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# GCAM-USA

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Joint Global Change Research Institute

JGCRI Annual Integrated Assessment Workshop and GCAM Community Modeling Meeting

- ▶ Overview of GCAM-USA and existing level of detail
- ▶ Recent and ongoing work using GCAM-USA
- ▶ Ongoing model development



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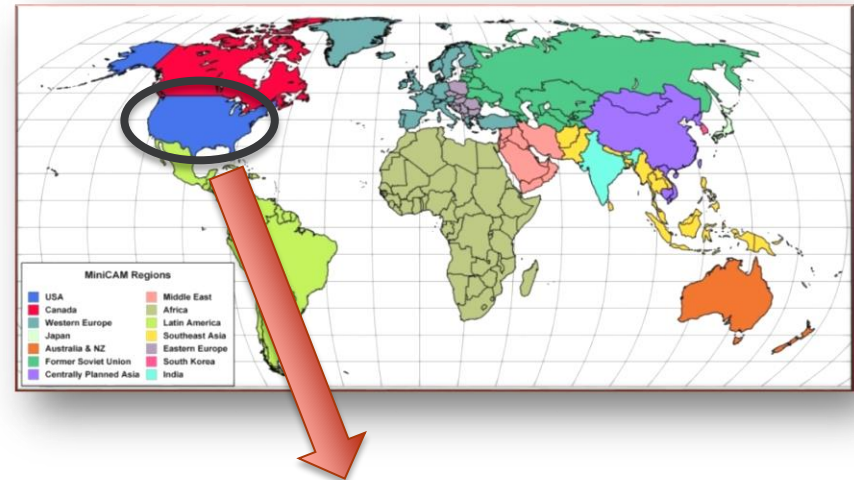
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# Overview of GCAM-USA

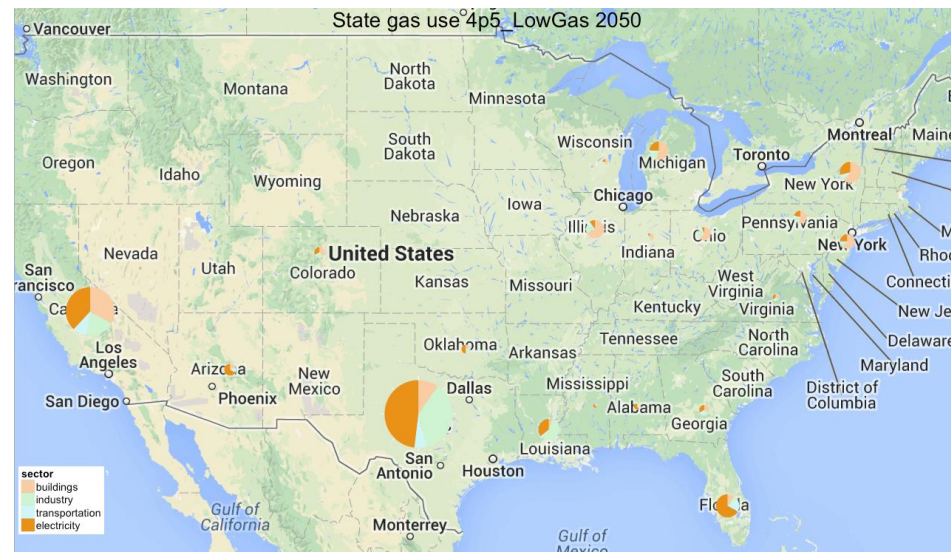
# GCAM-USA: Overview

- ▶ GCAM-USA is a version of GCAM with state-level detail in the United States.
- ▶ The 50-state version is embedded within the global version of GCAM.
- ▶ It is actively being used to explore energy-water-land interactions and conduct policy analysis
- ▶ Participating in EMF-32

## GCAM



## GCAM - USA





# Current level of detail in GCAM-USA

- ▶ Socioeconomics at the state-level
  - Population
  - GDP
- ▶ Energy transformation at the state level
  - Electricity generation and refining by state
- ▶ Electricity trade within and between 15 grid regions
- ▶ Carbon storage resources at the state level
- ▶ Renewable resources at state level
  - Wind, solar, and geothermal
- ▶ Final energy demand at the state level
  - Buildings: commercial, residential with detailed services
  - Transportation: passenger & freight with detailed technologies
  - Industry: aggregate energy demand
- ▶ Non-CO2s at the state-level



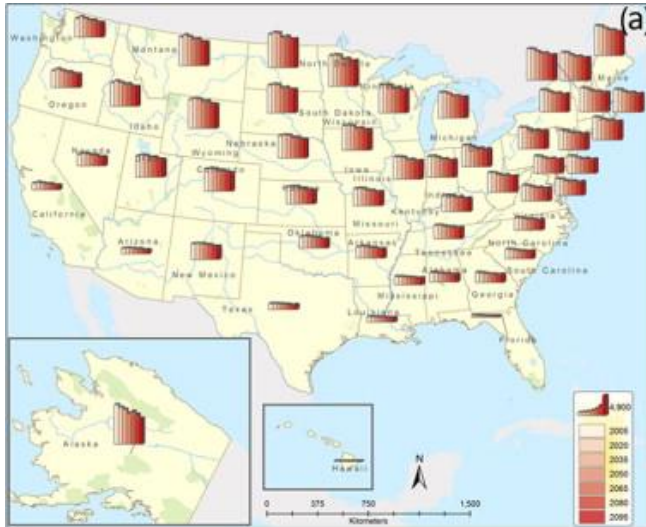
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# Recent and ongoing work using GCAM-USA

# Impacts of climate change on building energy use

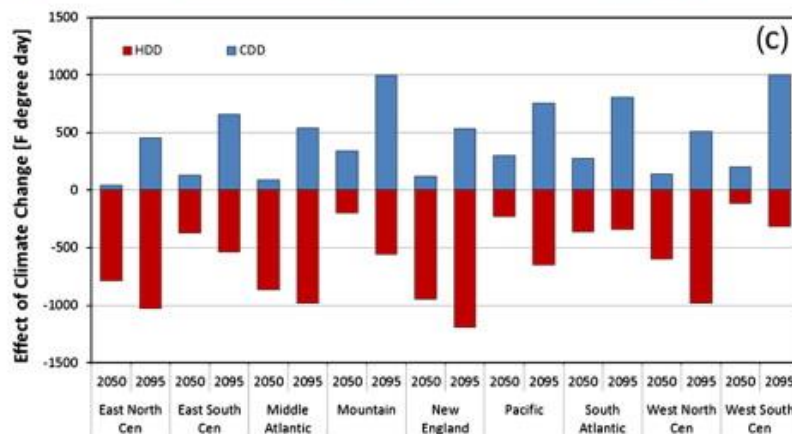
HDD



CDD



- Incorporated influence of Climate change on HDDs and CDDs

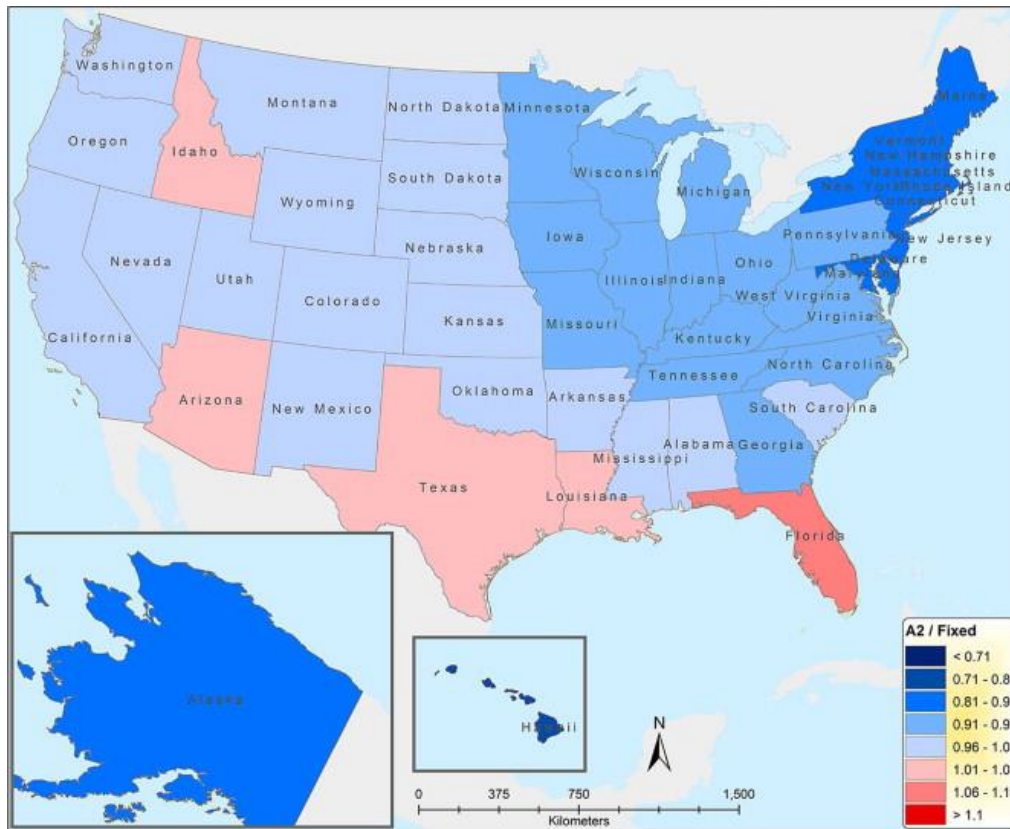


Zhou Y, et al. 2014. "Modeling the effect of climate change on U.S. state-level buildings energy demands in an integrated assessment framework." *Applied Energy* 113:1077-1088. doi:10.1016/j.apenergy.2013.08.034



# Heterogeneous impacts for building energy use

**Cumulative buildings energy use in the 21st century with consideration of climate feedback (A2) relative to that use without consideration of climate feedback (Fixed)**



- ▶ Compared a scenario that represents the impacts of temperature change on HDD/CDDs exogenously with one that did not
- ▶ Building energy and fuel mix impacts depend on total scale of the buildings sector and relative changes in HDDs and CDDs

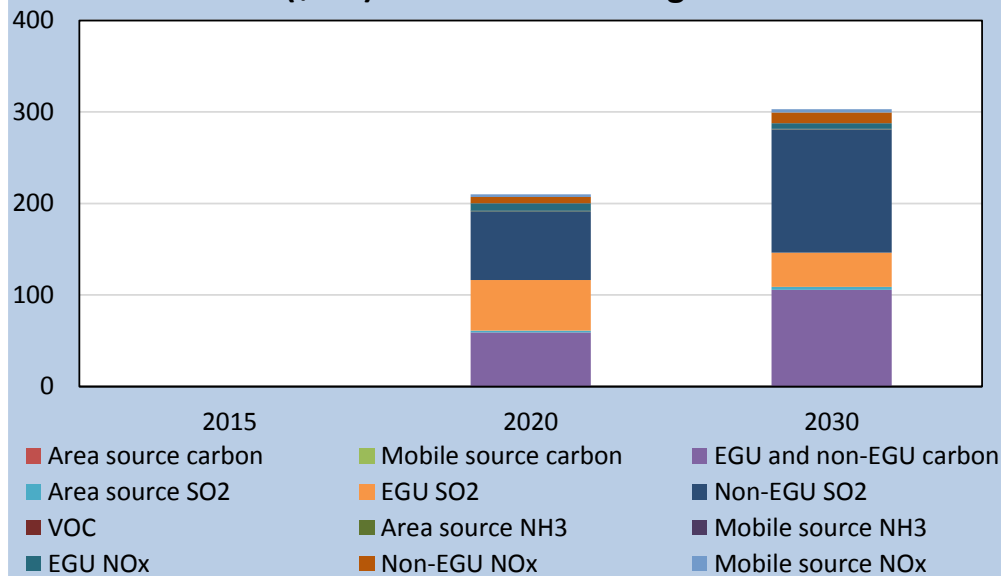




# Detailed Air Quality Modeling

## PM-related Health impacts in a 450 ppm mitigation scenario

Approximation of annual U.S. PM-related health benefits (\$mil) from the GHG mitigation scenario



(EGU refers to the electric sector)

Source: Dan Loughlin (EPA-ORD), Steve Smith (PNNL/JGCRI), etc.

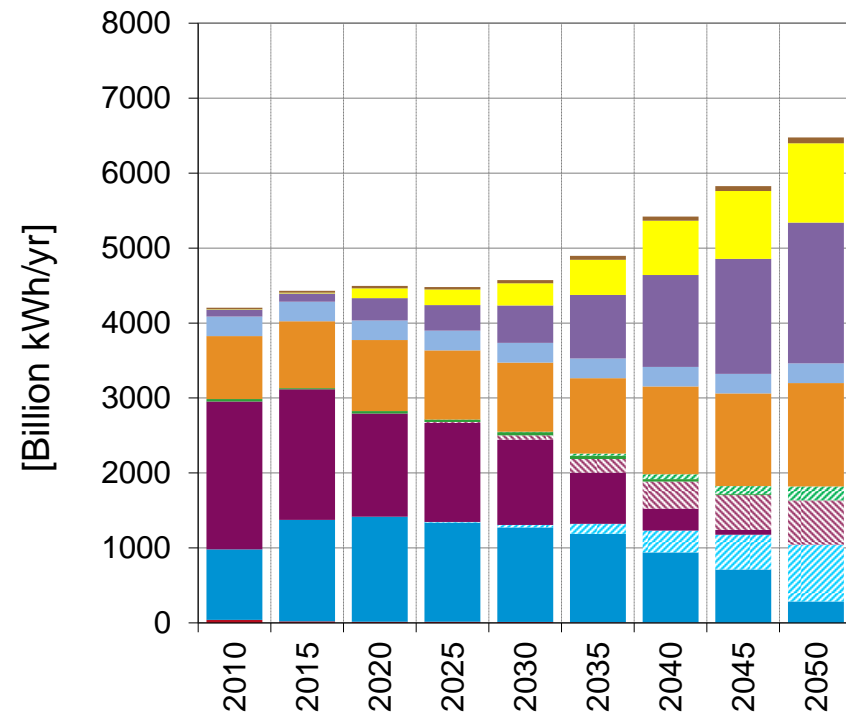
- ▶ Detailed representation of air pollutants in GCAM-USA
  - GCAM-USA model with air pollutant base-year emissions calibrated to match US National Emissions Inventory
  - Improved representation of air pollutant emissions at the technology level (freight vs passenger vehicles, etc.)
  - Improved representation of current policies (Clean Air Act, NSPS, etc.)
- ▶ Health impacts approximated using particulate matter (PM)-mortality impact factors from Fann et al. (<https://www.epa.gov/benmap/response-surface-model-rsm-based-benefit-ton-estimates>)

# GCAM-USA is contributing to the development U.S.'s Mid-century Strategy and DOE's Quadrennial Energy Review

- ▶ Pathways for deep decarbonization
  - Sectoral fuel mixes
  - Technology and fuel mix implications under tradeoffs between deployment of emissions sinks and sources

- ▶ We're using this process to improve technology assumptions and develop alternative technology scenarios
  - Reference
  - Advanced technology
  - Improved Energy Efficiency

**U.S. Electricity generation [EJ]  
under deep decarbonization**





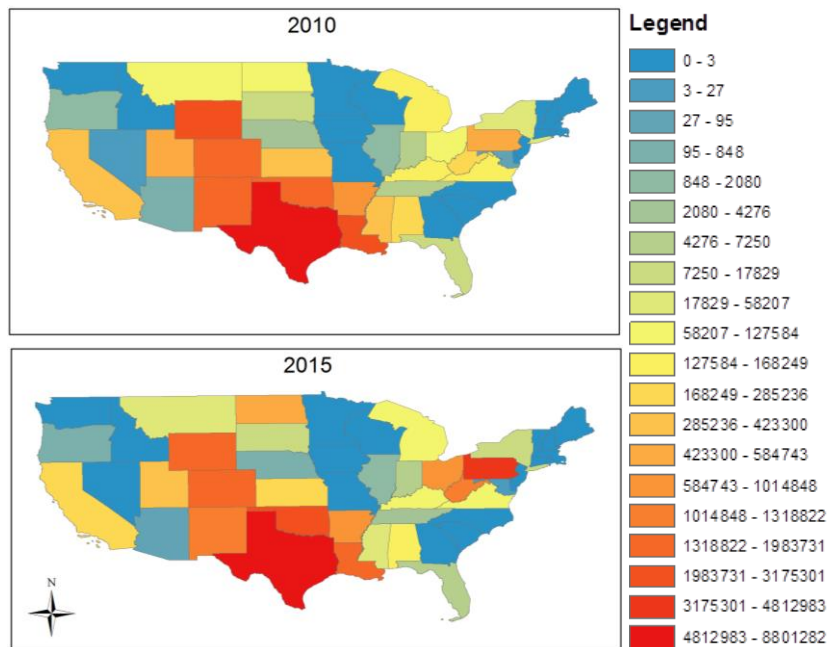
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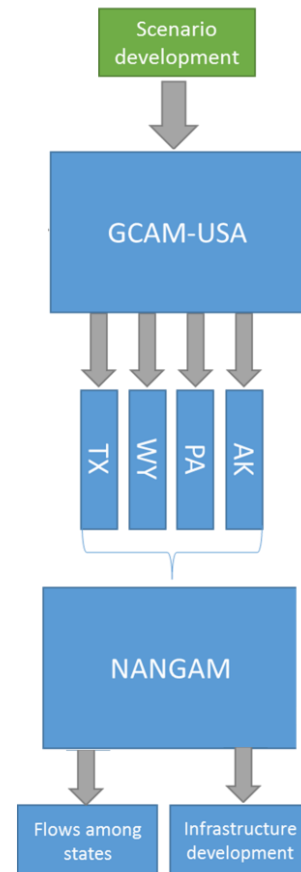
# Model Developments in progress

# State-level Natural gas supply and infrastructure modeling

Natural gas production by state [MMcf]  
(source: AEO 2015)



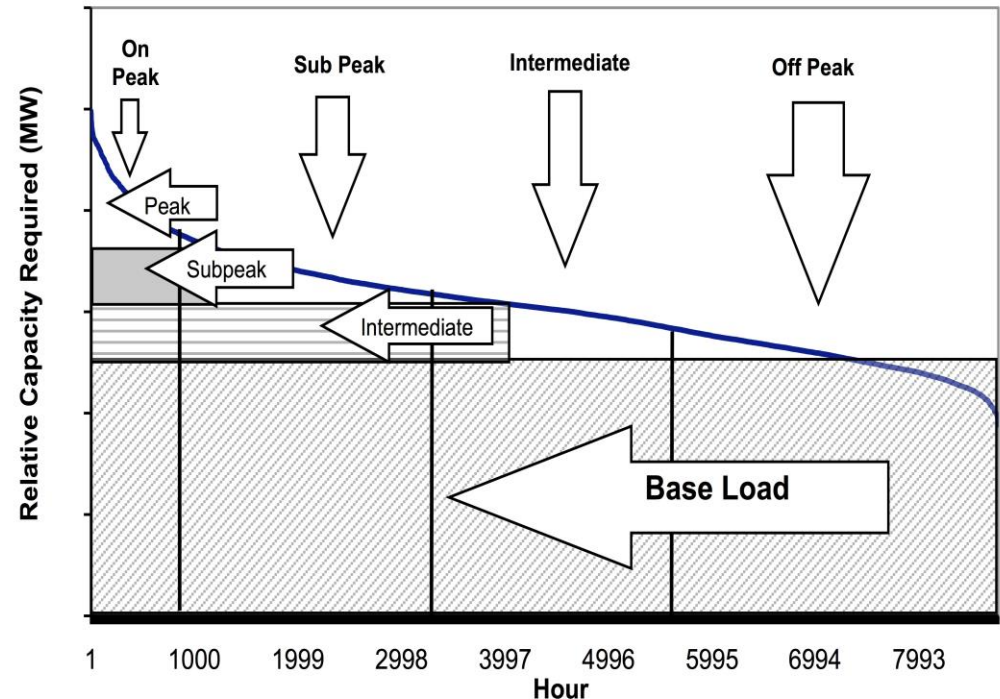
Source: Feijoo et al., GCAM  
Annual Meeting 2016



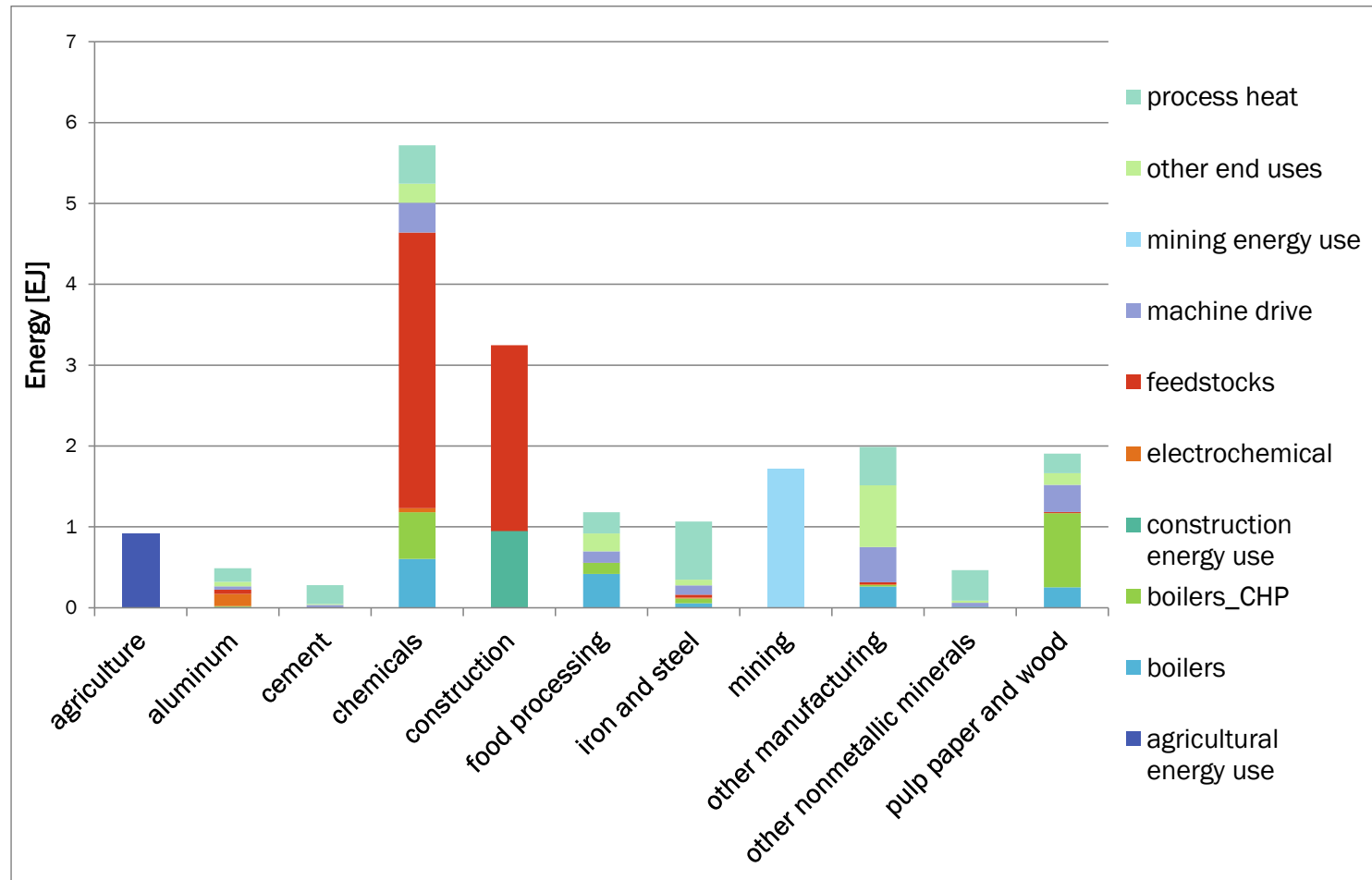
- ▶ State-level natural gas supply curves based on data from U.S. Geological Survey
- ▶ Representation of natural gas trade
- ▶ Collaboration with Johns Hopkins University's natural gas infrastructure model (NANGAM) to evaluate natural gas infrastructure development under deep decarbonization

# Energy System Impacts of Climate Variability and Extreme Weather Events

- ▶ Representing load variability through load duration curves
- ▶ Capacity Markets
- ▶ Dynamic electricity demand response, and thus a changing load duration curve, in response to climate output and to extreme weather events



# Detailed Industrial energy consumption modeling at state-level



Source: Wise, MA, P Sinha, SJ Smith, and JP Lurz (2007) Long-Term US Industrial Energy Use and CO2 Emissions. PNNL-17149





# Future Developments and activities

- ▶ Detailed Land-use modeling
  - Currently we model land-use at the national level
  
- ▶ Energy-Land-Water interactions

# Thank you for supporting the development of GCAM-USA

- ▶ Platform for Regional Integrated Modeling and Analysis
- ▶ Integrated Assessment Research Program at the DOE Office of Science
- ▶ DOE Office of Energy Policy and Systems Analysis
- ▶ US Environmental Protection Agency



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# Thank You