

Building a GCAM Modeling Community: An Overview

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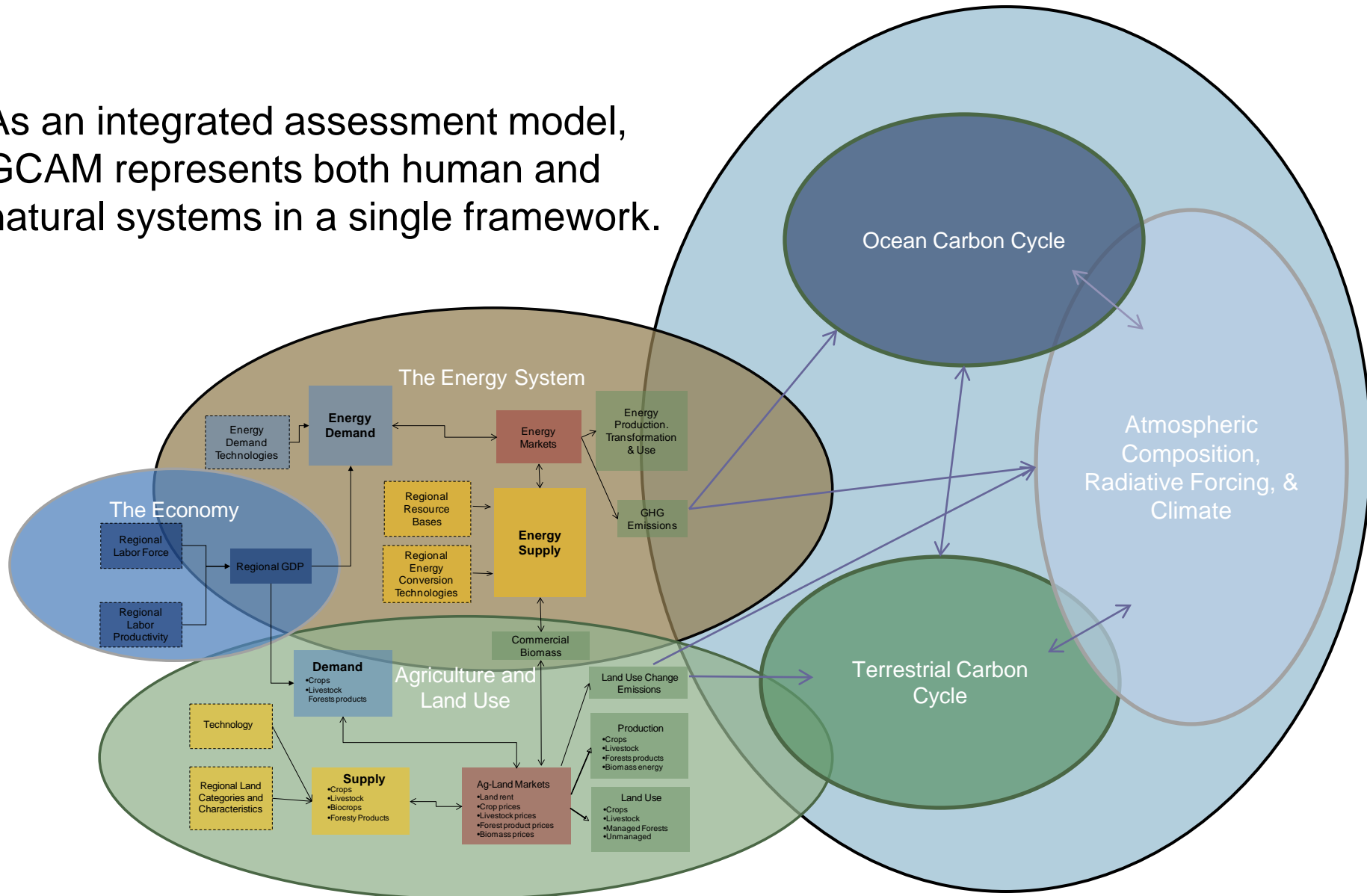


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GCAM is an Integrated Assessment Model

As an integrated assessment model, GCAM represents both human and natural systems in a single framework.



GCAM is among the most prominent and sophisticated integrated assessment models

- ▶ One of four models chosen to create the representative concentration pathways for the IPCC's AR5
- ▶ One of three models used to create scenarios for the CCSP's scenario analysis.
- ▶ A prominent tool for analysis in the Climate Change Technology Program.
- ▶ Participated in virtually every major climate/energy/economics assessment over the last 20 years:
 - Every EMF study on climate
 - Every IPCC assessment that used IA models
- ▶ Used for strategic planning by energy and other private companies.
- ▶ Now used by research institutions and governments internationally.



More Details on GCAM

- ▶ Human decisions are modeled using basic economic principles.
 - GCAM is an economic equilibrium model. GCAM finds a vector of prices so that supplies and demands are in balance in all markets.
 - GCAM does not simulate the entire economy. It simulates those parts that are directly connected to the energy system, including agriculture and land use.
 - GCAM is a long-term model. GCAM makes no attempt to simulate short-term phenomena, such as business cycles.
 - GCAM is a dynamic-recursive model. GCAM does not seek to optimize solutions over the entire span of the simulation – i.e. it does not have “perfect foresight.”
- ▶ GCAM has used MAGICC as a convenient reduced-form model to represent the physical climate
 - As a more sophisticated experiment, we are developing an iESM with LBL, ORNL, UMD.
 - We are also constructing a new, reduced-form model to represent these processes.
- ▶ GCAM is written in C++.
 - It includes over 100,000 lines of code
- ▶ Running GCAM requires xml input files, an executable, and a range of library files.
- ▶ GCAM output is captured in an XML database. This data can be viewed by multiple methods, including
 - Direct viewing in the dataviewer, and
 - Output to CSV files and hence to Excel.



Moving to a community framework is an exciting step forward for GCAM.

- ▶ We have discussed the evolution of GCAM as a community model for some time
- ▶ DOE SC has also encouraged us to make this step
- ▶ We did a fair amount of research on other modeling communities and the benefits and costs of community approach
- ▶ Concluded that for us, the benefits of a community approach are worth it.
 - A broader community means more feedback on the model.
 - A broader community means more high-quality researchers that can be part of the GCAM development in the long-run.
 - A broader community means a **better model and better research**
- ▶ This is a new step for the integrated assessment community.

What's the long-term vision for a GCAM modeling community?

- ▶ A community of researchers that
 - Uses GCAM;
 - Tailors GCAM to their own research needs;
 - Communicates regularly;
 - Identifies key areas for GCAM development;
 - Contributes to GCAM's development.
- ▶ The community should include forums for interactions, including
 - Annual meetings;
 - Web-based tools for interaction.
- ▶ PNNL will remain at the center of GCAM management and development.

Evolution of GCAM as a
Community Model



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GCAM has a formal development structure.

- ▶ There is a continually evolving core version of GCAM. This version consists of
 - xml input files and configuration files
 - the C++ code
 - the queries that accompany the GUI for data access and viewing.
- ▶ Versions of the GCAM core model are tagged with two identifiers:
 - The overall version of GCAM (i.e., GCAM 1.1);
 - The precise revision number in the code and data repository (e.g., rev.3720).
- ▶ Changes to the core model must go through formal process:
 - The management of GCAM is conducted by the GCAM Core Model Committee at JGCRI.
 - Proposals are sent to the committee, which meets regularly to approve proposals, decline proposals, or request changes.
- ▶ Individual researchers within and without PNNL are welcome to make any changes they like for their own research interests.
 - However, any revised version must be identified not as GCAM but as GCAM-xxxx. For example, the GCAM version that has been customized to India is referred to as GCAM-IIM (for India Institute of Management)



Who is part of the GCAM Community?

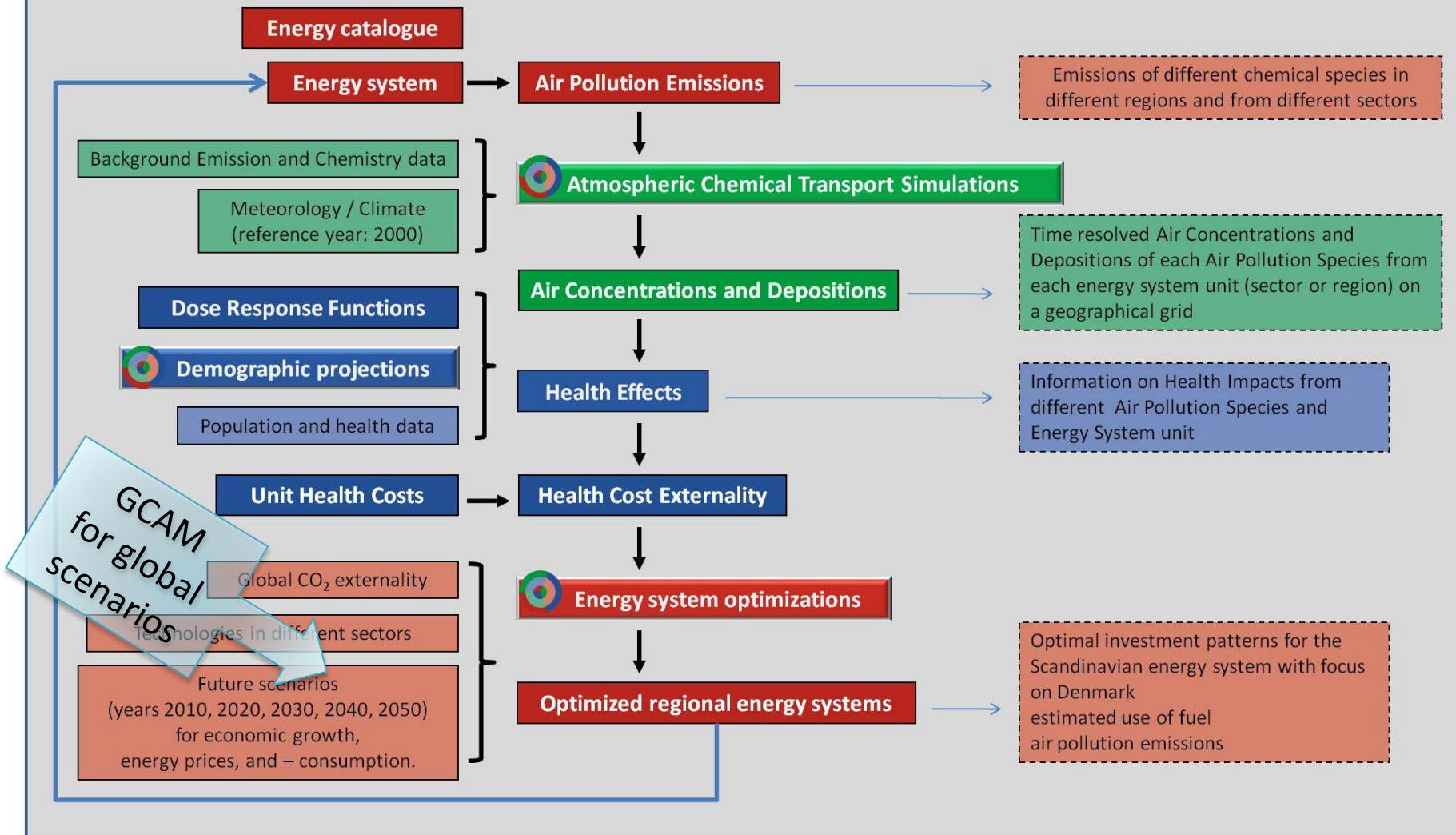
- ▶ Since March of 2010, we have distributed GCAM to over 70 individuals.
- ▶ The individuals come from around the globe: China, India, Norway, Sweden, Australia, the United Kingdom, Korea, Singapore, Spain, Canada, and the United States.
- ▶ Consistent with the integrated assessment framework, users are focusing on both human and natural system applications.



Center for Energy, Environment, and Health, Copenhagen, Denmark

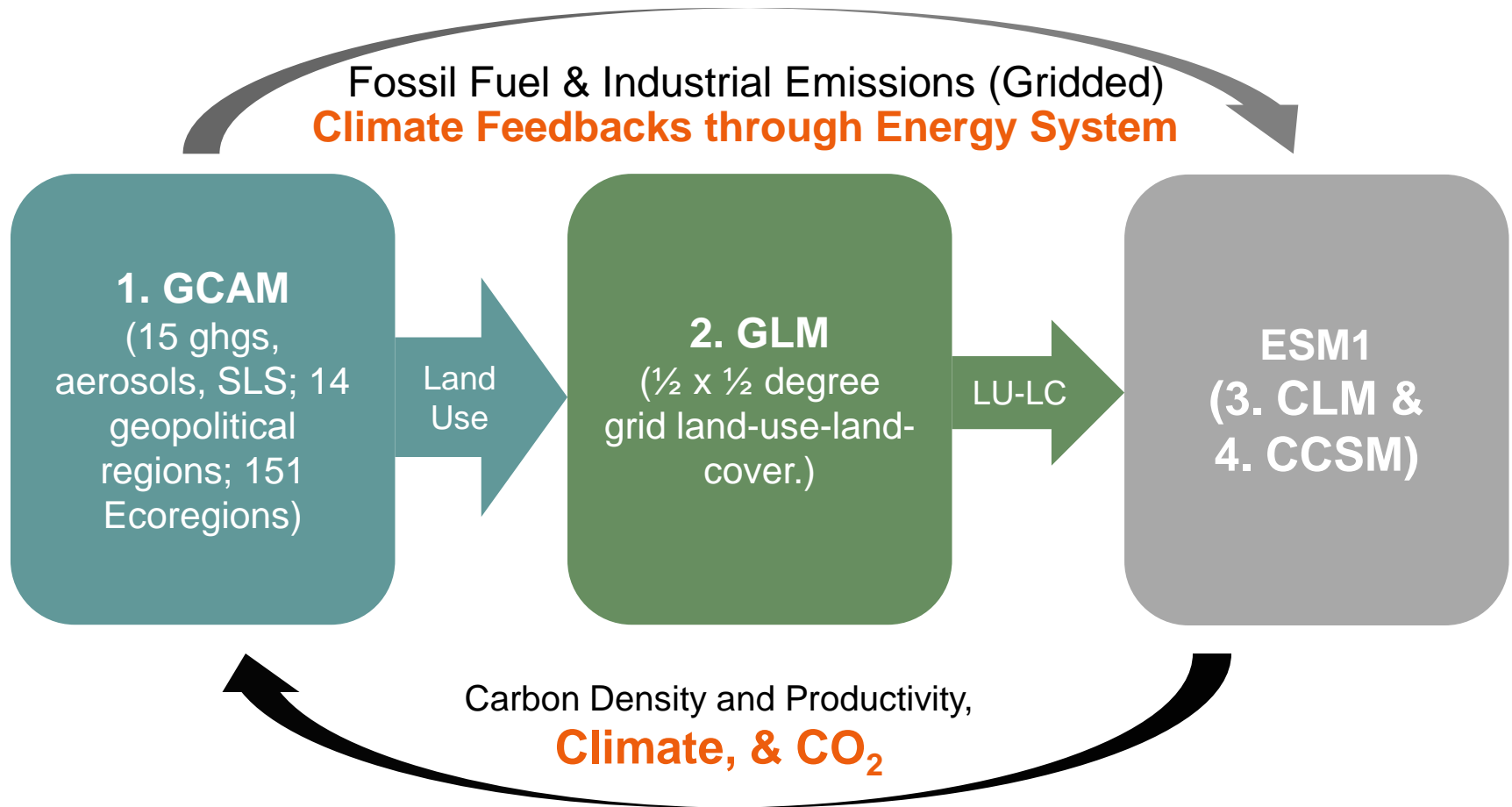


The CEEH model pathway for Health Impact Assessment in Energy System Optimization. The boxes with white text indicate work done in CEEH. The boxes marked with a button icon indicate model tools that must run in each simulation. Results are listed in the right boxes.



The iESM Project is linking four modeling systems: GCAM, GLM, CLM, and CCSM.

Collaborating institutions are PNNL, ORNL, and LBNL



Modifications have been made to GCAM to allow it to be integrated with the other modeling platforms.

Integrated analysis of forests and air quality



YALE UNIVERSITY
School of Forestry
& Environmental Studies
environment.yale.edu

Submitted Proposal

Lead: Nadine Unger (Yale)

Interactions between forest growth, aerosols, and tropospheric ozone have the potential to alter projections of carbon storage and radiative forcing through short-lived climate forcers (SLCFs).

The proposed project will use an enhanced earth systems model, together with GCAM, to examine vegetation-chemistry-climate feedbacks, including chemical, biophysical, and carbon cycle interactions.

Questions to be addressed include:

- ⦿ How do forests affect climate and air quality?
- ⦿ What are the biogeochemical, biophysical, and carbon cycle effects of tropical, boreal, and temperate reforestation and avoided deforestation ?
- ⦿ How to maximize benefits to climate and air quality?

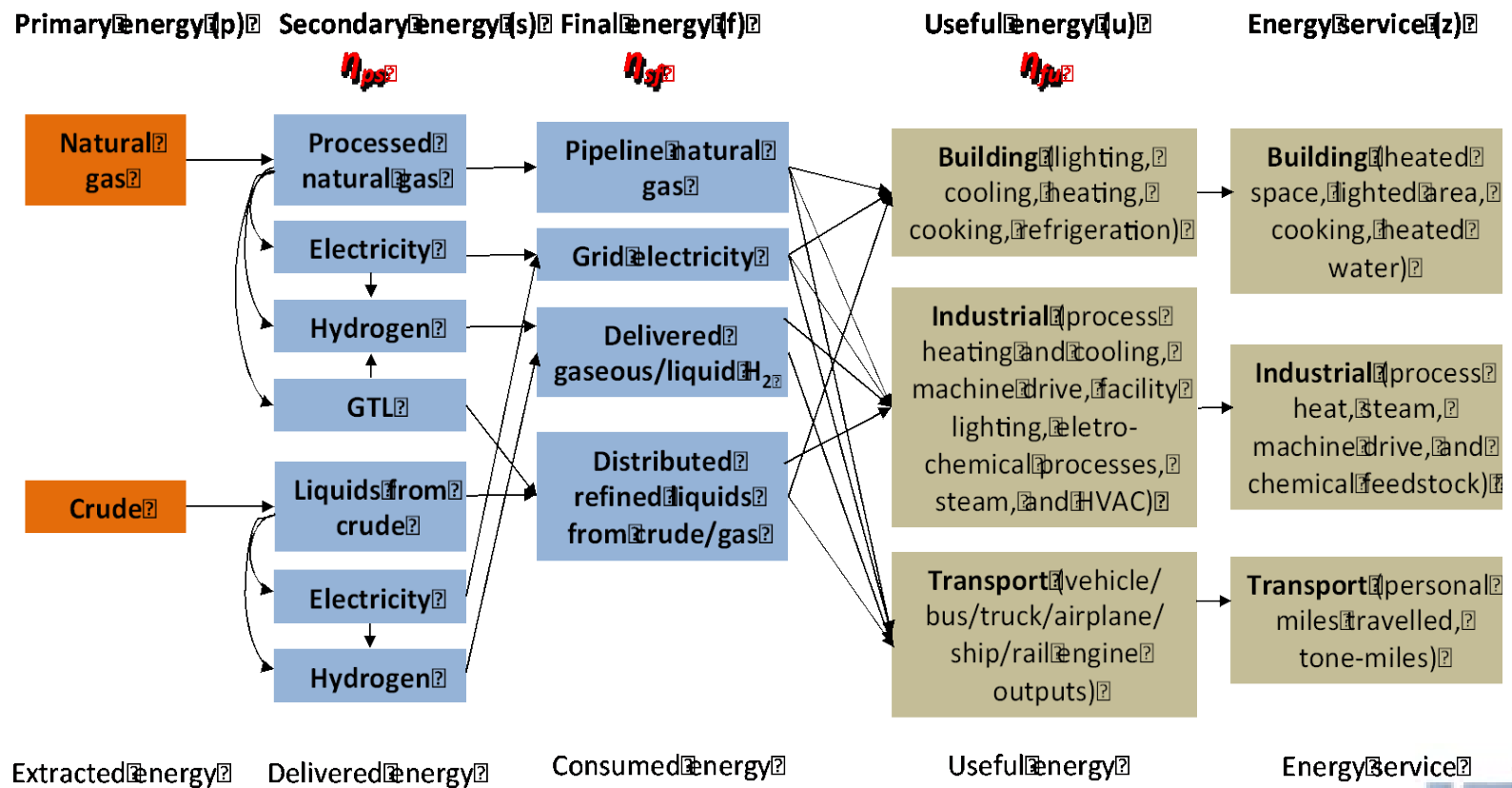


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Economy-wide Lifecycle Efficiencies of Petroleum and Natural Gas

- Characterize economy-wide lifecycle efficiencies by fuel pathway and their changes over time and by scenario



Economy-wide Lifecycle Efficiencies of Petroleum and Natural Gas

Modified Transport Module

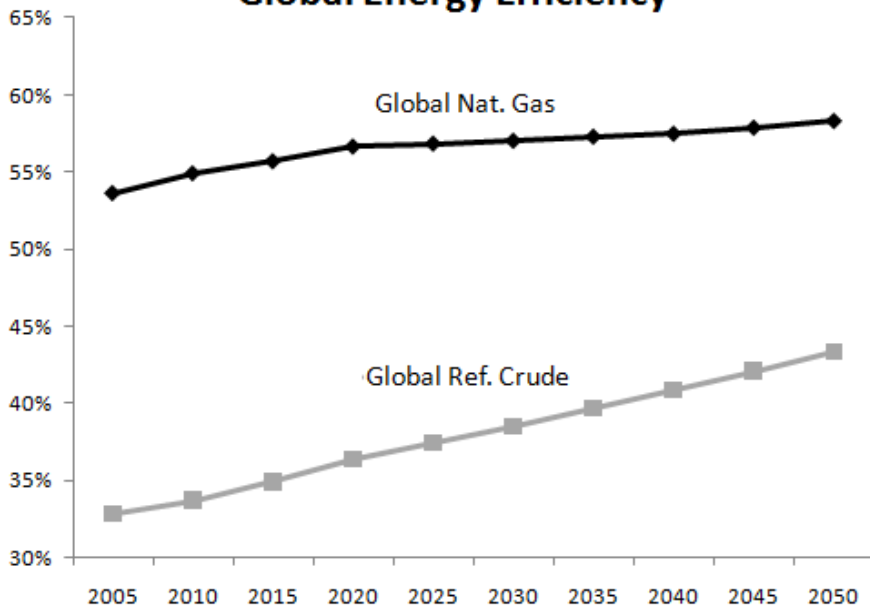
Update

- Transport technology energy intensities
- Load Factors; average speeds; income/price elasticities
- Value-of-time (VOT) multiplier

New

- New modes: 2- and 3-wheelers in India/China;
- Passenger air: domestic vs. freight

Global Energy Efficiency



Energy pathway (primary → secondary → final → useful)					Efficiency
1	Oil	→ Liquids from crude	→ LDV		= 14.0%
		100%		14%	
2	Oil	→ Liquids from crude	→ Electricity	→ LDV	= 15.0%
		100%	44%	34%	
3	Oil	→ Liquids from crude	→ Electricity	→ H ₂ → LDV	= 6.8%
		100%	44%	67% 23%	
4	Natural gas	→ Processed natural gas	→ Electricity	→ LDV	= 19.7%
		100%	58%	34%	
5	Natural gas	→ Processed natural gas	→ H ₂	→ LDV	= 17.5%
		100%	76%	23%	
6	Natural gas	→ Processed natural gas	→ Liquid	→ LV	= 8.7%
		100%	62%	14%	
7	Natural gas	→ Processed natural gas	→ Electricity	→ H ₂ → LDV	= 8.9%
		100%	58%	67% 23%	

Long term evolution of building energy services and fuel choices in India



- More than 45% of total final energy in India consumed in the residential and commercial building sector (WEO 2007), understanding long term evolution critically important.

- Significant difference in rural and urban energy consumption profiles.

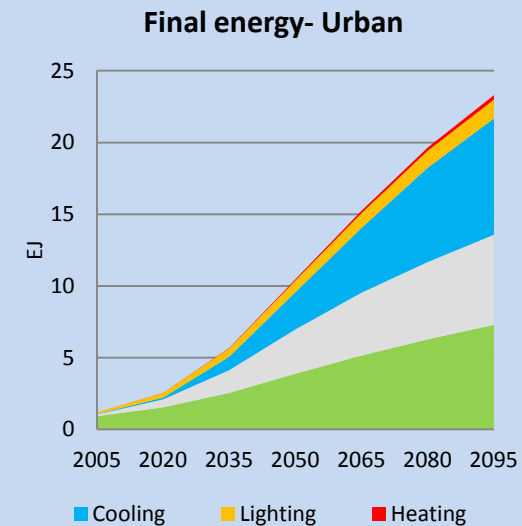
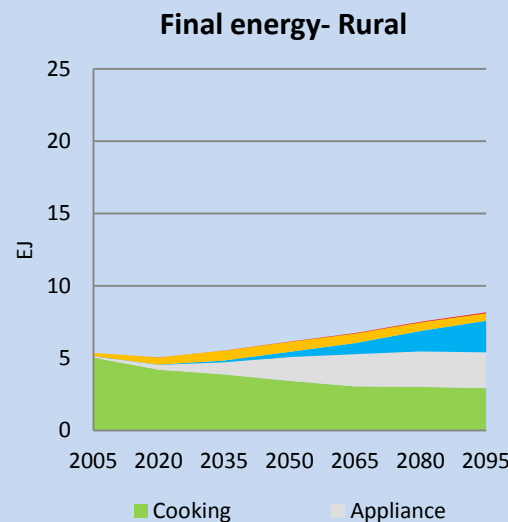
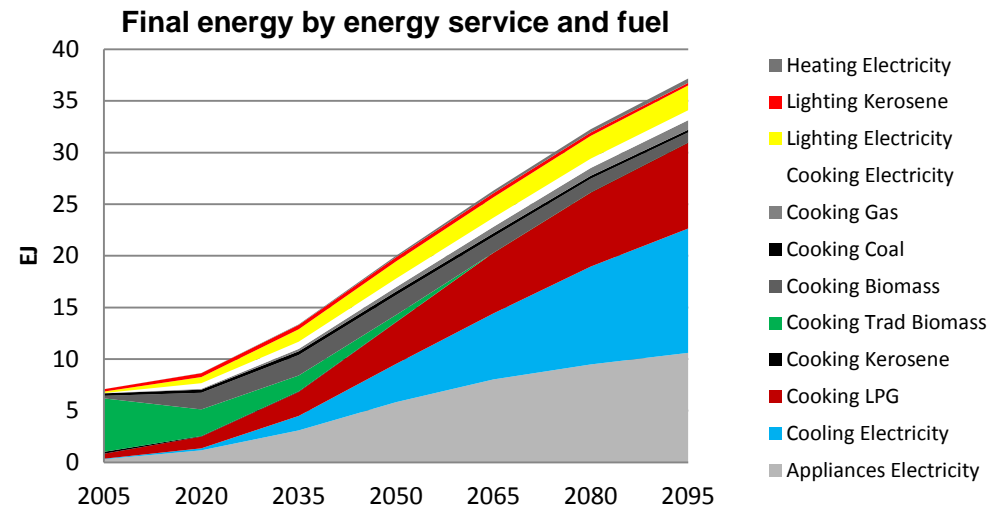
RESULTS

- Cooling energy service and appliances/ equipment energy demand to increase rapidly, especially in urban residential sector. Cooking service will also take a high share.

- High reliance on electricity (for cooling, heating and appliances), and gas (particularly LPG, and some NG in urban areas) for meeting cooking energy needs. Limited fuel substitution opportunity exists.

- Low impact of climate policy on reducing final energy demand, as fuel choices limited in Indian building sector unlike other regions of the world.

- Alternative energy demand reduction policies needed to significantly reduce demand.



Moving Forward

▶ Status of GCAM as a Community Model

- We held our first meeting of the GCAM Modeling Community in September, 2010.
- We have continued to distribute the model to a range of users nationally and internationally.
- We have implemented a listserve as a means both for discussion of issues by the community and to alert the community about changes to the model.
- We will be posting wiki-based documentation on the web shortly.

▶ Moving Forward

- Resolve issues with technical support as the community expands.
- Working with PNNL to allow the use of an open-source license. This will make it easier to distribute the model.
- Development of an enhanced Community Modeling website.
- Next Community Modeling meeting is in November of this year.

