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# The Global Change Assessment Model A potential component of ABaCAS?

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# Forward

## 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

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# **Abbreviations**

- ABaCAS Air Benefit and Cost and Attainment System
- CCS carbon capture and sequestration
- $CH_4$  methane
- CO carbon monoxide
- CO<sub>2</sub> carbon dioxide
- CSV comma separated values (document format)
- EJ Exajoule (10^18 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 (10^6 tonnes)
- NOx nitrogen oxides
- PNNL Pacific Northwest National Laboratory
- SMOKE Sparse Matrix Operator Kernel Emissions modeling system
- SO<sub>2</sub> sulfur dioxides
- Tg Teragram (10^12 grams
- XML Extensible Markup Language (document format)

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# Outline

## . 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

## Conclusions and additional thoughts

- Direction: GLIMPSE-ABaCAS integration



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

### **ABaCAS Components:**

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Name:	International Cost Estimation Tool	Response Surface Model Visualization and Analysis Tool	Software of Model Attainment Test – Community Edition	Benefits MAPping and Analysis Program – Community Edition	
Function:	Develop air pollutant emission control strategy	Estimate resulting changes in pollutant concentrations	Estimate reduction in air quality standard exceedances from control strategy	Estimate the control strategy's health benefits	
Output:	Source category-level emission reductions and control costs (\$)	Change in air pollutant concentrations (µg/m <sup>3</sup> )	Daily value concentrations at monitoring sites and estimate of number of exceedances	Health benefits (\$)	

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

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- 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?

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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?

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# 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





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## 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., NOx, 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, I hour runtime

32 global economic and energy regions
283 agriculture and land use regions
233 water basins

Image: Constraint of the second second

Source: Joint Climate Change Research Institute, PNNL

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

## **GCAM** Components

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Source: Joint Climate Change Research Institute, PNNL

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

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



GHG emissions

### Sectoral fuel use

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### CO2 emissions by sector (MTC) Industrial fuel use (EJ) NOx emissions by subsector (Tg) 45 4000 Electric sector building 40 3500 Hydrogen Industrial fuel combusion electricity 35 3000 15 Industrial fuel chain Biomass 30 2500 gas systems Industrial other 25 2000 Doal hydrogen 10 Residential and commercia 20 1500 Passenger vehicles industry Electricity 15 1000 Freight vehicles liquid systems 5 10 500 Refined liquids Other transportation 5 transportation Agriculture and land use Gas -500 biomass systems 2005 2010 2015 025 090 095 100 Other 010

### Illustrative results

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

### 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



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Source: U.S. EIA, https://www.eia.gov/analysis/studies/electricity/









## **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

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(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 NOx)

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



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

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

## **GCAM-USA**

## **Generating emissions growth factors**

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### GCAM-USA technology- and pollutant-specific results can be used to develop state- and pollutant-specific emission projection factors for use in emissions and air quality modeling

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	Mobile - On-Road Gasoline Light Duty Trucks 3&4
	Mobile - On-Road Gasoline Heavy Duty 2b-8b&Buses
	Mobile - On-Road Diesel Light Duty Vehicles
	Mobile - On-Road Diesel Light Duty Trucks 1-4
	Mobile - On-Road Diesel Heavy Duty
	Mobile - On-Road Diesel Heavy Duty
	Mobile - On-Road Diesel Heavy Duty
	Mobile - On-Road Diesel Heavy Duty
	Mobile - On-Road Diesel Heavy Duty
	Mobile - On-Road Diesel Heavy Duty Buses
	Mobile - Aircraft
	Mobile - Commercial Marine Vessels
	Mobile - Marine Pleasure Craft
	Mobile - Marine Militan/Vessels

Mobile - Marine Military Vessels

# GLIMPSE Adding a Graphical User Interface

# 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

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### Scenario Builder: Managing scenarios Creating a new scenario - 0 % GCAM-USA Scenario Creator from existing Library of Candidate Scenario Components filter: Construct or Edit Scenario components Name: CO2CapNE\_update File Name Address Created scenario Components: 2CapNortheast.txt C:\Projects\GCAM-GUI\io\ScenarioComponen... Mon Oct 26 16:49:54 ... File Name components CO2CapUSA.txt C:\Projects\GCAM-GUI\io\ScenarioComponen... Mon Oct 26 16:47:41 . CO2CapNortheast.txt 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\jo\ScenarioComponen... Mon Oct 26 16:53:27 ... SolarPVSubsidyWest.... C:\Projects\GCAM-GUI\io\ScenarioComponen... Mon Oct 26 16:52:17 ... Run Create New Edit Delete Working Scenarios filter: Run Name Components Run Date Analyze Management CO2TaxUSA CO2TaxUSA.txt: Mon Oct 26 16:57:34 EDT 2015 Mon Oct 26 16:57:34 EDT 2015 and execution CO2TaxNortheast CO2TaxNortheast.txt: CO2CapUSA CO2CapUSA.txt; Mon Oct 26 16:57:34 EDT 2015 of scenarios CO2CapNortheast Mon Oct 26 16:57:34 EDT 2015 CO2CapNortheast.txt; SolarPVSubsidyWest SolarPVSubsidyWest.txt; Mon Oct 26 16:57:34 EDT 2015 Mon Oct 26 16:57:34 EDT 2015 SolarPVSubsidyUSA SolarPVSubsidyUSA.txt;



## **Results visualizer: Exploratory data analysis**



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# **Conclusions and additional thoughts**

# 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 nationallevel analyses in China
- GCAM-China has the potential to support provinciallevel analyses



# **Conclusions and additional thoughts**

## 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.







# **Questions?**

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