

A computational framework for supporting Environmental-Climate-Energy decision-making

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Foreword

• Objective

 Discuss an ongoing collaborative research project with linkages to air quality management in China

Intended audience

- Site visitors from the PowerChina Huadong Engineering Corp.

Additional contributors

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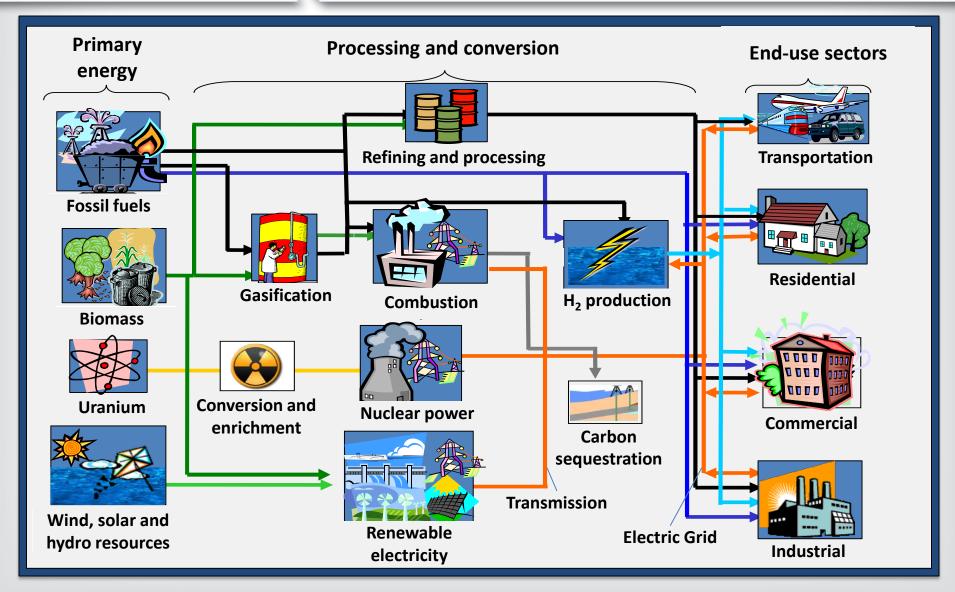
Disclaimer

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Energy and the environment

SEPA

The energy system





Energy and the environment

Environmental impacts of energy

Energy system contributions to U.S. environmental concerns:

Air quality

- Photochemical smog: 92% of nitrogen oxide (NOx) emissions*
- Acid rain: 86% of sulfur dioxide (SO₂) emissions*
- Toxics: 87% of mercury (Hg) emissions*

Climate change

- Greenhouse gas emissions: 97% of carbon dioxide (CO₂) emissions*
- Major source of short-lived climate pollutants (e.g., black carbon, methane)

Water

- Demands: electricity production accounts for 51% of fresh water withdrawals
- Pollution:
 - wastewater from fuel extraction and processing, seepage from waste
 - eutrophication from N deposition, acidification from S deposition

Waste production

Mine tailings, combustion residues, agricultural wastes

* Percentage of U.S. anthropogenic emissions due to the energy system



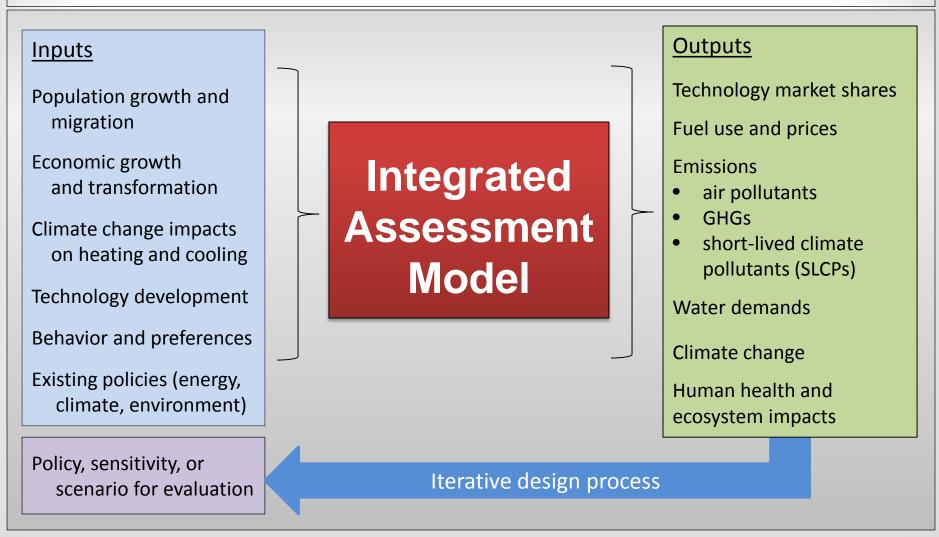
Science questions

- How can we simultaneously achieve environmental, climate change mitigation, and energy goals?
- What are the tradeoffs and synergies among these goals?
- Are there unintended consequences that may arise with various management strategies? Can we anticipate and prepare for these?
- What are the broader health, environmental and ecological impacts of different pathways for meeting society's energy needs?
 - Impacts under consideration include:
 - <u>air quality</u> and resulting <u>human health</u> effects,
 - damage to crops and timber, ecosystem impacts from N and S deposition,
 - <u>water use</u> by agricultural and energy sectors, and
 - resilience to drought and other climate change impacts.

The GLIMPSE project

GLIMPSE: a modeling framework for exploring the answers to these questions

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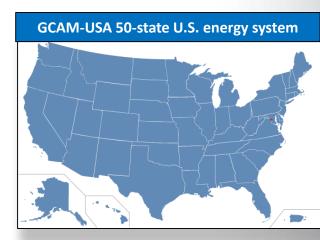


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A component of GLIMPSE:

The Global Change Assessment Model (GCAM)

- Developed by Pacific Northwest National Laboratory
- Regions: 32 economic and energy; 283 agriculture and land use; 233 water basins
- 5-year time steps, extending from 2005 to 2100
- Technology-rich energy system detail
- Pollutant species
 - Climate forcers: CO₂, CH₄, SO₂, N₂O, BC, OC, HFCs
 - Air pollutants: NOx, SO₂, VOC, CO, NH₃, direct PM
- Open source and freely available, I hour runtime







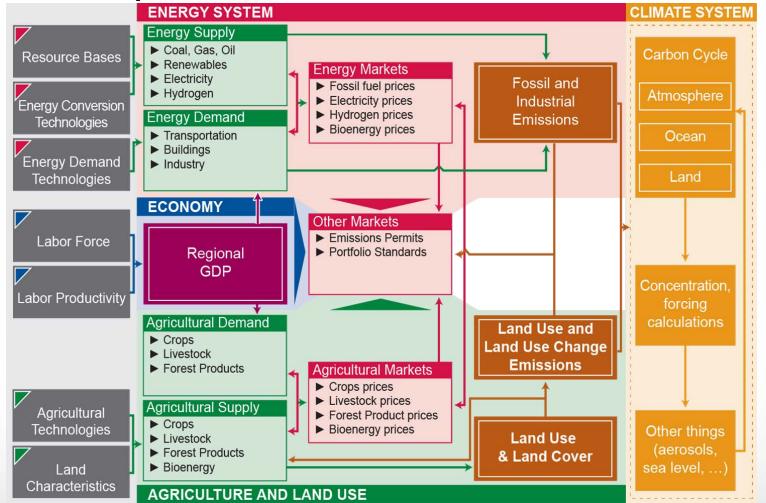
283 agriculture and land use regions



GCAM sectoral coverage

GCAM Components

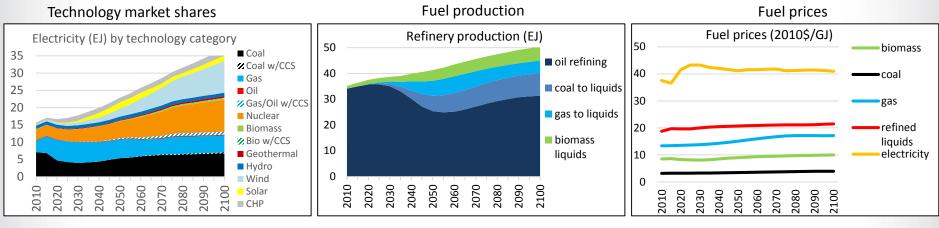
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Source: JGCRI. PNNL

Example GCAM outputs

Example GCAM national-scale outputs for a hypothetical scenario

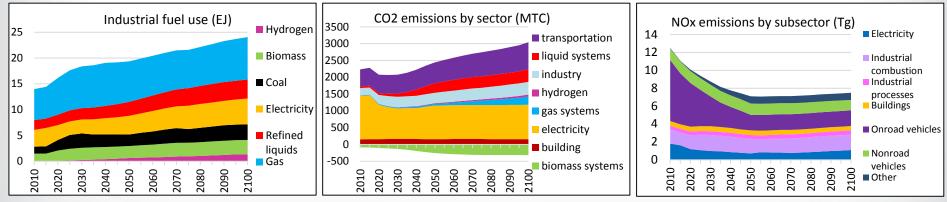




SEPA



Air pollutant emissions



⇔EPA

Additional GCAM outputs

- **Primary energy consumption**
- Final energy consumption
- Fuel use in electricity production
- Sectoral energy demand by service
- Sectoral fuel use and price by service
- **Technology stock by service**
- Industrial output (e.g., cement production)
- Land use by agro-ecological zone (AEZ)
- Agricultural production and prices
- Fertilizer use by crop
- Meat production and prices
- Feed production and prices
- **Biomass production and consumption**

- **GHG** emissions
- Air pollutant emissions
- CO₂ concentrations
- **Climate forcing**
- **Global mean temperature**
- **Policy costs**
- Regional CO₂ marginal abatement curve by period
- **Energy-related water demands**
- Also, through ongoing work:
- **PM** mortality health benefits
- **Ozone-related crop and timber impacts**
- **Deposition of N from NOx and NH₃**
- Life cycle impacts



The GLIMPSE project

Tools for supporting decision making

We are developing a Scenario Builder to facilitate the construction of management strategies and running GCAM. We are also enhancing tools for exploring GCAM outputs.

Scenario Builder graphical interface

CAM-USA Scenario C	reator			
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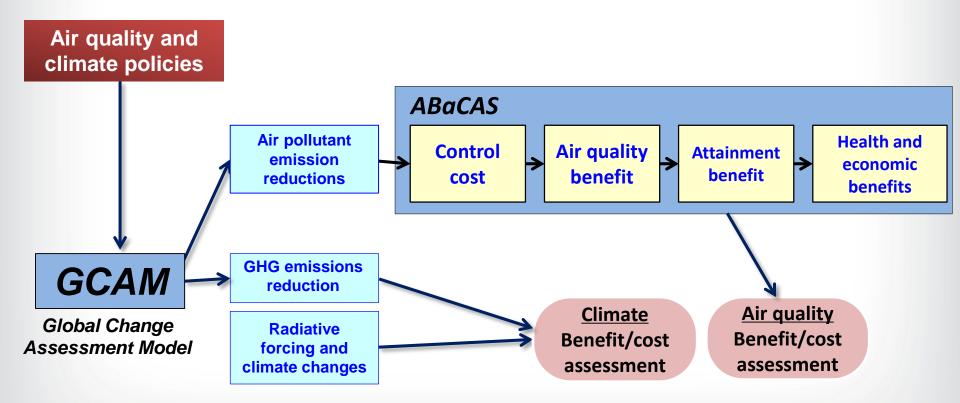
Exploratory data analysis tools

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RD-POL,d		g Domass	0.002	0.004	0.004	0.003	0	0.001	0.002	0.001	0.001				
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RD-POL,d.		kHydro	0.004	0.005	0.005	0.005	0.005	0.005	0.005	0.005					
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RD POL.d. RD POL.d. RD RD d.	NC NC	e Coel c Gas e Ol	0.582 0.001 0.001	0.286	0.033	0.036	0.039	0.041	0.044	0.046	0.049	Year Year			

Illustrative results



GCAM can also be integrated with the Air Benefit and Cost Assessment System (ABaCAS).

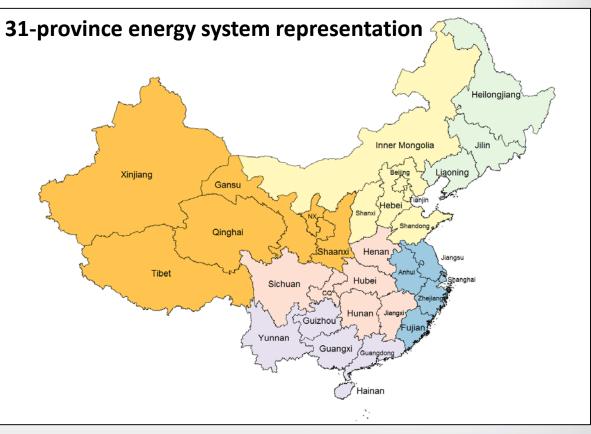




GCAM-China

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.





Summary

- GLIMPSE has the potential to support long-term, coordinated environmental, climate and energy planning
- A component of GLIMPSE, the GCAM Integrated Assessment Model, is being customized to have additional country-level resolution
 - GCAM-USA: State-level for the U.S.
 - GCAM-China: Province-level for China

Questions? Comments? Thank you! 谢谢!