



Modeling U.S. air pollutant emissions and controls in GCAM-USA

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Objective of this presentation

We describe extensions to the GCAM-USA modeling framework that facilitate exploration of the co-benefits, tradeoffs and synergies among strategies for addressing climate, air quality, and other environmental goals.

Intended audience

The material presented here is intended for GCAM and other IAM modelers. For other audiences, please contact Dan Loughlin (loughlin.dan@epa.gov).

Disclaimers

Modeling results are provided for illustrative purposes only.

While this presentation has been reviewed and cleared for publication by the U.S. Environmental Protection Agency, the views expressed here are those of the authors and do not necessarily represent the official views or policies of the Agency.

- 1. The GLIMPSE project**
- 2. Science questions being addressed in GLIMPSE project**
- 3. Why GCAM-USA?**
- 4. Modifications to GCAM-USA**
 - **U.S. emission factors (EFs), controls and policies**
 - **Scenario builder and analysis tools**
- 5. Effects of modifications**
- 6. Illustrative application**
- 7. Summary and next steps**

I. The GLIMPSE project

- **GLIMPSE is a project being conducted by the U.S. EPA's Office of Research and Development.**
- **The primary goals of the project:**
 - **develop information and computational tools for assessing strategies for meeting air, climate, and energy goals simultaneously, and,**
 - **support air-climate-energy planning at various levels (national, regional & state).**
- **GLIMPSE has focused on extending EPA's MARKAL modeling capabilities by adding air, climate and environmental impact factors.**
- **This presentation outlines ongoing work to integrate GCAM-USA into the framework.**

2. Science questions

- **How can we simultaneously (and cost-effectively and robustly) achieve air quality, climate change mitigation and energy goals?**
- **What are the tradeoffs and synergies among these goals?**
- **What are the implications of state-level energy efficiency and renewable energy measures on GHG and air pollutant emissions?**
- **How do these measures and end-of-pipe controls work together most effectively in a control strategy?**
- **What are the broader health, environmental and ecological impacts of different pathways for meeting society's energy needs?**
 - **Impacts under consideration include:** Air quality and resulting human health effects, agricultural damage to crops and timber, ecosystem impacts from N and S deposition, water use by agricultural and energy sectors, and resilience to drought and other climate change impacts

3. Why GCAM-USA?

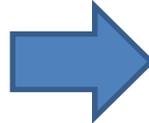
GCAM-USA is being integrated into GLIMPSE. Why?

- **Model is open source, freely available.**
- **Runtime <1 hr without specialized hardware or proprietary software.**
- **Input/output format is amenable to integration with a user interface.**
- **Includes air pollutants of interest to EPA**
 - **NO_x, SO₂, CO, PM_{2.5}, PM₁₀, VOC, NH₃.**
- **Allows examination of national and state actions in global context.**
- **Expands current MARKAL-based GLIMPSE capabilities:**
 - **Spatial resolution: Census Div. -> State**
 - **Spatial bounds: U.S. -> Global**
 - **Temporal horizon: 2055 -> 2100**
 - **Sectoral coverage: Energy system -> Energy system plus economy, land use, agriculture, climate**

Limitations for our purposes

How being addressed...

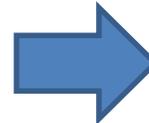
Air pollutant emission factors (EFs) decrease as a function of GDP growth, but do not explicitly reflect US regulations (e.g., Tier 3 and New Source Performance Standards).



Developed base-year and projected EFs using:

- Integrated Planning Model (IPM)
- Mobile Vehicle Simulator of Emissions (MOVES)
- WebFIRE EF database
- EPA Greenhouse Gas Inventory

Other regulations that cap state-level emissions are not currently included (e.g., Cross-State Air Pollution Rule, Clean Power Plan).



Added state-level pollutant caps derived from EPA Regulatory Impact Analyses.

Option to retrofit existing power plants with air pollutant controls is not implemented (e.g., Selective Catalytic Reduction for NOx)



Developed retrofit control characterizations based upon EPA's CUECost, CoST, and MARKAL modeling

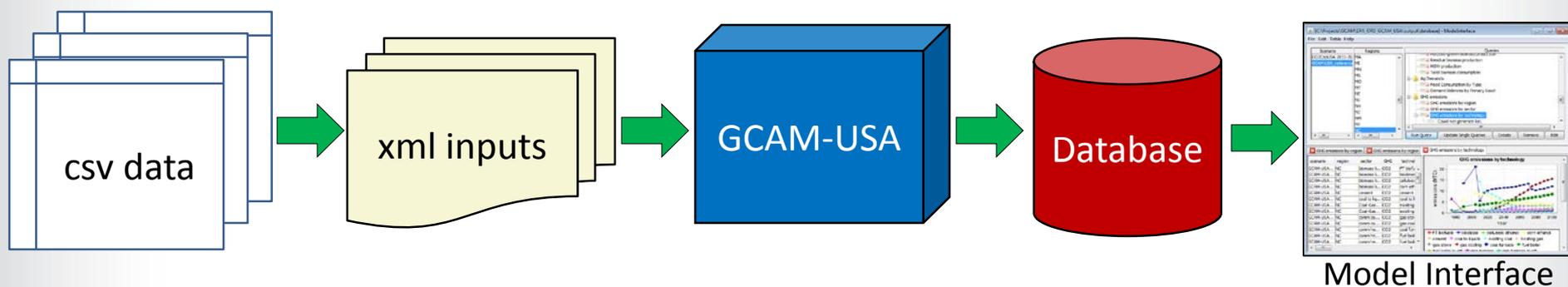
Development and management of GCAM-USA inputs files currently is not user-friendly.



Developing a Scenario Builder and tools for analyzing and comparing results.

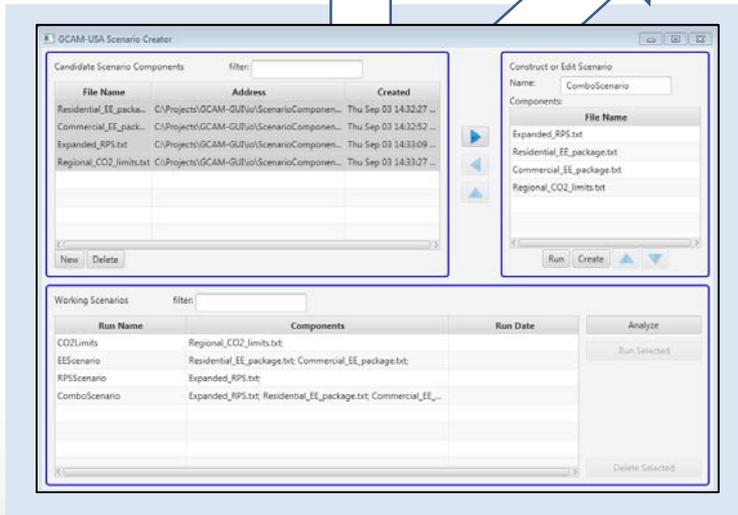
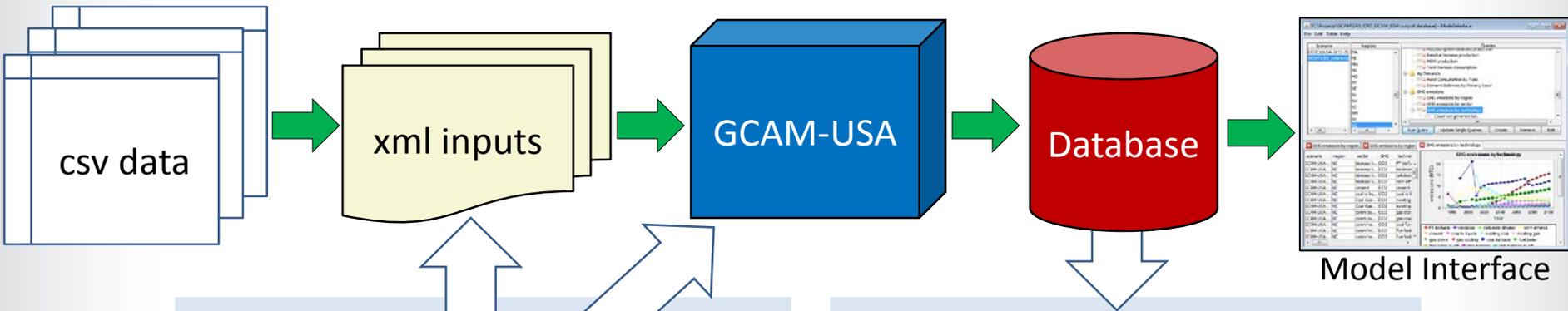
4. GCAM-USA modifications

GCAM-USA workflow:

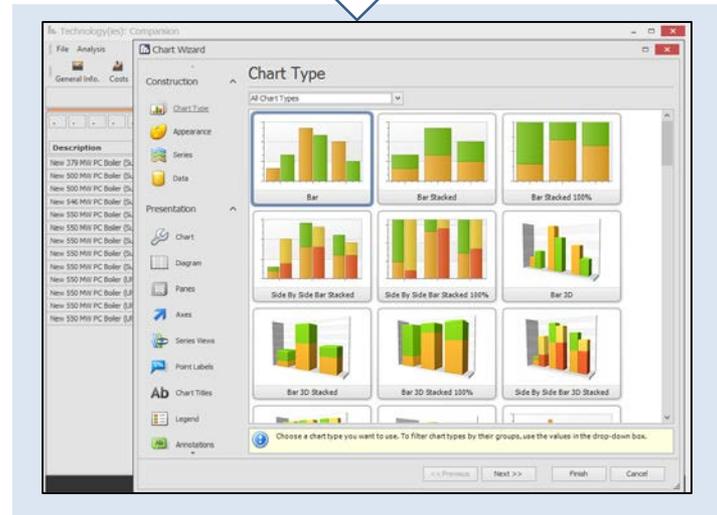


4. GCAM-USA modifications

Scenario Builder and analysis tools:



Front end: Develop, manage and execute scenarios, set model options



Back end: View, analyze and compare scenario results

4. GCAM-USA modifications

Scenario Builder: Creating scenario components

Scenario options

Year	Value
2020	10.00
2025	12.76
2030	16.29
2035	20.79
2040	26.53
2045	33.86
2050	43.22
2055	55.16
2060	70.40
2065	89.85
2070	114.67

States and/or global regions to which to apply the changes

Tools for populating data table

Data table of values to use



4. GCAM-USA modifications

Scenario Builder: Managing scenarios

Library of scenario components

The screenshot shows the GCAM-USA Scenario Creator interface. It is divided into three main sections:

- Candidate Scenario Components:** A table listing various component files and their addresses.
- Construct or Edit Scenario:** A panel for creating a new scenario, currently named "CO2CapNE_update", with a list of selected components.
- Working Scenarios:** A table listing scenarios that have been created and their execution dates.

Creating a new scenario from existing components

Management and execution of scenarios

Candidate Scenario Components filter:

File Name	Address	Created
CO2CapNortheast.txt	C:\Projects\GCAM-GUI\io\ScenarioComponen...	Mon Oct 26 16:49:54 ...
CO2CapUSA.txt	C:\Projects\GCAM-GUI\io\ScenarioComponen...	Mon Oct 26 16:47:41 ...
CO2TaxNortheast.txt	C:\Projects\GCAM-GUI\io\ScenarioComponen...	Mon Oct 26 16:35:14 ...
CO2TaxUSA.txt	C:\Projects\GCAM-GUI\io\ScenarioComponen...	Mon Oct 26 16:33:19 ...
SolarPVSubsidyUSA.txt	C:\Projects\GCAM-GUI\io\ScenarioComponen...	Mon Oct 26 16:53:27 ...
SolarPVSubsidyWest....	C:\Projects\GCAM-GUI\io\ScenarioComponen...	Mon Oct 26 16:52:17 ...

New Edit Delete

Construct or Edit Scenario

Name:

Components:

File Name
CO2CapNortheast.txt

Run Create

Working Scenarios filter:

Run Name	Components	Run Date
CO2TaxUSA	CO2TaxUSA.txt;	Mon Oct 26 16:57:34 EDT 2015
CO2TaxNortheast	CO2TaxNortheast.txt;	Mon Oct 26 16:57:34 EDT 2015
CO2CapUSA	CO2CapUSA.txt;	Mon Oct 26 16:57:34 EDT 2015
CO2CapNortheast	CO2CapNortheast.txt;	Mon Oct 26 16:57:34 EDT 2015
SolarPVSubsidyWest	SolarPVSubsidyWest.txt;	Mon Oct 26 16:57:34 EDT 2015
SolarPVSubsidyUSA	SolarPVSubsidyUSA.txt;	Mon Oct 26 16:57:34 EDT 2015

Analyze

Run Selected

Delete Selected



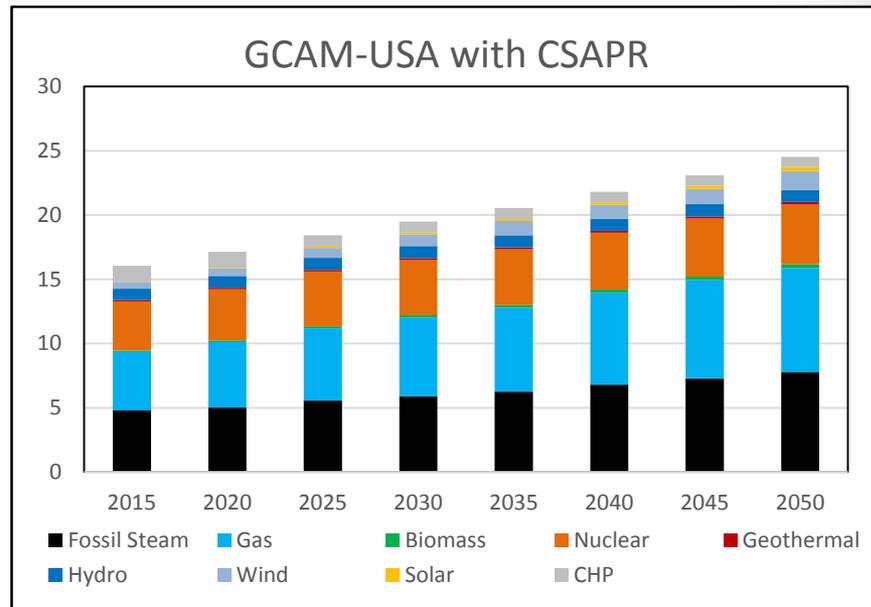
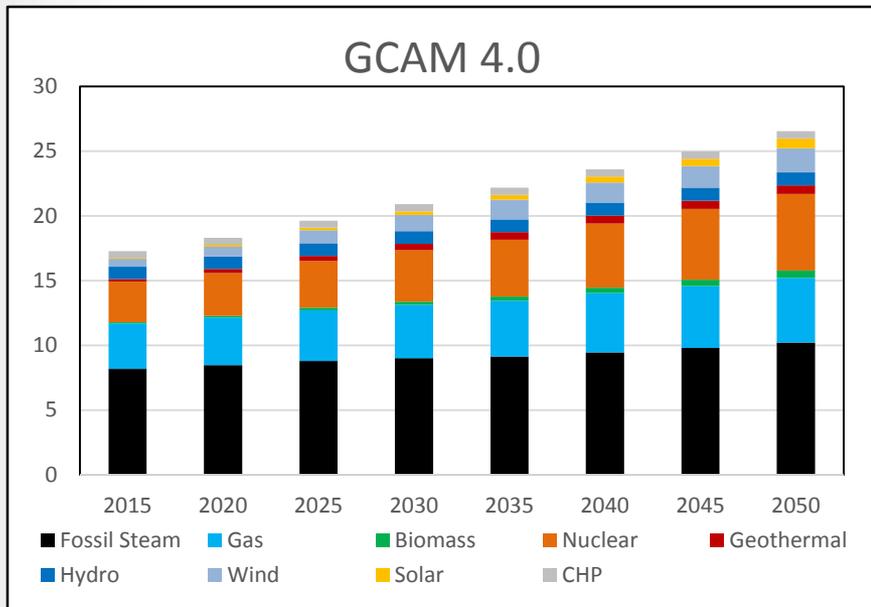
5. Effects of modifications

Note:

Results shown in this presentation are created using the GCAM-USA model, modified to include US-specific EFs provided by the EPA GLIMPSE team.

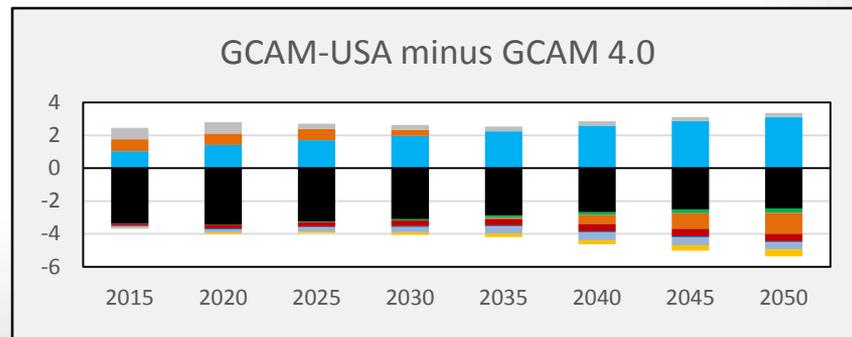
5. Effects of modifications

U.S. electricity production (EJ) by aggregated technology category



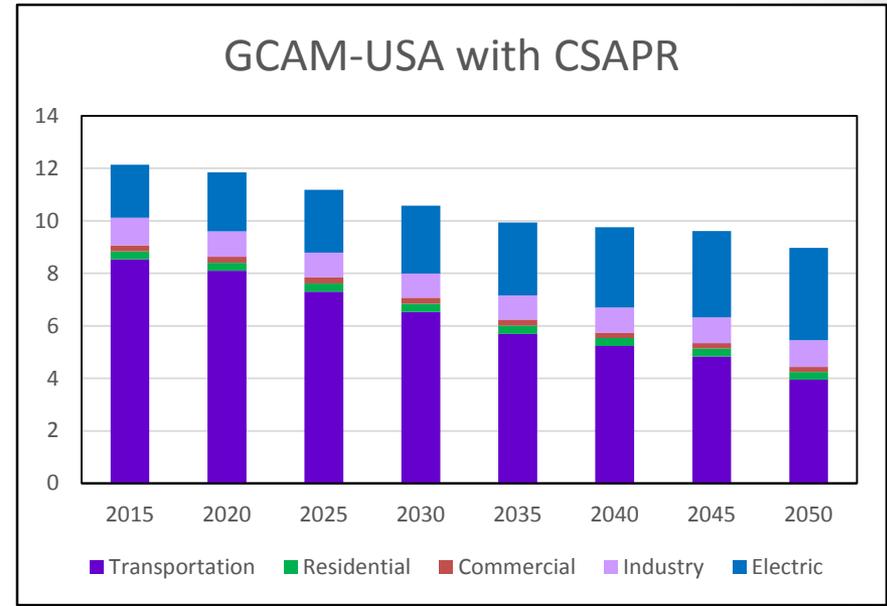
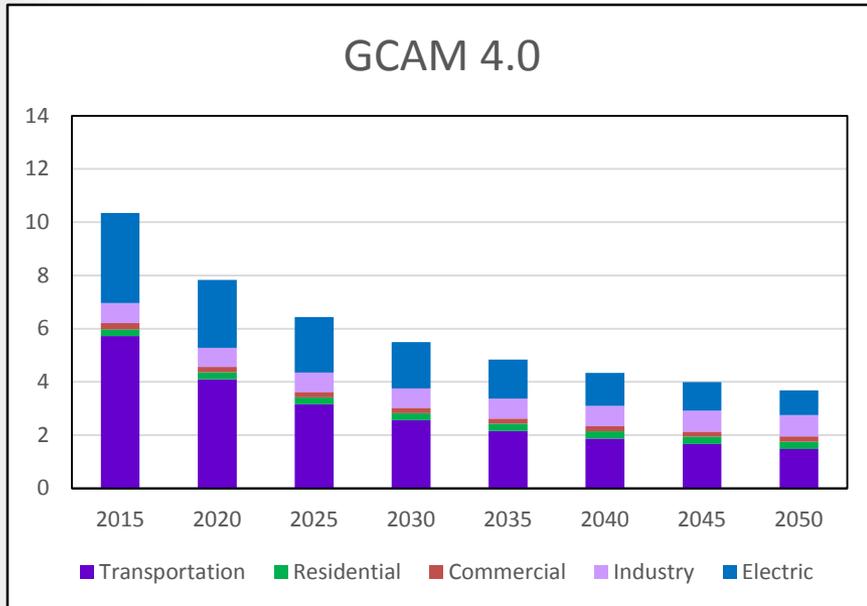
Changes in GCAM-USA:

- State-level resolution
- New U.S.-specific emission factors
- Representation of CSAPR
- Clean Power Plan is not included

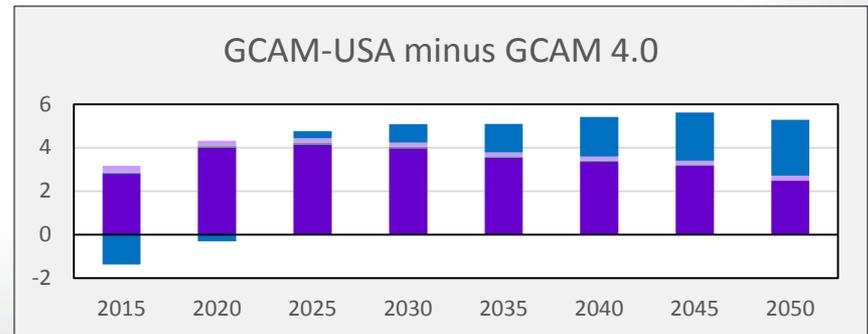


5. Effects of modifications

U.S. NOx emissions (Tg) by sector



- Changes in GCAM-USA:
- State-level resolution
 - New U.S.-specific emission factors
 - Representation of CSAPR
 - (Clean Power Plan not in either)

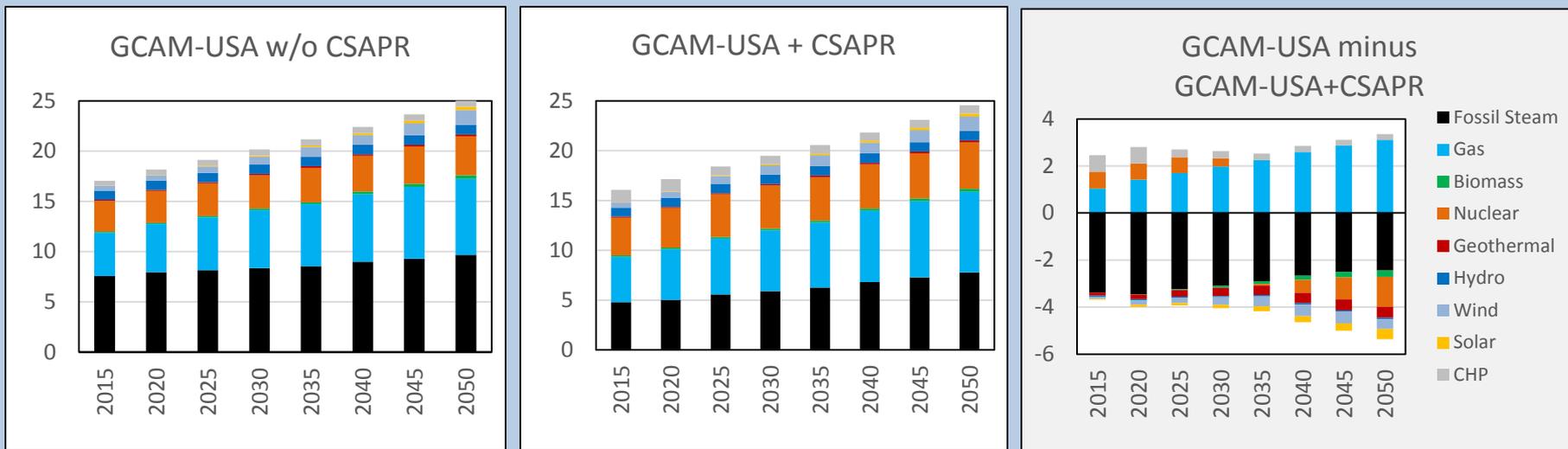


5. Effects of modifications

Observations:

- These are illustrative results from a work in progress.
- The emission projection from **GCAM-USA** does not represent future policies (beyond what is 'on the books'), while **GCAM 4.0's** projection implicitly does with its EFs being a function of change in gross domestic product.
- The timing of emission reductions differs between the models.
- Addition of **CSAPR** changes the electricity production pathway.

U.S. electricity production (EJ) by aggregated technology

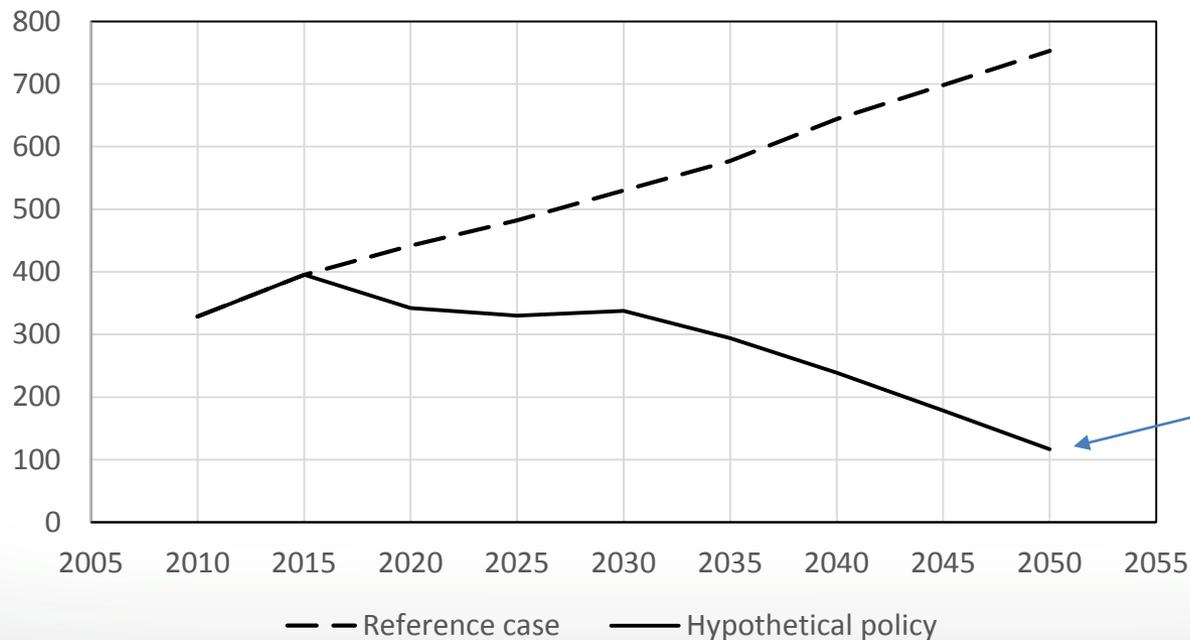


6. Example application

Objective:

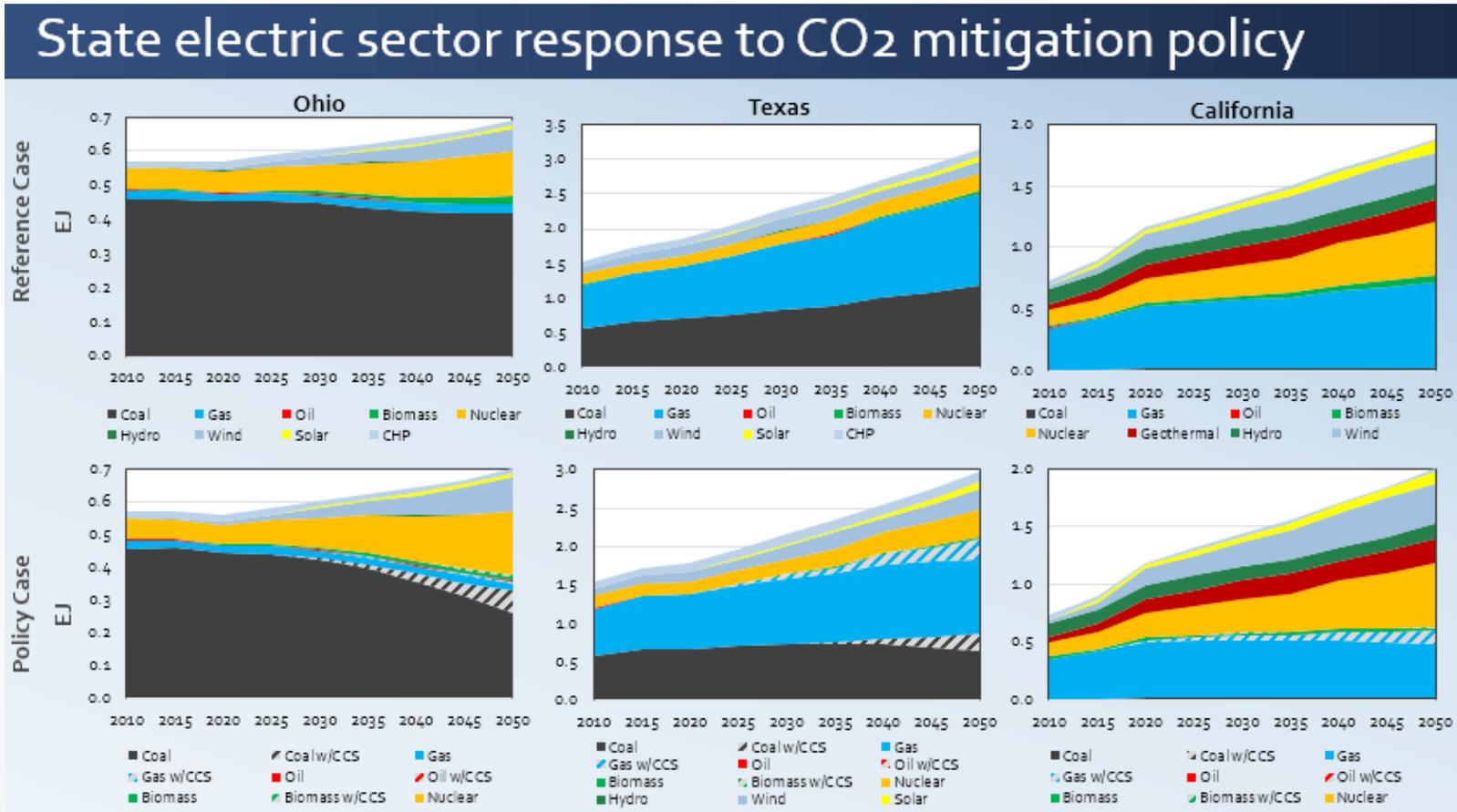
Examine the air pollutant co-benefits associated with a hypothetical CO₂ mitigation pathway.

National electric-sector CO₂ emissions (Tg)



50% reduction from 2010 level, implemented as national cap on electric sector CO₂.

6. Example application

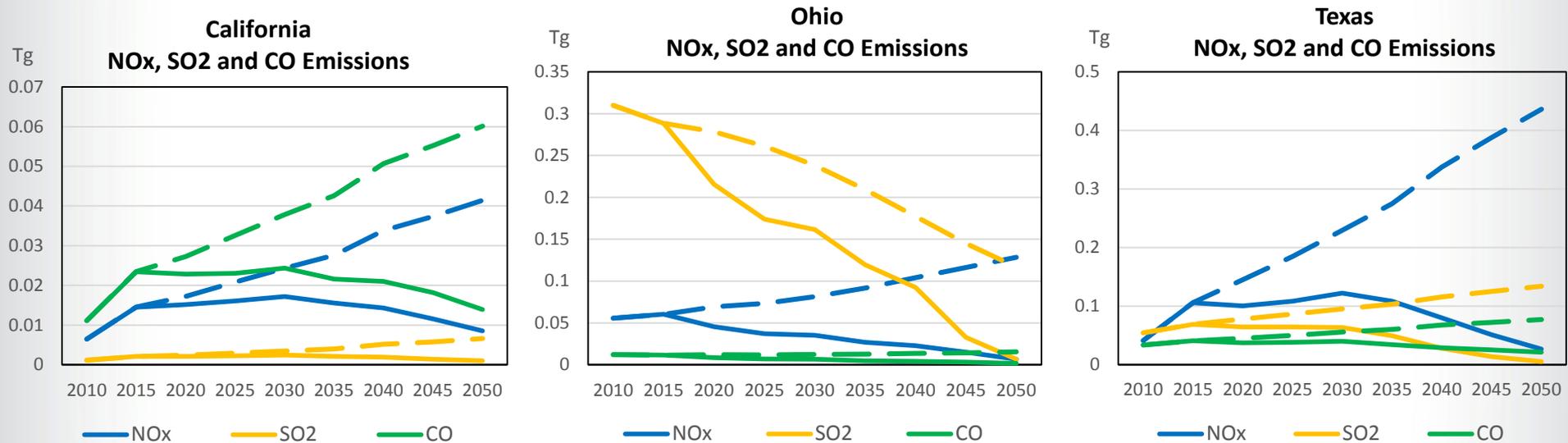


[Note: these need to be updated to be compatible with modeled scenario]

6. Example application

Air pollutant emission reduction co-benefits in the electric sector

Solid line represents CO2 mitigation scenario results, dashed line is reference case



Observation:
 There are NOx, SO2 and CO co-benefits in each of these three states.

7. Summary and next steps

- **We have made great strides in modifying GCAM-USA to include air pollutant emissions, controls and regulations.**
- **The system has successfully been tested to evaluate the air pollutant implications of a GHG mitigation pathway.**
- **We have also made progress in developing a working Scenario Builder for use with GCAM-USA.**
- **Ongoing work includes:**
 - **testing our representation of air pollutant controls**
 - **adding industrial air pollutant control options**
 - **evaluating synergies and tradeoffs among air quality, climate and energy goals, and,**
 - **exploring the implications of energy technologies, fuels, and pathways on various environmental and health endpoints.**



Questions?

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Steve Smith, JGCRI – ssmith@pnnl.gov

For information on the GLIMPSE project:

Akhtar, F.H., Pinder, R.W., Loughlin, D.H., and Henze, D.K. (2013). GLIMPSE: a rapid decision framework for energy and environmental policy. *Environ Sci Technol*, 47(21), 12011-12019. doi:10.1021/es402283j