



JOINT GLOBAL CHANGE RESEARCH INSTITUTE

Insights for International Energy-Economy Modeling from The Global Change Analysis Model (GCAM)

June 29, 2022

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The GCAM Core Principle

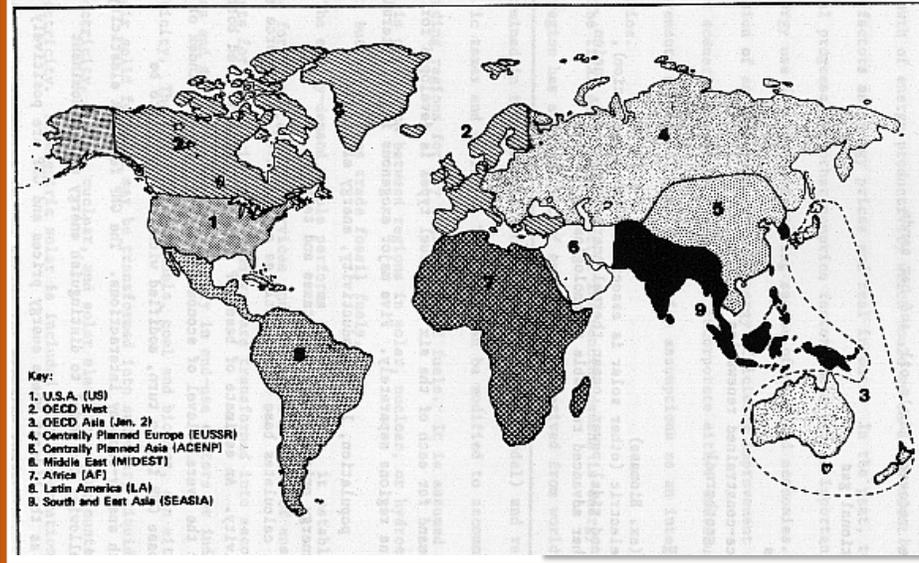
BUILD THE MODEL FROM THE PROBLEM BACK

The original problem, back in 1978, was to explore GLOBAL CO₂ emissions to 2050 as part of DOE's Carbon Cycle Science Program

Inputs

Population
GDP
Technologies
Resources
Policies

GCAM 1978



Outputs

Energy
CO₂
Energy Prices,
Production,
Consumption,
& Trade

The GCAM Core Principle

BUILD THE MODEL FROM THE PROBLEM BACK

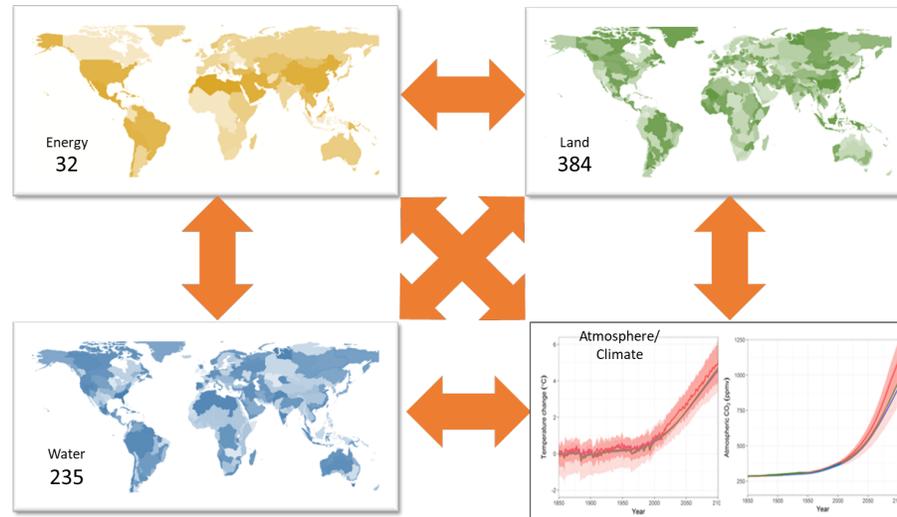
As the climate problem has unfolded, the model has added functionality
agriculture-land-use, water, atmosphere-climate-oceans

Inputs

Population
GDP
Technologies
Resources
Policies

GCAM 6.0

Coupled in Code



Outputs

Energy, Land & Water
Emissions
Prices
Production
Consumption
Trade

Emissions

- CO₂
- CH₄
- N₂O
- F-gases
- SO₂
- BC
- OC
- CO
- NO_x
- NMVOC
- NH₃

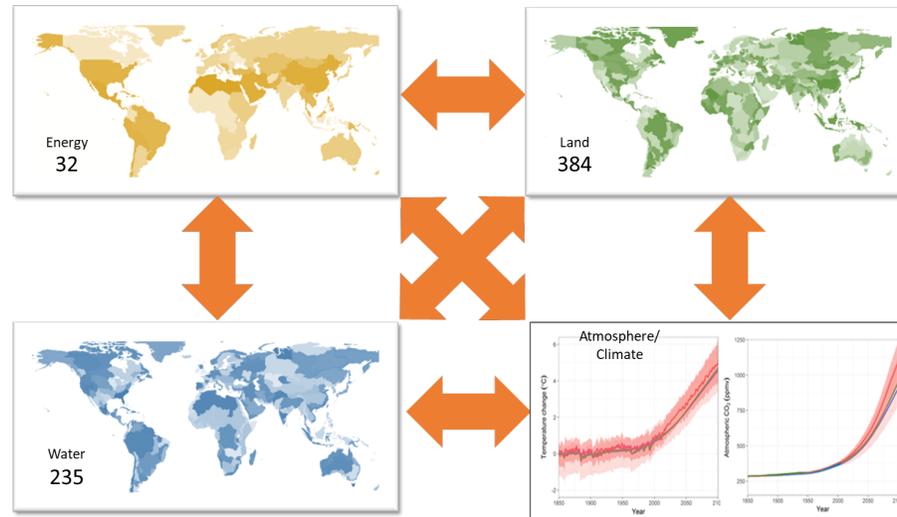
Principle #2: Maintain a clear distinction between what's inside GCAM and what's outside

Inputs

Population
GDP
Technologies
Resources
Policies

GCAM

Coupled in Code



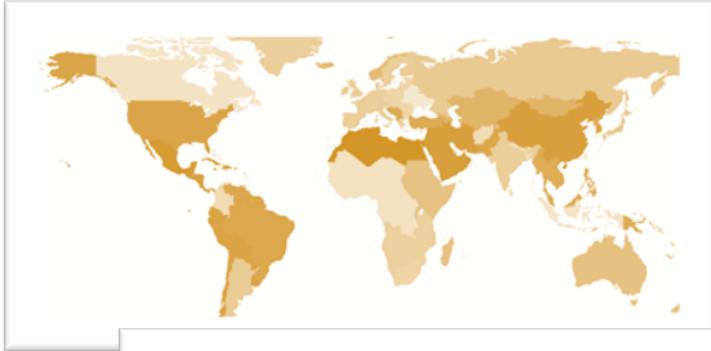
Outputs

Energy, Land & Water
Emissions
Prices
Production
Consumption
Trade

Key Decisions

Model Coverage

32 Energy &
Economy
Regions



384 Land
Regions



235 Water
Basins

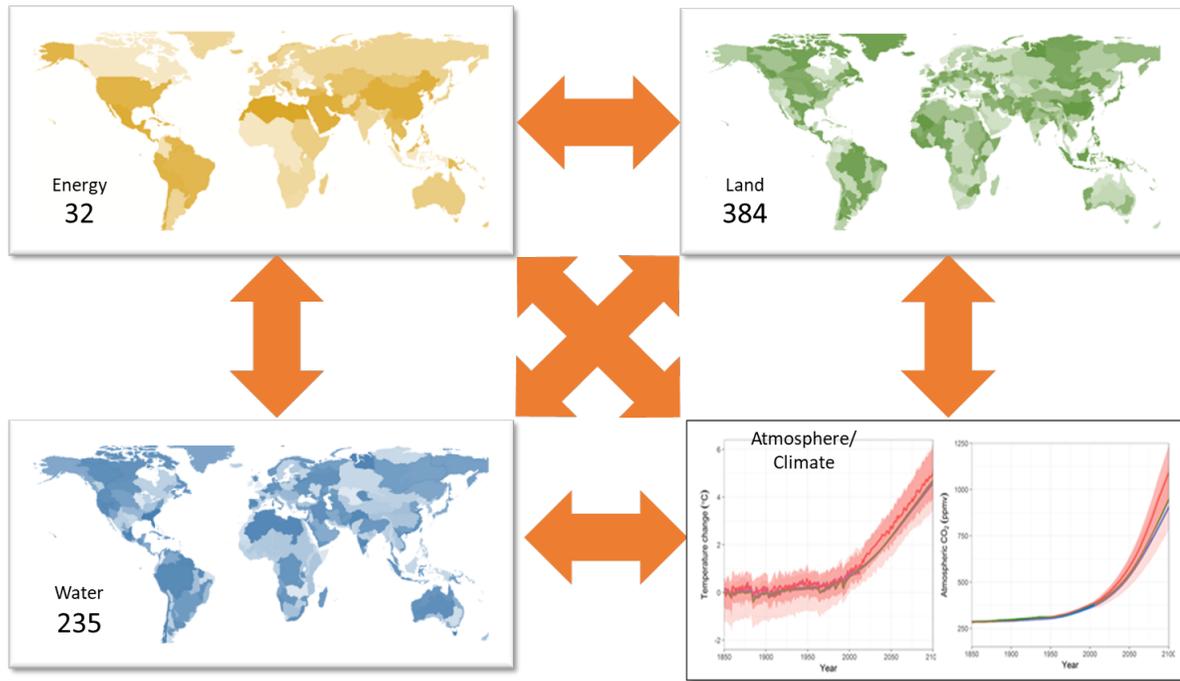


- GCAM is built around an ECONOMIC paradigm
- The main job of the solver is to find a set of prices that simultaneously clear all markets.

Key Decisions

GCAM

Coupled in Code

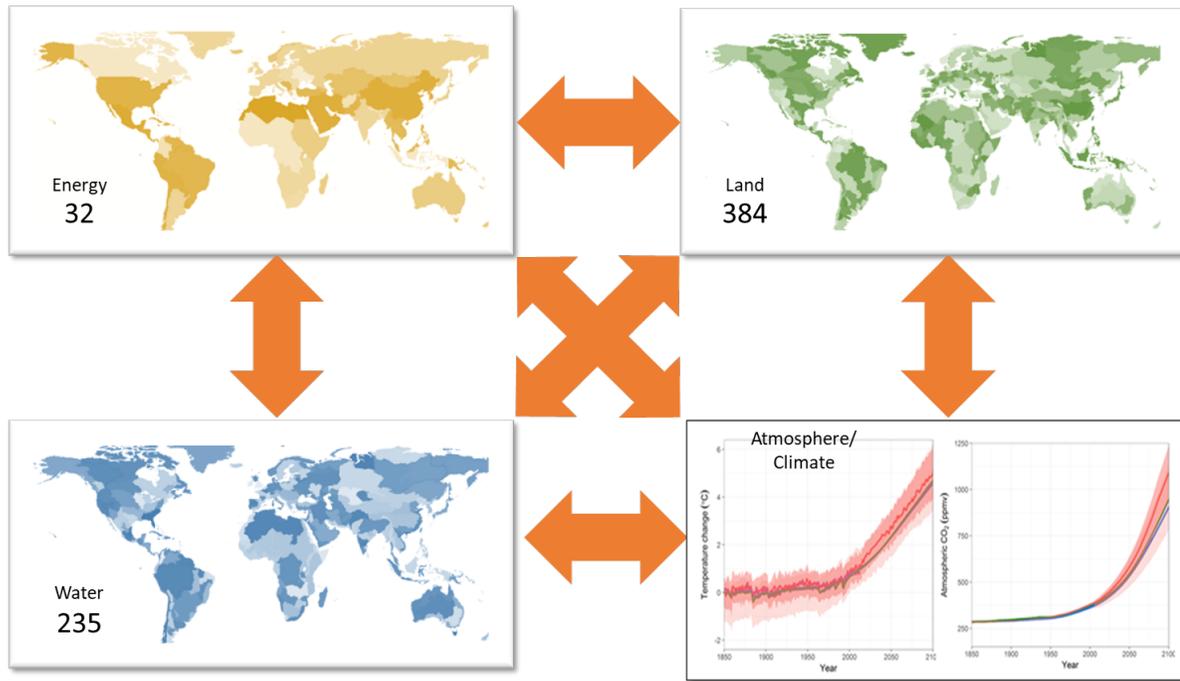


- COUPLE ALL SYSTEMS IN CODE
- Solve ALL SYSTEMS SIMULTANEOUSLY
- energy, economy, agriculture, land-use, water availability and disposition, atmosphere, oceans and climate

Key Decisions

GCAM

Coupled in Code

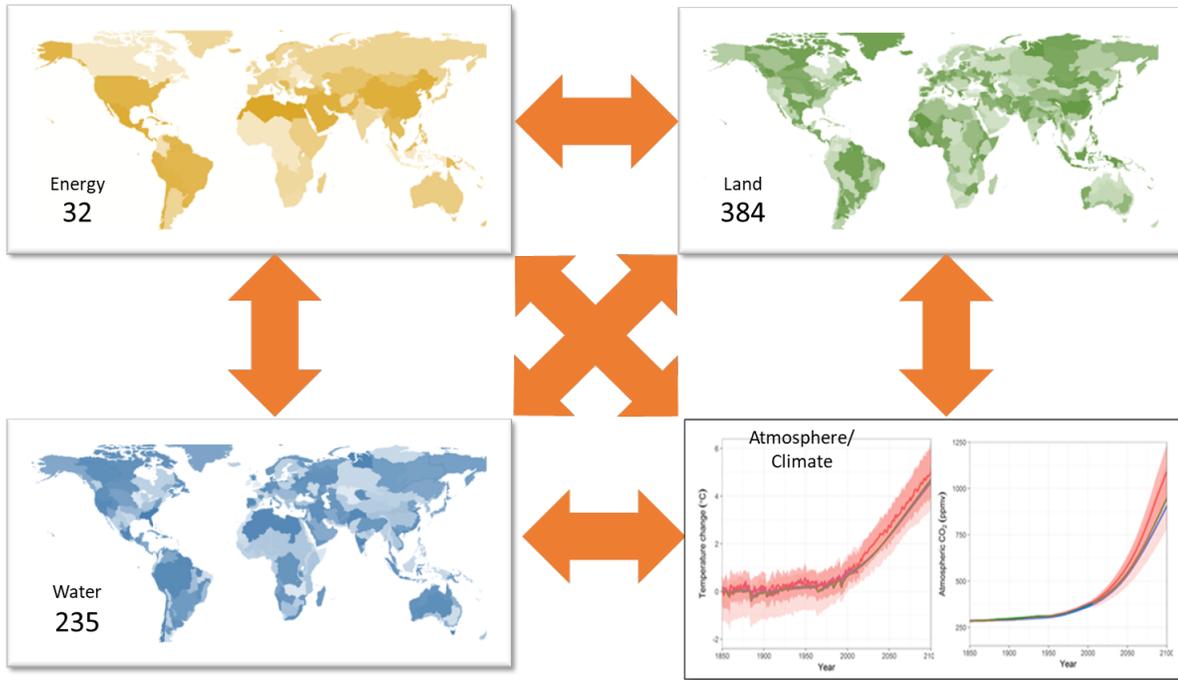


- GCAM is dynamic-recursive.
- It is NOT dynamic-optimization.
- Economic agents in GCAM don't know the world oil price 10-100 years into the future.
- Economic agents in GCAM can make mistakes.

Key Decisions

GCAM

Coupled in Code

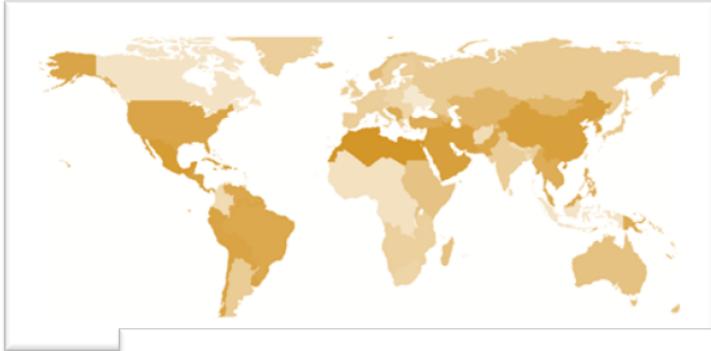


- GCAM is a strategic model
- 2100 time horizon
- 1-5 year time step

Key Decisions

Model Coverage

32 Energy &
Economy
Regions



384 Land
Regions



235 Water
Basins

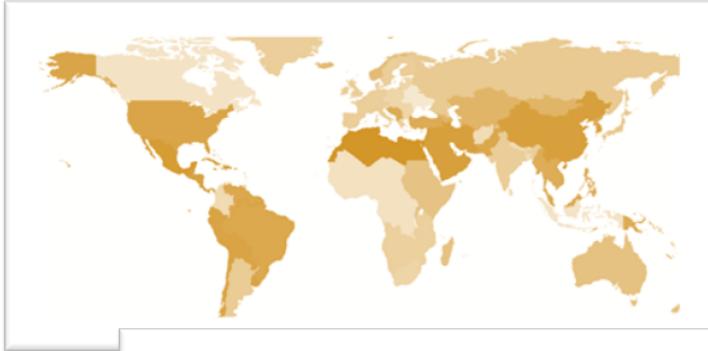


- GCAM is global with regional detail
- The degree of regional detail is expandable and contractable
- Release version of gcam
 - 32 energy-economy regions
 - 384 land units
 - 235 water basins

Key Decisions

Model Coverage

32 Energy &
Economy
Regions



384 Land
Regions

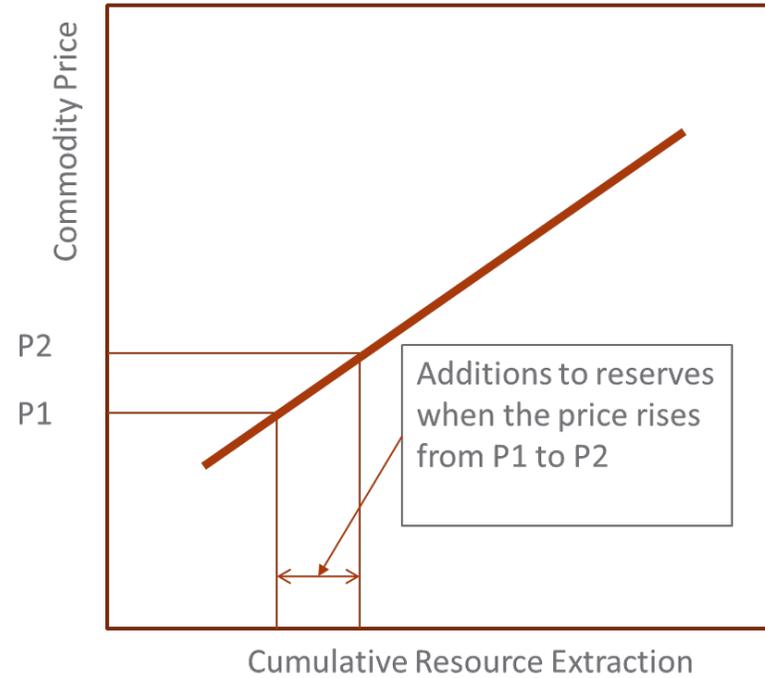


235 Water
Basins

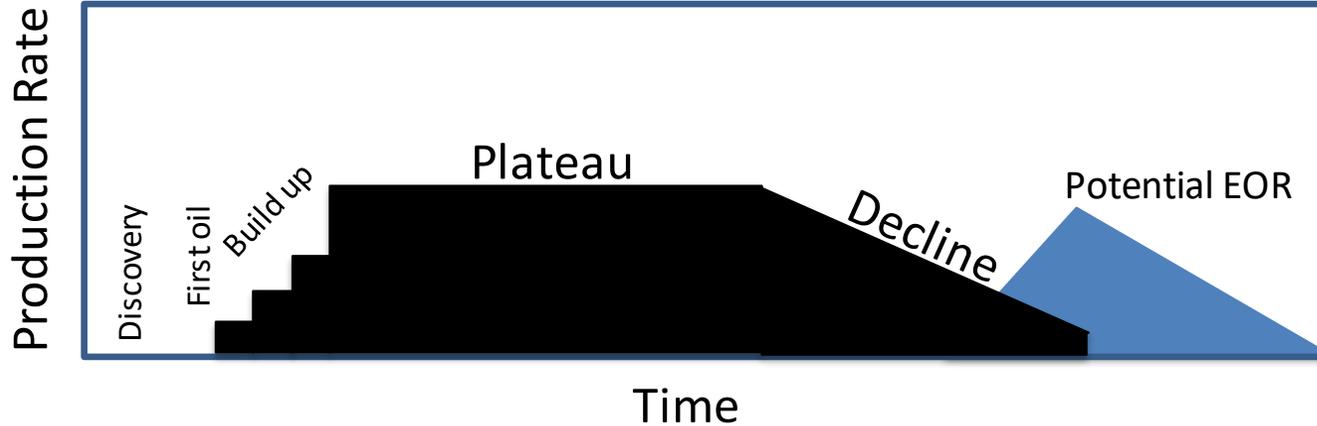


- Community Model
- <https://github.com/JGCRI/gcam-core/releases>
- Open-source code
- Open data
- Open documentation
- All experiments are reproducible—data, code and outputs archived

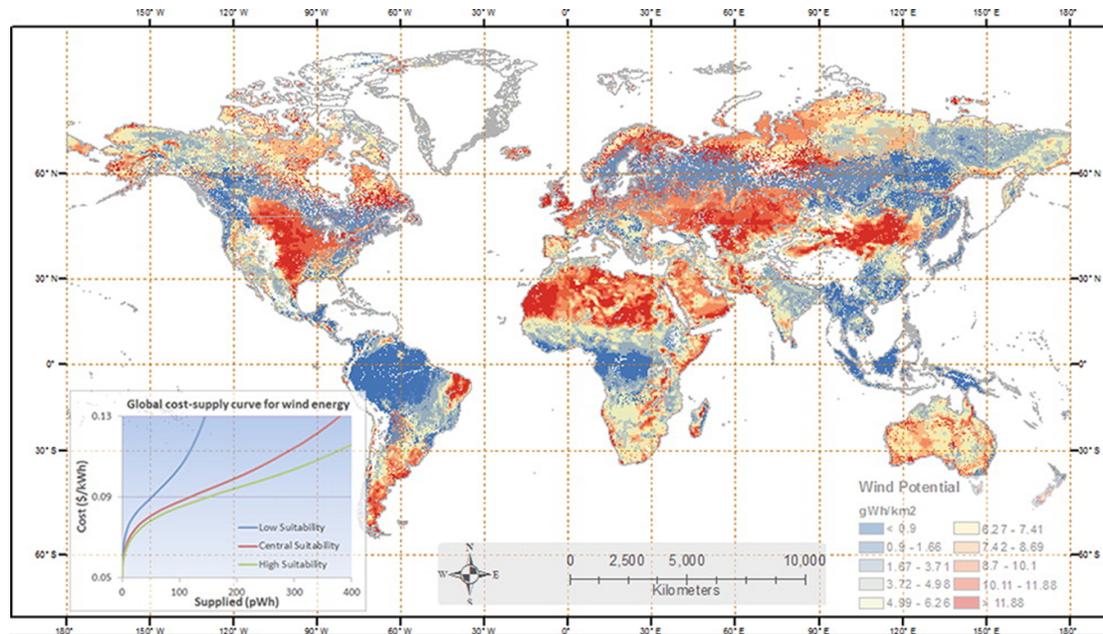
Technology Detail Is Important



- Energy supply



Technology Detail Is Important

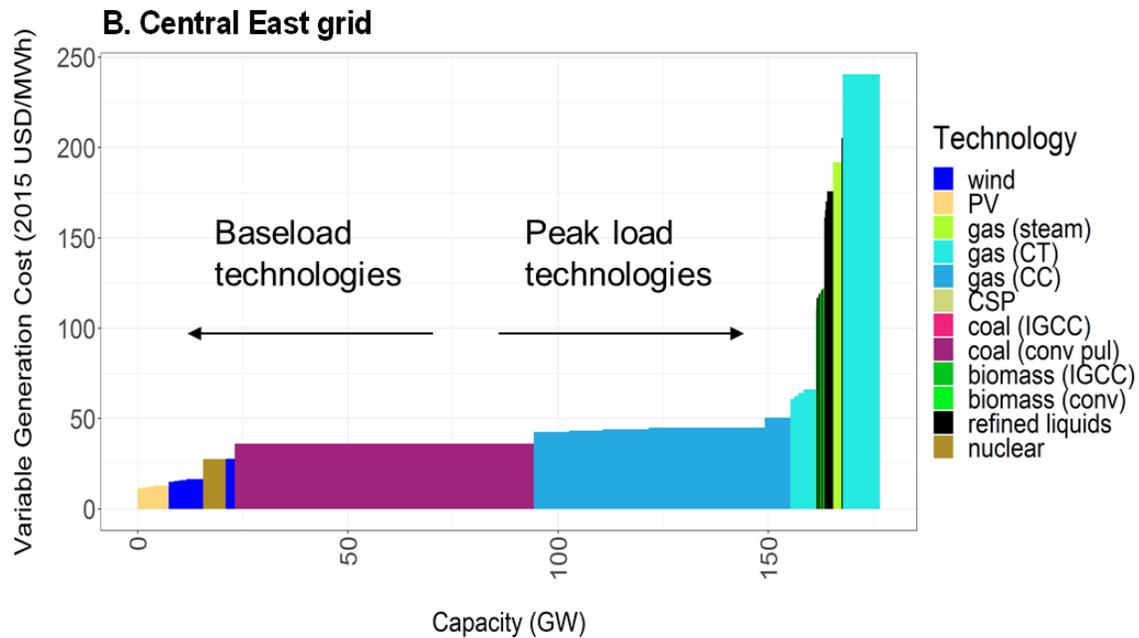


$$Q = \maxSubResource * \frac{pCurveExponent}{(MidPrice^{CurveExponent} + p^{CurveExponent})}$$

- Energy supply

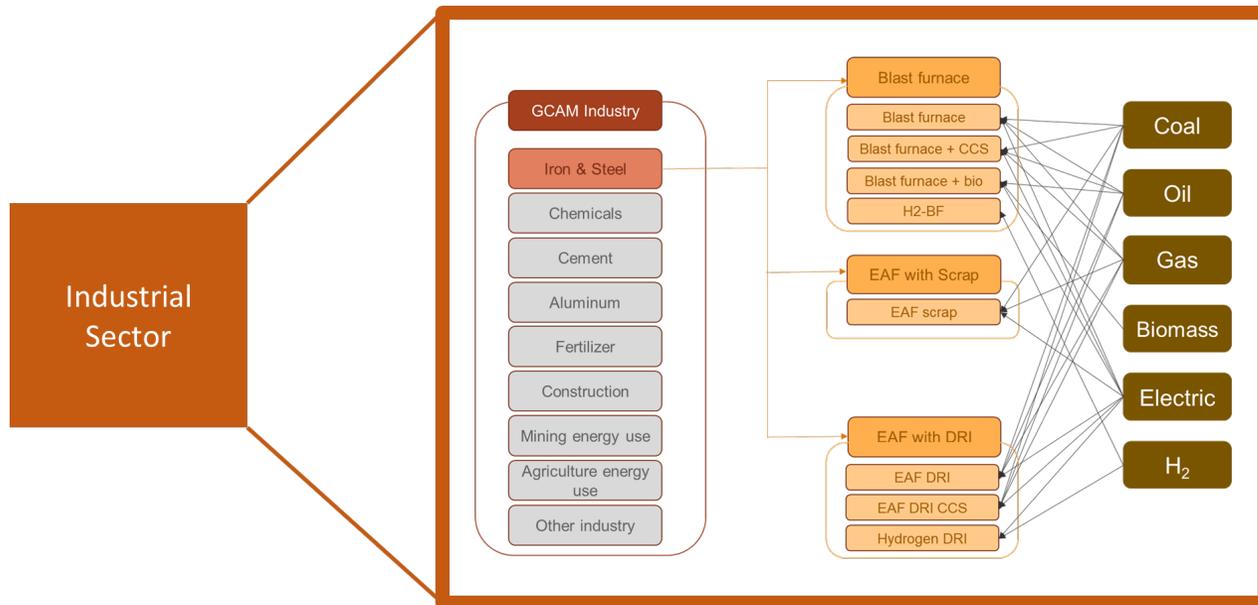
Technology Detail Is Important

Capacity is built to meet peak demands.
Dispatch decisions are based on merit order
(i.e., least to highest variable cost)



- Energy transformation

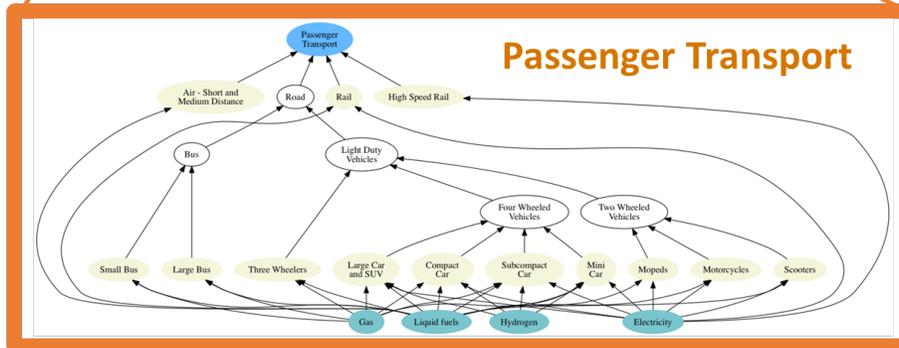
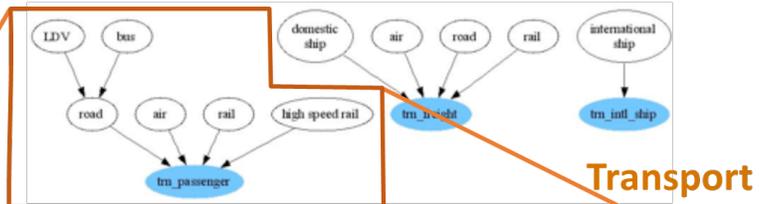
Technology Detail Is Important



- Energy use

Technology Detail Is Important

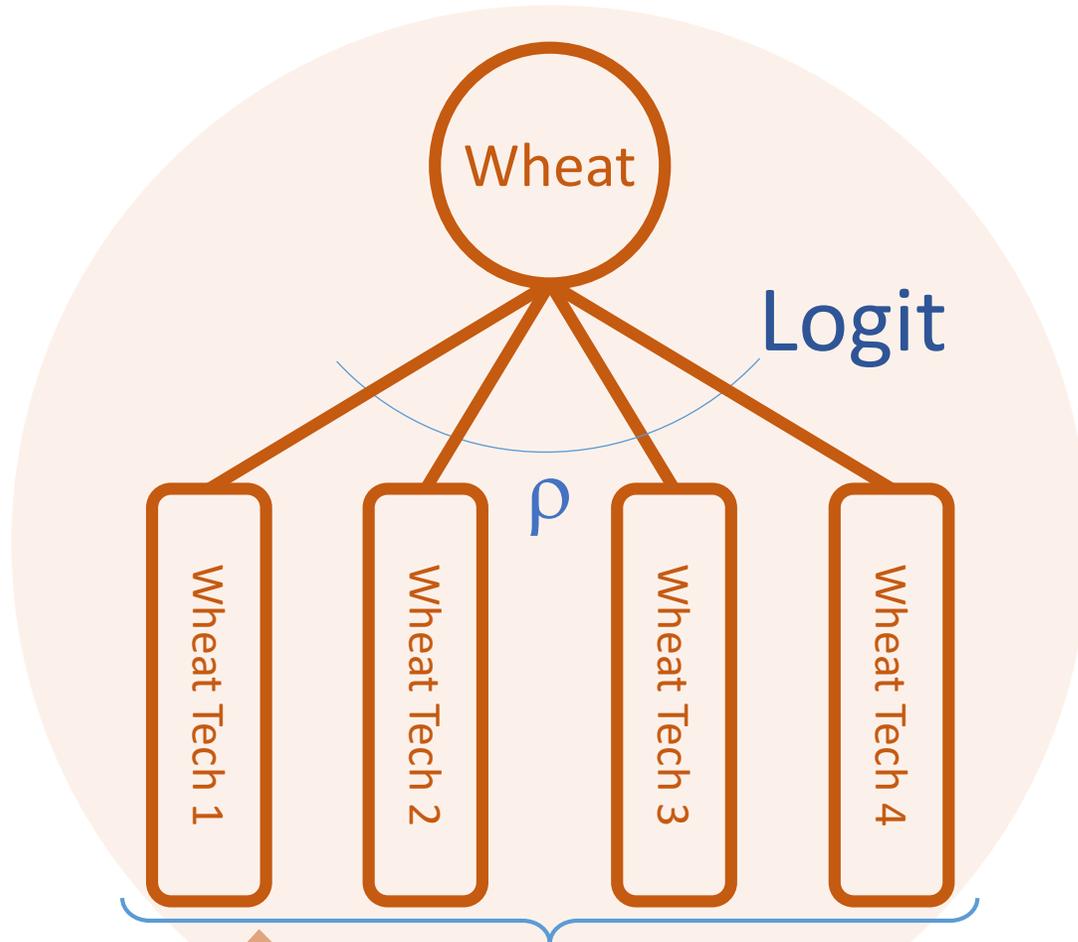
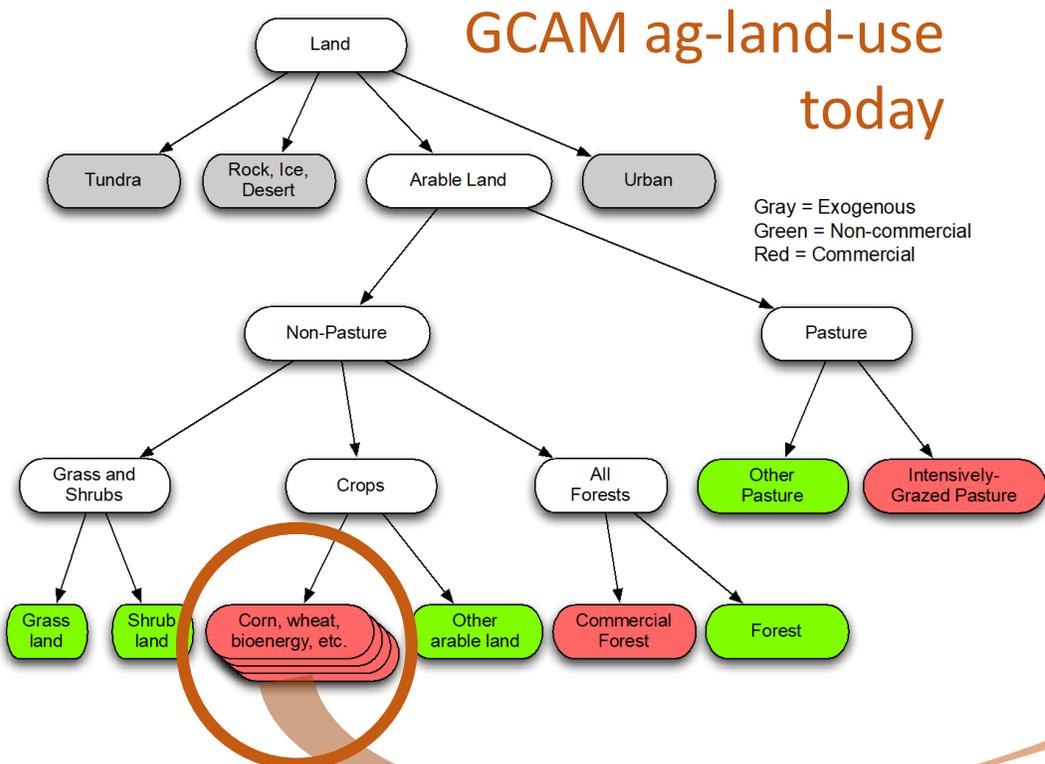
Transportation Sector



- Energy use

Ag Land-Use

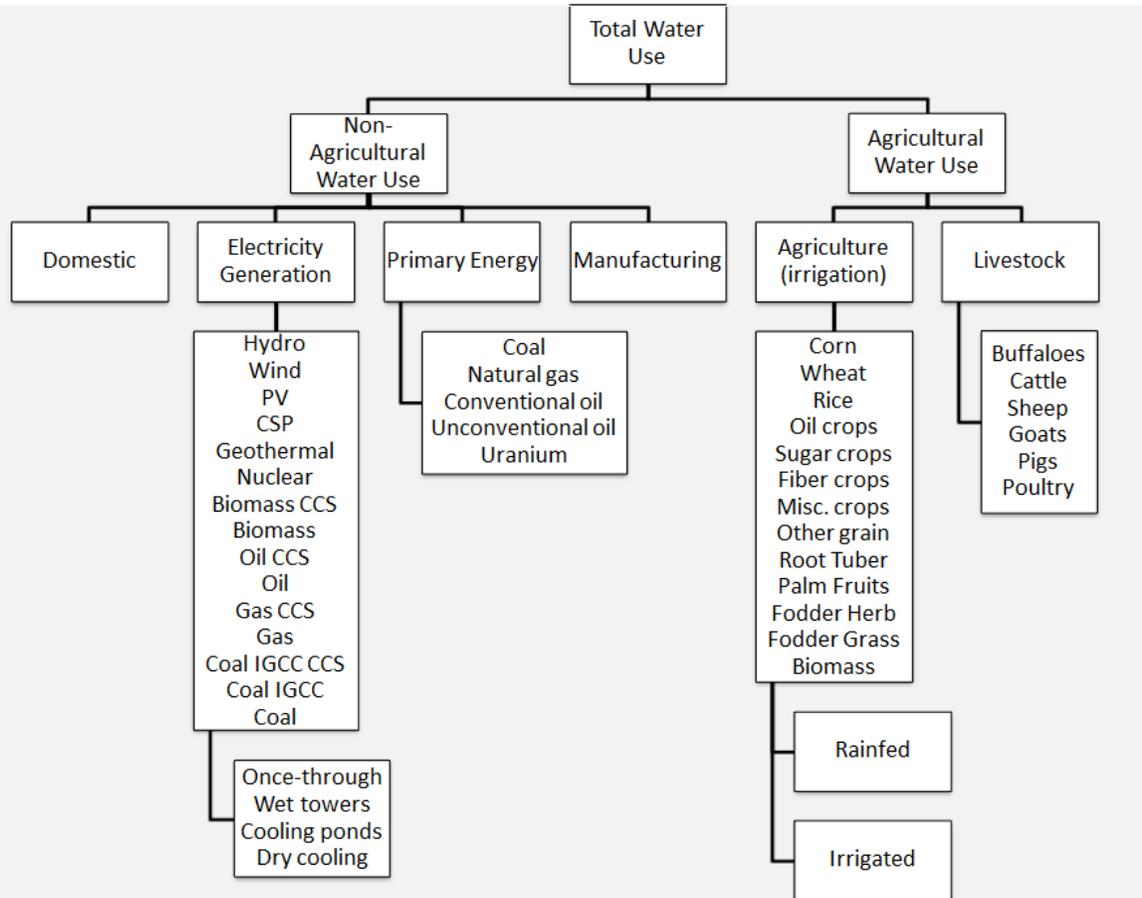
GCAM ag-land-use today



Wheat Tech i | $\Pi_i = (P_{\text{wheat}} - h_i) * g_{\text{wheat},i}$

- Π_i is the expected profit rate for wheat using technology i .
- P_{wheat} is the price per unit of wheat,
- $g_{\text{wheat},i}$ is the yield per ha for wheat using technology i ,
- h_i is the cost of a unit of wheat using technology i

Technology Detail Is Important



- Hydrology

Send questions to Jae@PNNL.gov