



# **The Global Change Assessment Model**

## **A potential component of ABaCAS?**

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- **Objectives of this presentation**

Present the Global Change Assessment Model (GCAM) Integrated Assessment Model and initiate a discussion of its utility as a component of the Air Benefits and Cost and Attainment Assessment System (ABaCAS)

- **Intended audience**

The ABaCAS developer and user community

- **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. Environmental Protection Agency



# Abbreviations

- ABaCAS – Air Benefit and Cost and Attainment System
- CCS – carbon capture and sequestration
- CH<sub>4</sub> - methane
- CO – carbon monoxide
- CO<sub>2</sub> – carbon dioxide
- CSV – comma separated values (document format)
- EJ – Exajoule (10<sup>18</sup> joules)
- GCAM – Global Change Assessment Model
- GCAM-USA - Global Change Assessment Model with state-level resolution for the U.S.
- GDP – Gross Domestic Product
- GHG – greenhouse gas
- GLIMPSE - an energy-environmental-climate decision support tool. Acronym no longer applies.
- IAM – Integrated Assessment Model
- JGCRI – Joint Global Change Research Institute
- MTC – Megatonnes of carbon (10<sup>6</sup> tonnes)
- NO<sub>x</sub> – nitrogen oxides
- PNNL – Pacific Northwest National Laboratory
- SMOKE – Sparse Matrix Operator Kernel Emissions modeling system
- SO<sub>2</sub> – sulfur dioxides
- Tg – Teragram (10<sup>12</sup> grams)
- XML – Extensible Markup Language (document format)

## 1. Context

- Overview of ABaCAS
- Alternative scenarios in ABaCAS?
- Additional endpoints?

## 2. A role for Integrated Assessment Models (IAMs)?

- What is an IAM?
- The Global Change Assessment Model (GCAM)

## 3. GCAM-USA

- Adding spatial resolution to GCAM
- Importance of state-level resolution
- Improving emission projections
- Generating emission growth factors

## 4. GLIMPSE

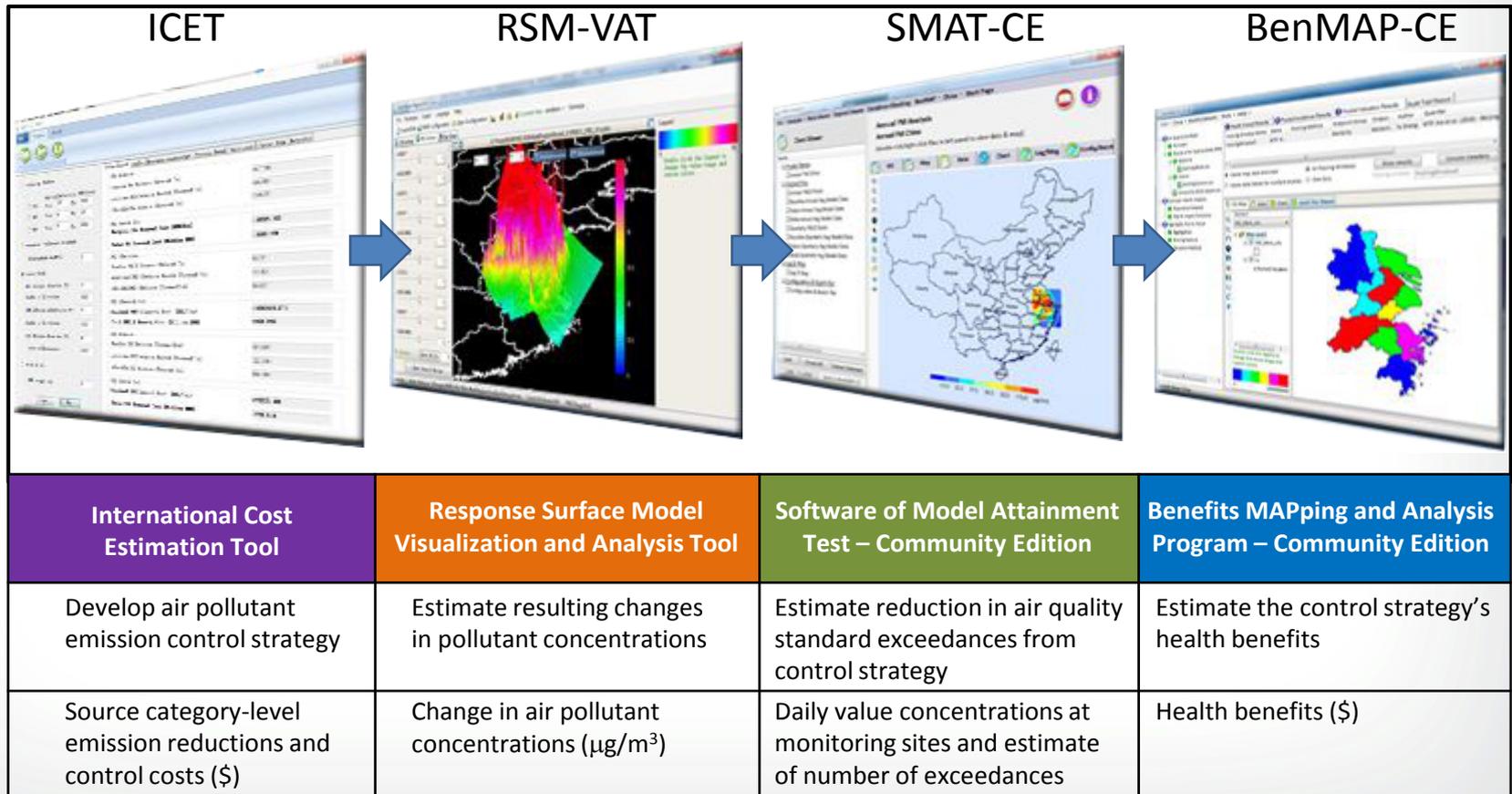
- Adding a Graphical User Interface
- Scenario Builder
- Results Analyzer

## 5. Conclusions and additional thoughts

- Direction: GLIMPSE-ABaCAS integration

**ABaCAS Objective:** Facilitate cost-benefit analysis of air quality management strategies

**ABaCAS Components:**



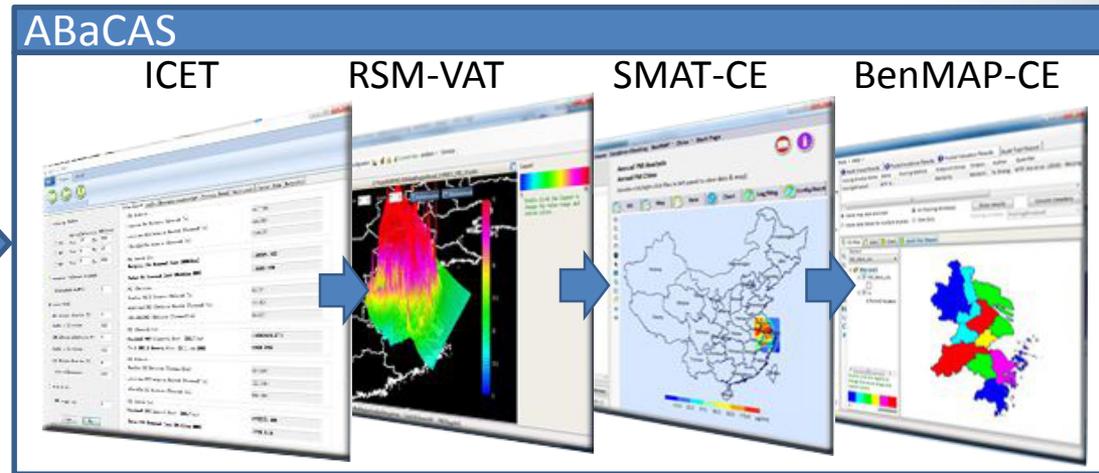
Source: Derived from abacas-dss.com



## Context: Alternative scenarios in ABaCAS?

Factors affecting baseline emissions and the performance of controls:

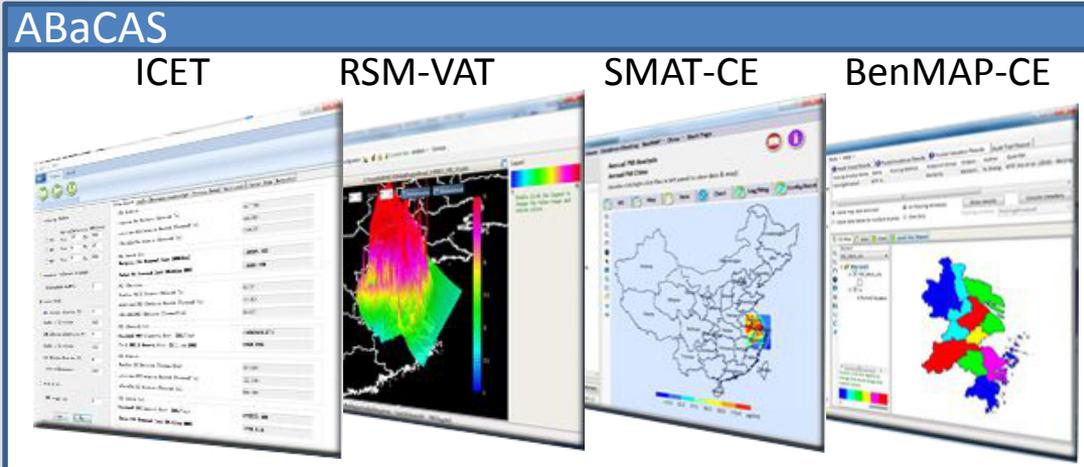
- Population growth and migration
- Economic growth and transformation
- Technology development
- Land use change
- Climate change
- Behavior and preferences
- Future environmental and energy policies



Can ABaCAS be used to evaluate air quality management benefits and costs for alternative assumptions about the baseline?

Can we generate internally consistent scenarios for use with ABaCAS?

## Context: Additional endpoints?



### Management strategy impacts

- Pollutant concentrations
- Air quality standard exceedances
- Air quality-related health effects
- Greenhouse gas and co-emitted pollutants\*
- Energy-related water demands\*
- Waste production\*
- Ecosystem damage from deposition\*

(Currently items with a \* are not addressed in ABaCAS)

Can ABaCAS be expanded to provide insights into these additional metrics?

How can the additional metrics be considered as ABaCAS is used to identify “optimal” air quality management strategies?



# A role for Integrated Assessment Models?

## What is an IAM?

### ● IAMs:

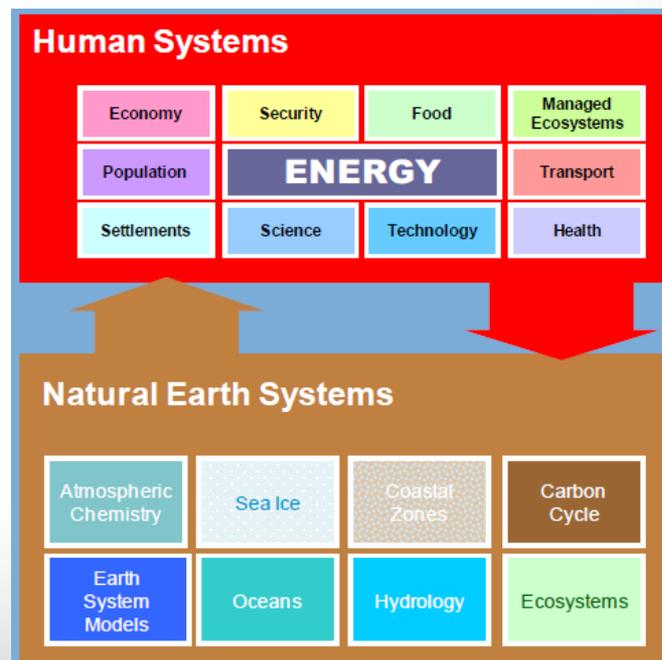
- Have been used for more than 30 years to assess GHG emissions and strategies for climate change mitigation
- Integrate representations of human and natural systems and their interactions
- Are global in scope
- Include anthropogenic sources of GHGs and often pollutant emissions
- Typically model a time horizon stretching to 2100 or beyond

### ● There is significant variation across IAMs, depending on intended purpose:

- Spatial resolution
- Inclusion of gases and other substances
- Energy system detail
- Representation of agriculture and land use
- Economic assumptions
- Degree of foresight
- Sophistication of the climate component

### ● Applications of IAMs include:

- Long-term emissions and climate projections
- National and global change mitigation strategies





# A role for Integrated Assessment Models? The Global Change Assessment Model

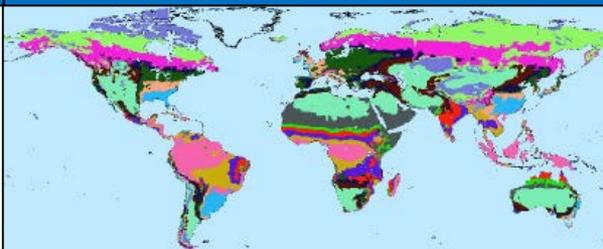
- **Emerging directions in IAM development:**
  - Finer spatial resolution (sub-national)
  - Finer temporal resolution (5 years)
  - Inclusion of GHGs and Short-Lived Climate Pollutants, many of which are also air pollutants (e.g., NO<sub>x</sub>, SO<sub>2</sub>, CH<sub>4</sub>, CO, and particulate matter)
  - Incorporation of detailed land use and water system linkages
- **Example: The Global Change Assessment Model (GCAM)**
  - Developed by Pacific Northwest National Laboratory
  - 32 economic and energy regions; 283 agriculture and land use regions
  - 233 global water basins
  - 5-year time steps, extending from 2005 to 2100
  - Technology-rich energy system detail
  - Open source and freely available, 1 hour runtime

Source: Joint Climate Change Research Institute, PNNL

32 global economic and energy regions



283 agriculture and land use regions



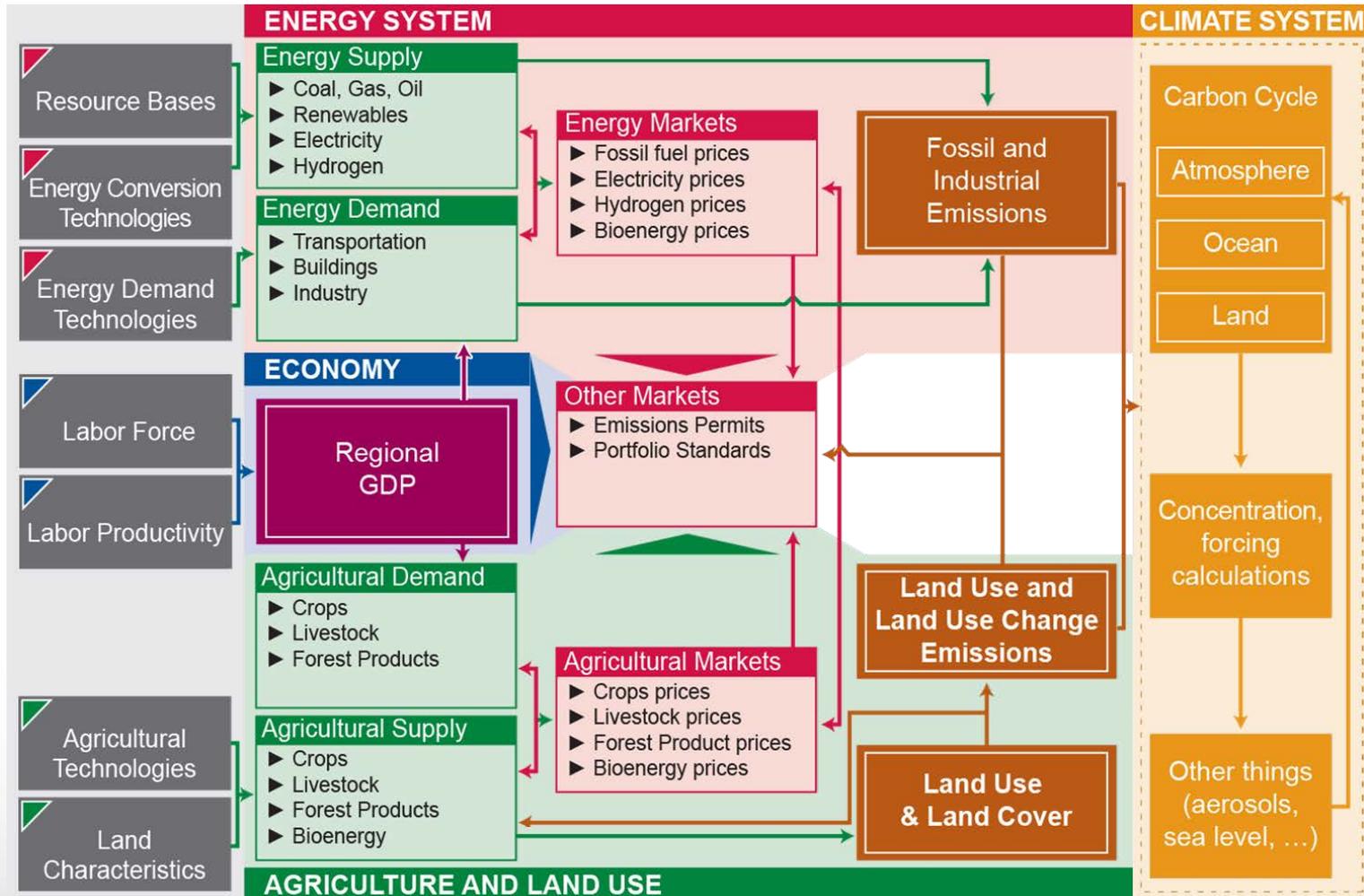
233 water basins





# A role for Integrated Assessment Models? The Global Change Assessment Model

## GCAM Components

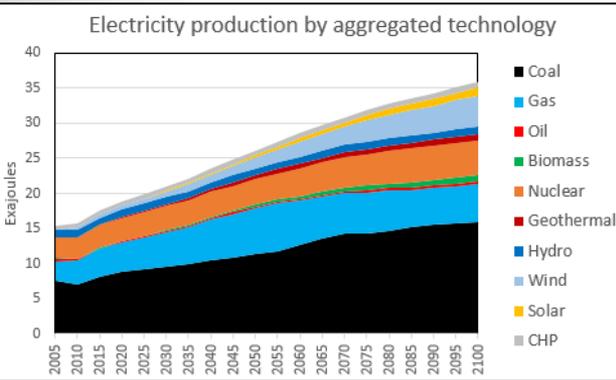




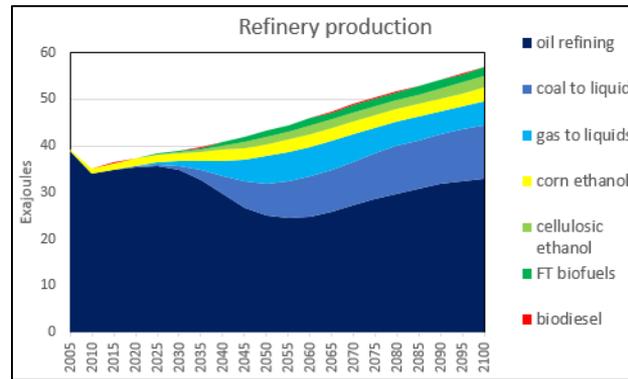
# A role for Integrated Assessment Models? The Global Change Assessment Model

## Example GCAM national-scale outputs for a hypothetical scenario

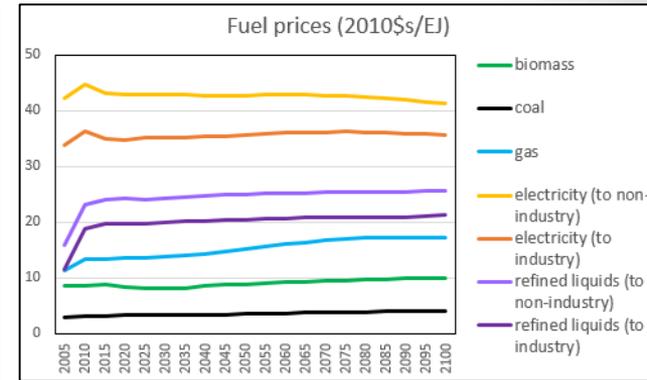
Technology market shares



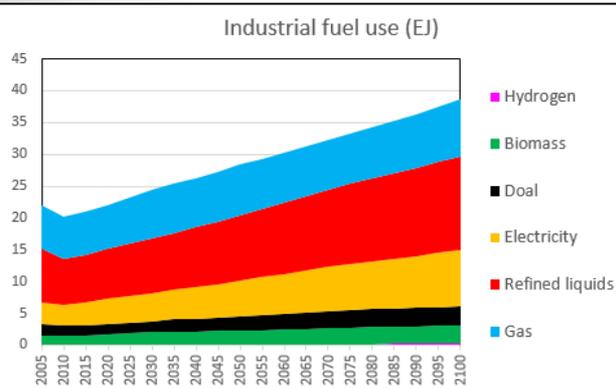
Fuel production



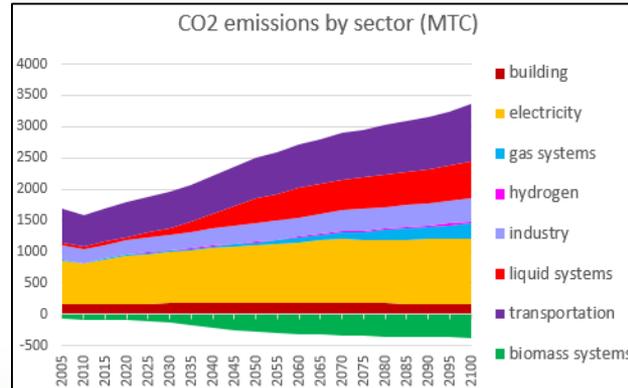
Fuel prices



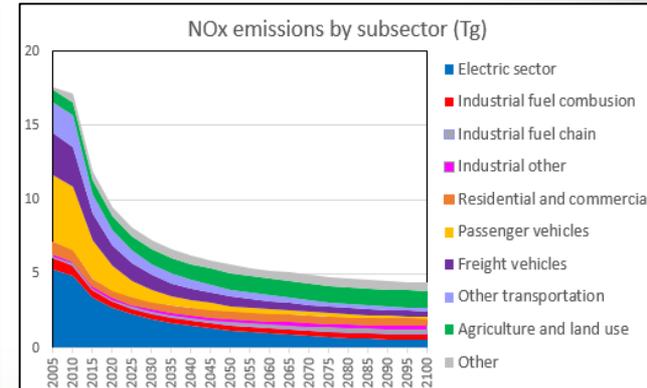
Sectoral fuel use



GHG emissions



Air pollutant emissions

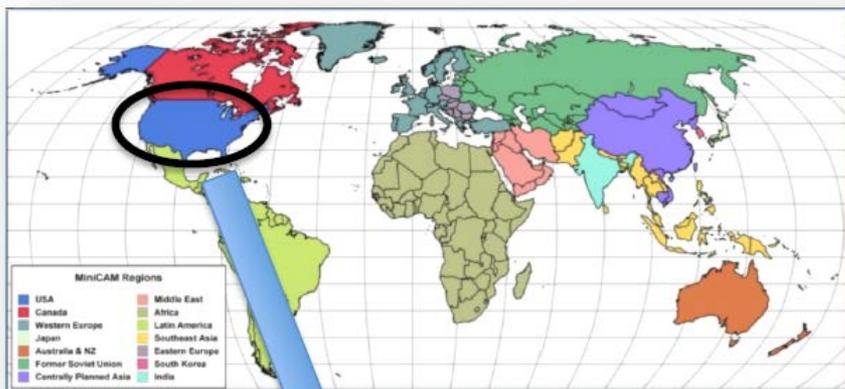




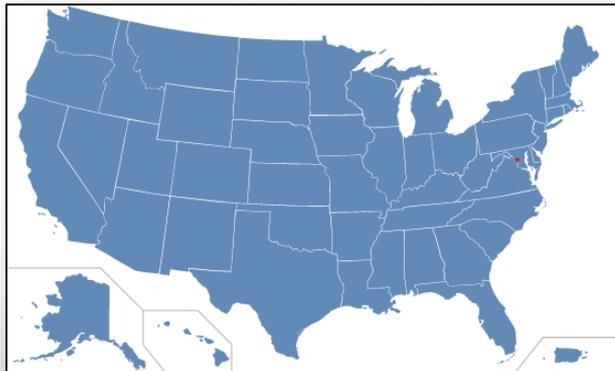
# GCAM-USA Adding spatial resolution to GCAM

**GCAM's object-oriented structure facilitates adding sub-national spatial resolution**  
**GCAM-USA and GCAM-China, with state-level detail, both are under development.**

## GCAM-USA



**50-state energy system representation**



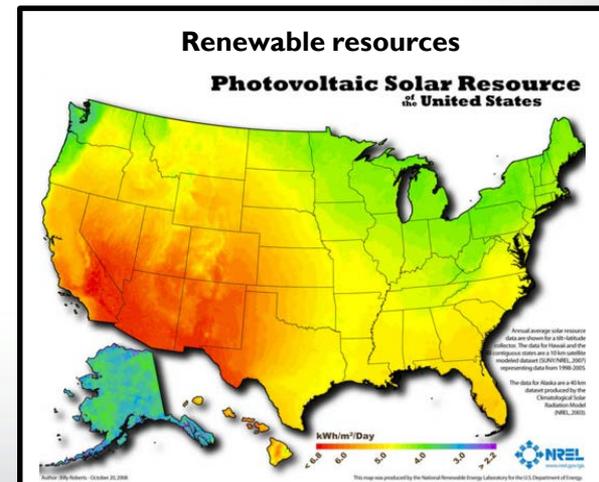
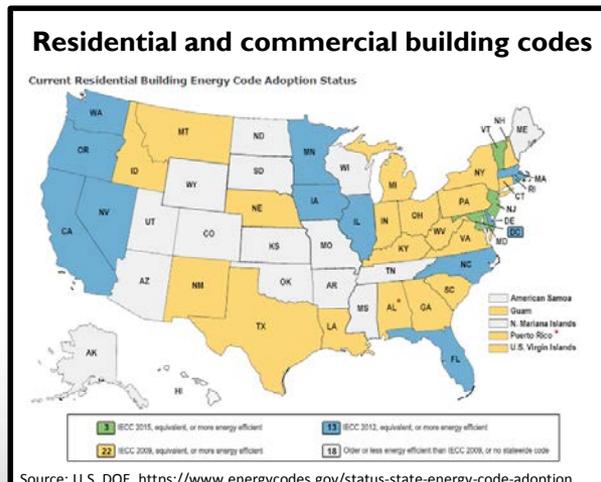
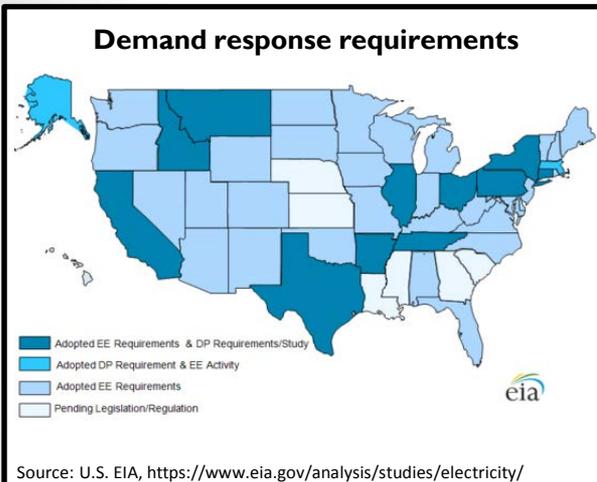
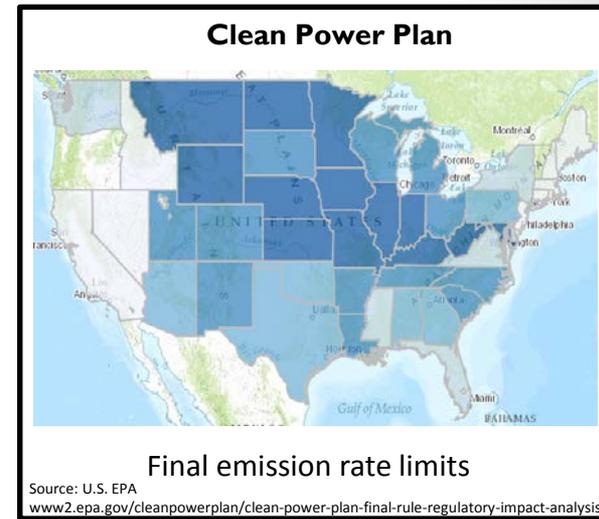
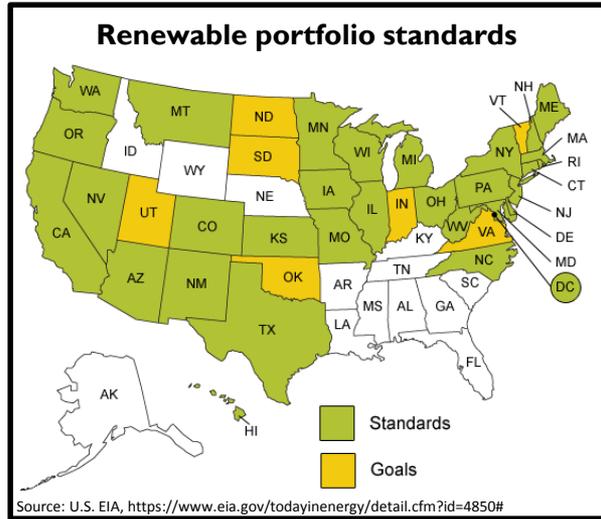
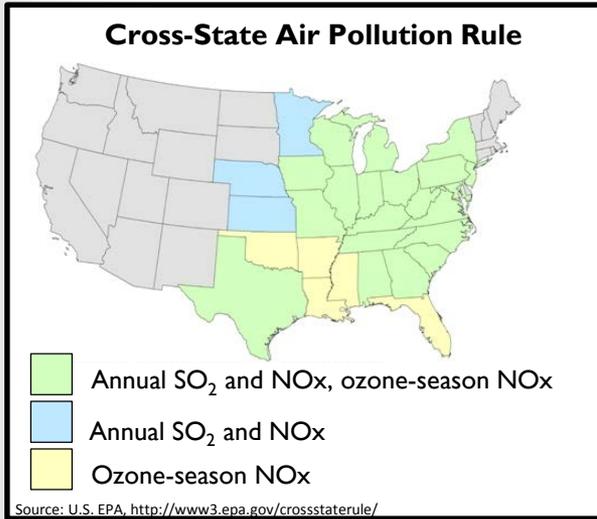
### GCAM-USA

- Each U.S. state is represented within a fully global IAM
- We are exploring how GCAM-USA can be used to support long-term, coordinated energy and environmental planning
- Projecting GHG and air pollution emissions for various global and U.S. scenarios



# GCAM-USA Importance of state-level resolution

Emissions and energy policies generally operate at the state-level, and resources vary subnationally



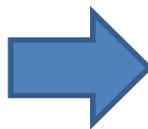


# GCAM-USA Improving emission projections

## Limitations for U.S. air pollutant projections

## How these limitations are being addressed...

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



Developed **base-year and projected EFs** from EPA modeling activities:

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

Other regulations that limit 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 of Cross-State Air Pollution Rule and the Clean Power Plan.

Option to retrofit existing power plants with air pollutant controls is not implemented (e.g., Selective Catalytic Reduction for NO<sub>x</sub>)



Developed **retrofit pollutant controls** based upon EPA's Control Strategy Tool (CoST) and MARKET ALlocation (MARKAL) modeling

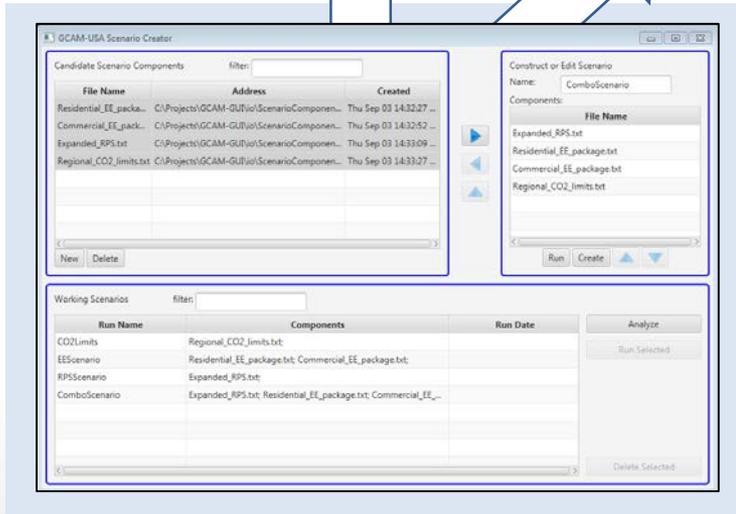
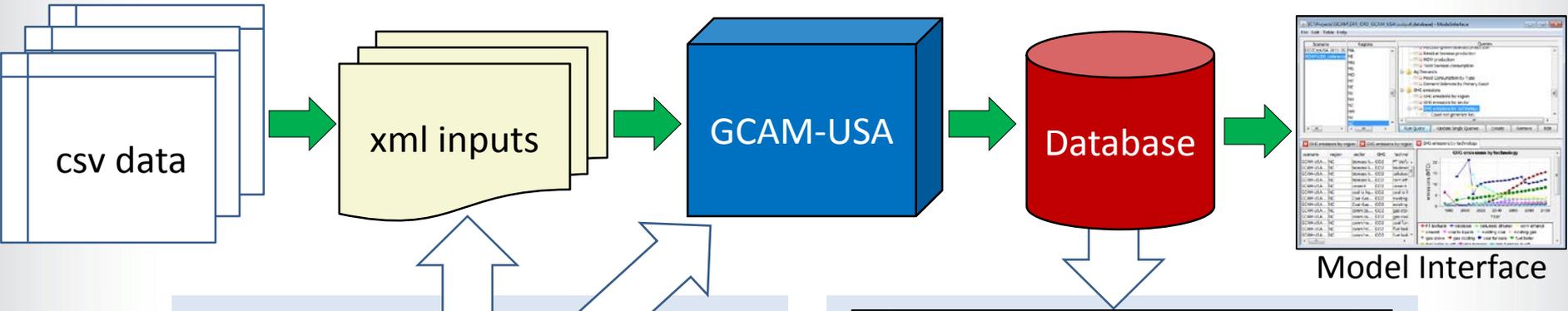
Development and management of GCAM-USA inputs files could be more user-friendly.



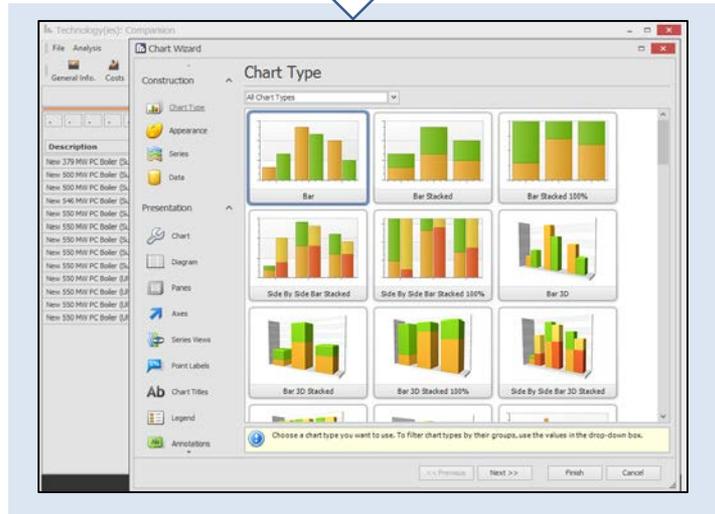
Integrating into the GLIMPSE prototype decision support tool, which includes a **Scenario Builder** and **Results Analyzer**.



We are developing a **Scenario Builder** and analysis tools to facilitate its use for policy analyses



**Scenario Builder:** Develop, manage and execute scenarios, set model options



**Results Analyzer:** View, analyze and compare scenario results



# GLIMPSE Scenario Builder

## Scenario Builder: Managing scenarios

Creating a new scenario from existing components

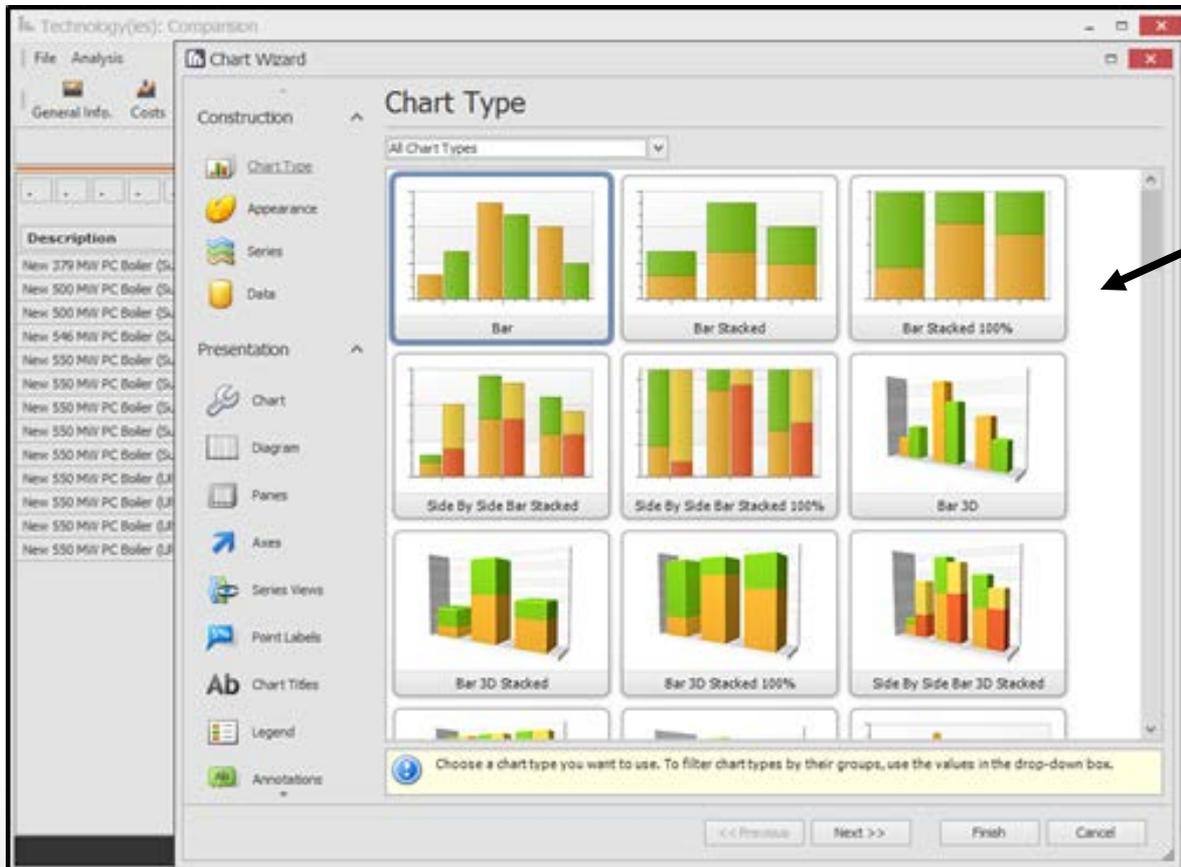
Library of scenario components

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

- Candidate Scenario Components:** A table listing various components with columns for File Name, Address, and Created. Buttons for New, Edit, and Delete are at the bottom.
- Construct or Edit Scenario:** A panel on the right where a scenario named "CO2CapNE\_update" is being created. It shows a list of components, with "CO2CapNortheast.txt" selected. Buttons for Run, Create, and navigation arrows are at the bottom.
- Working Scenarios:** A table at the bottom showing scenarios that have been run, with columns for Run Name, Components, and Run Date. Buttons for Analyze, Run Selected, and Delete Selected are on the right.

Management and execution of scenarios

## Results visualizer: Exploratory data analysis



Interactive nature facilitates exploratory data analysis

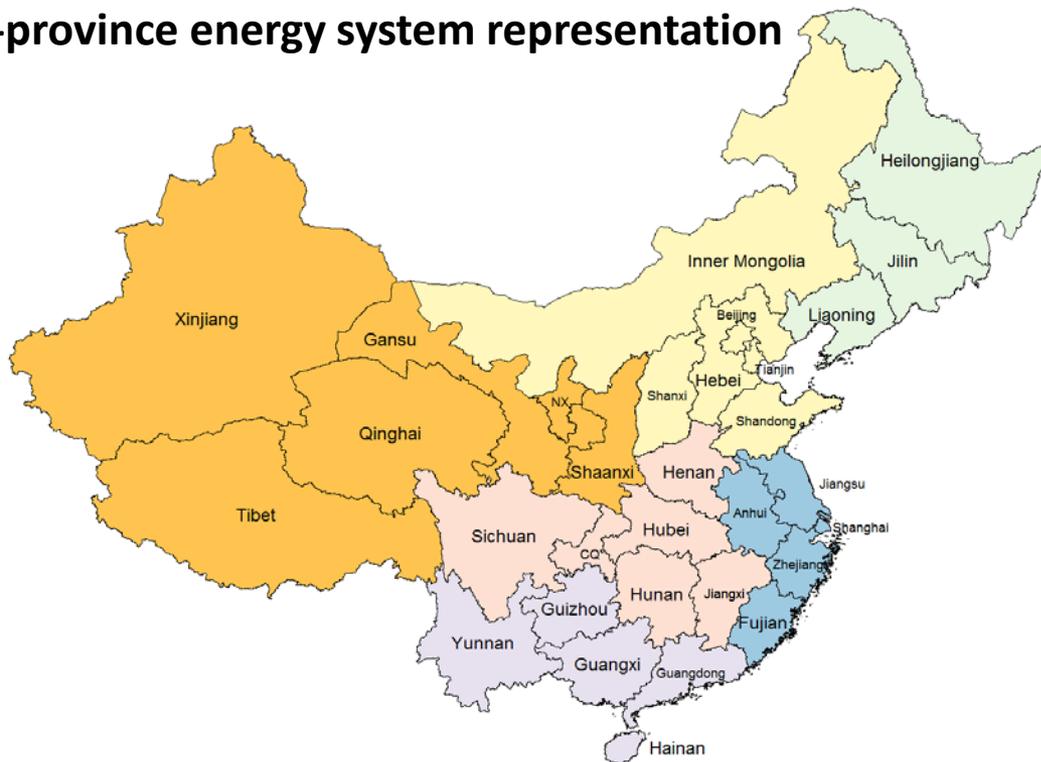
- **GCAM-USA and GLIMPSE are allowing researchers to:**
  - Generate air pollutant emission projections for alternative scenarios
  - Consider controls, energy efficiency and renewable energy in management strategies
  - Track impacts on additional endpoints, such as GHGs, water use, fuel use, and other system impacts
- **GCAM could be used in a similar fashion for national-level analyses in China**
- **GCAM-China has the potential to support provincial-level analyses**

## GCAM-China – a new tool for policy analysis in China

GCAM-China is being developed in collaboration between researchers at Tsinghua University and PNNL (at the Joint Global Change Research Institute)

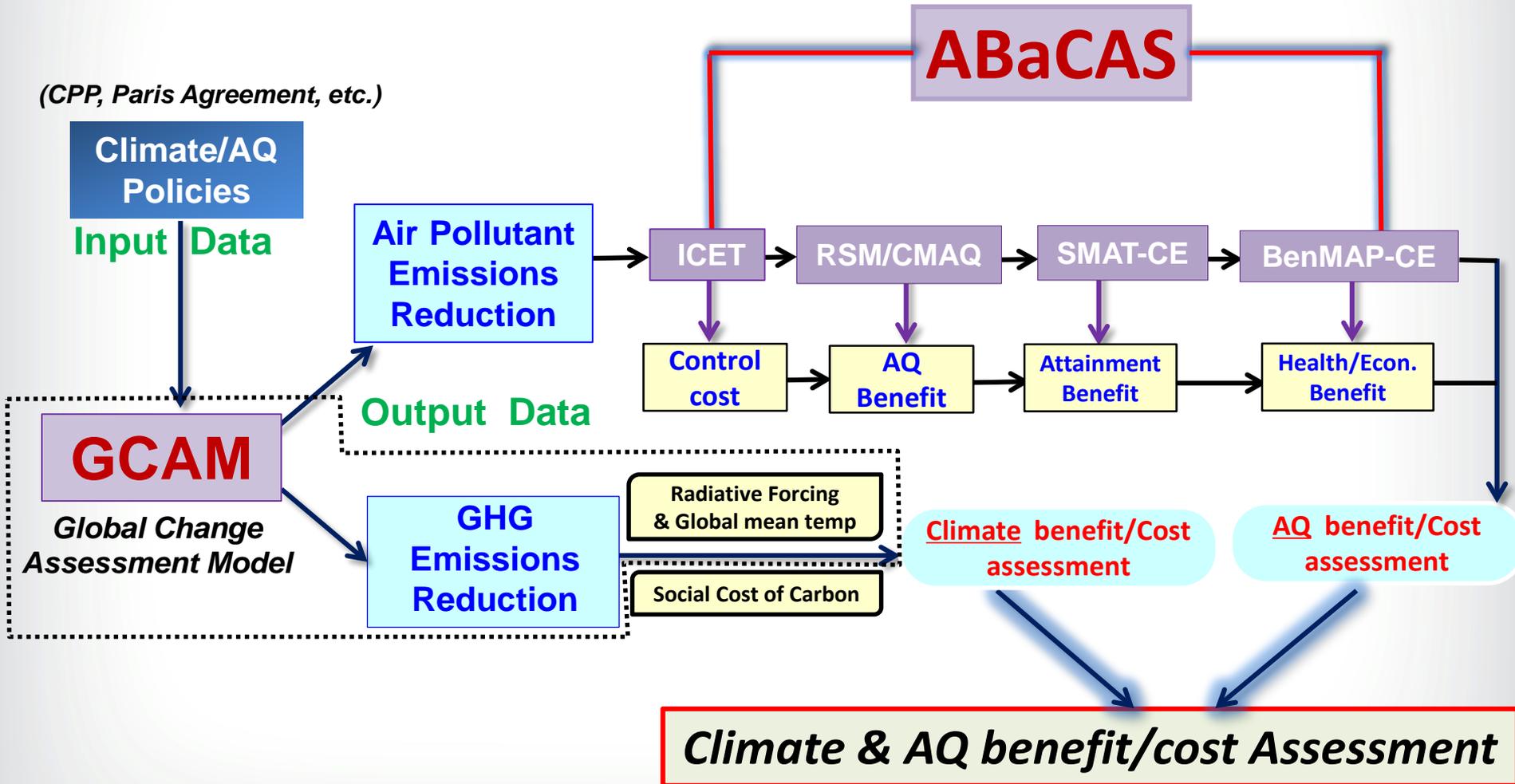
Potential applications of GCAM-China include analysis of national emission reduction targets, projection of air pollution emissions, and assessment of sectoral policies.

### 31-province energy system representation





# Direction GCAM-ABaCAS conceptual framework





# Questions?

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