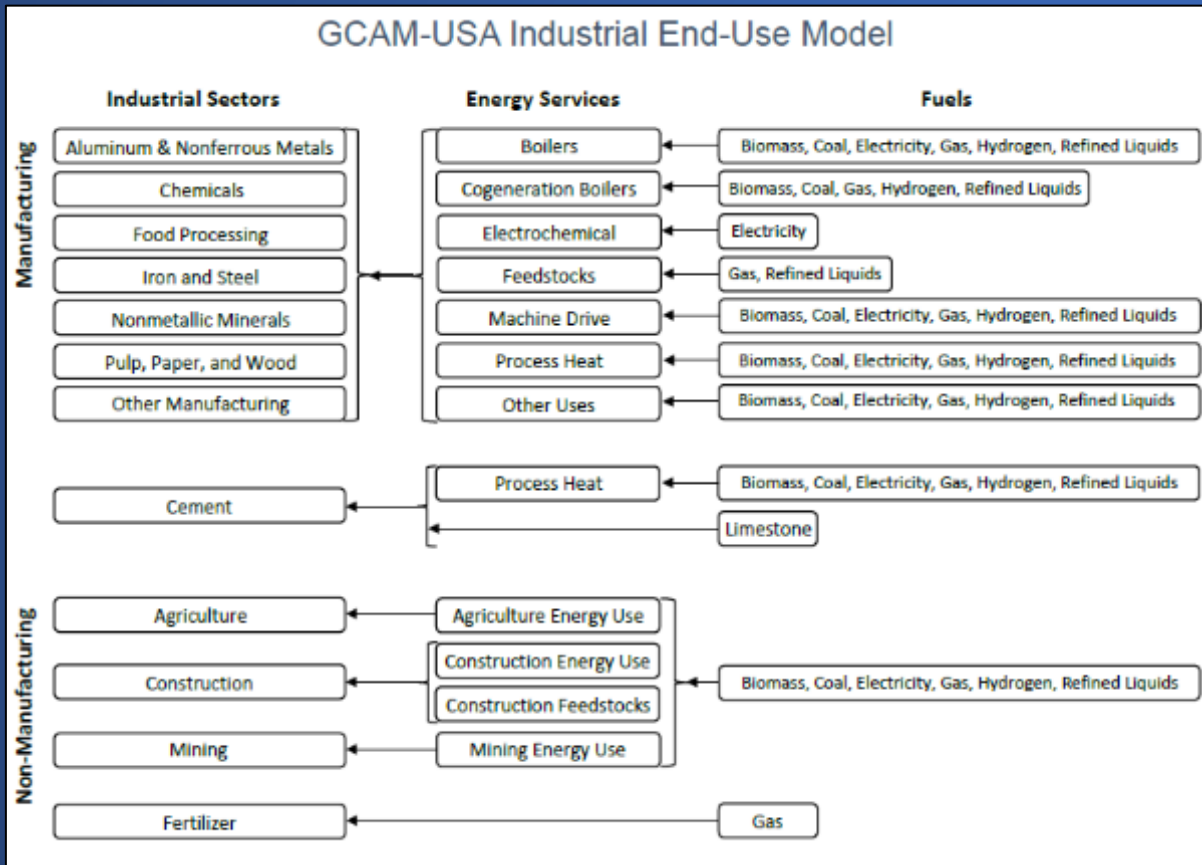
# Relevant GLIMPSE project citations

- Ou, Y., Kittner, N., Smith, S.J., Babaee, S., Nolte, C.G., and D.H. Loughlin (2021). "Evaluating long-term emission impacts of large-scale electric vehicle deployment in the US using a human-earth systems model." *Applied Energy*, 300(2021), 117364. https://doi.org/10.1016/j.apenergy.2021.117364.

- Babaee, S., Loughlin, D.H., and P.O. Kaplan (2020). "Incorporating upstream emissions into electric sector nitrogen oxide reduction targets." *Cleaner Engineering and Technology*, https://doi.org/10.1016/j.clet.2020.100017.

- Xia, J., Lu, X., Wang, S., Wang, T., Ding, D., Yu, S., Shindell, D., Ou, Y., Morawska, L., Li, S., Ren, L., Zhang, Y., Loughlin, D.H., Zheng, H., Zhao, B., Liu, S., Smith, K.R. and J. Hao (2020). "The quest for improved air quality may push China to continue its CO2 reduction beyond the Paris Commitment." P*NAS*, Nov., https://doi.org/10.1073/pnas.2013297117.

- Ou Y., West, J.J., Smith, S.J., Nolte, C.G., and D.H. Loughlin (2020). "Air pollution control strategies directly limiting national health damages in the US." *Nature Communications*, (2020)11:957, https://doi.org/10.1038/s41467-020-14783-2.

- Ou, Y., Smith, S.J., West, J.J., Nolte, C.G., and D.H. Loughlin (2019). "State-level drivers of future fine particulate matter mortality for the United States." *Environmental Research Letters*,14(2019) 124071, https://doi.org/10.1088/1748-9326/ab59cb.

- Ou, Y., Shi, W., Smith, S.J., Ledna, C.M., West, J.J., Nolte, C.G., and D.H. Loughlin (2018). "Estimating environmental co-benefits of U.S. GHG reduction pathways using the GCAM-USA Integrated Assessment Model." *Applied Energy*, 216C(2018) pp. 482-493. https://doi.org/10.1016/j.apenergy.2018:02.122

- Shi, W., Ou, Y., Smith, S.J., Ledna, C., Nolte, C.G., and D.H. Loughlin (2017). "Projecting state-level air pollutant emissions using an integrated assessment model: GCAM-USA." *Applied Energy*, 208(2017), pp 511-521. https://doi.org/10.1016/j.apenergy.2017.09.122.
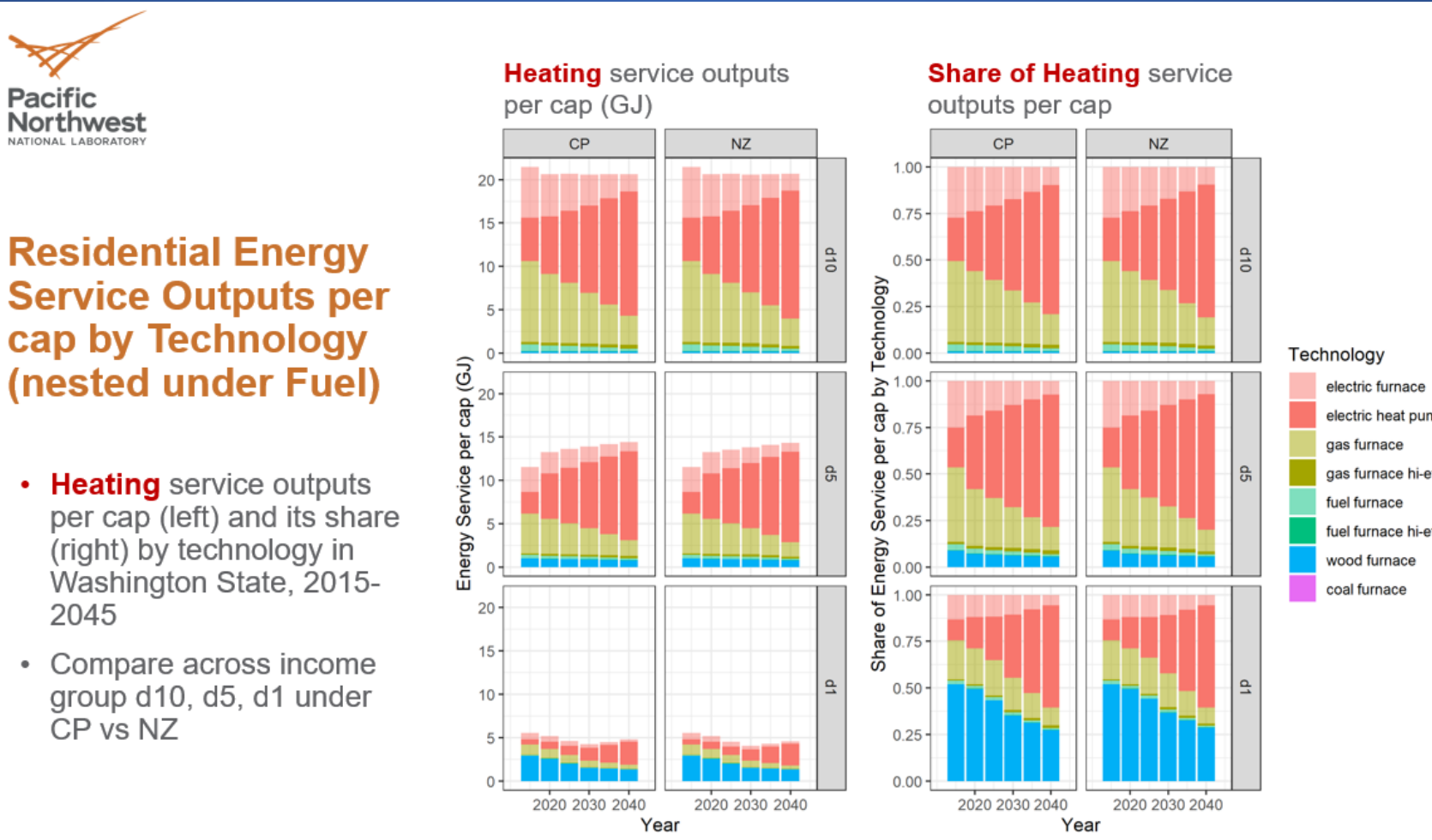
# On the horizon

Improvements that we expect to be available over the next year



GCAM-USA Industrial End-Use Model



Dispatch and investment segments in the electric sector

# On the horizon

Improvements that we expect to be available over the next year +

# Next steps for GLIMPSE

- Public release of GLIMPSE in June of 2023
- Trainings
- Interest from states and regions
  - Climate Action Plans
  - Ozone attainment strategies
  - Coordinated planning
- Interest from universities
  - Research and teaching
- Update later this year
  - Update to GCAM-USA 6.1
  - Incorporation of Inflation Reduction Act provisions, Good Neighbor Rule, new onroad vehicle emission standards
  - Adoption of new detailed industrial sector

# Thank you!

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