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Review of the Global Change Analysis Model

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Page Kyle
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U.S. DEPARTMENT OF ENERGY BATTELLE

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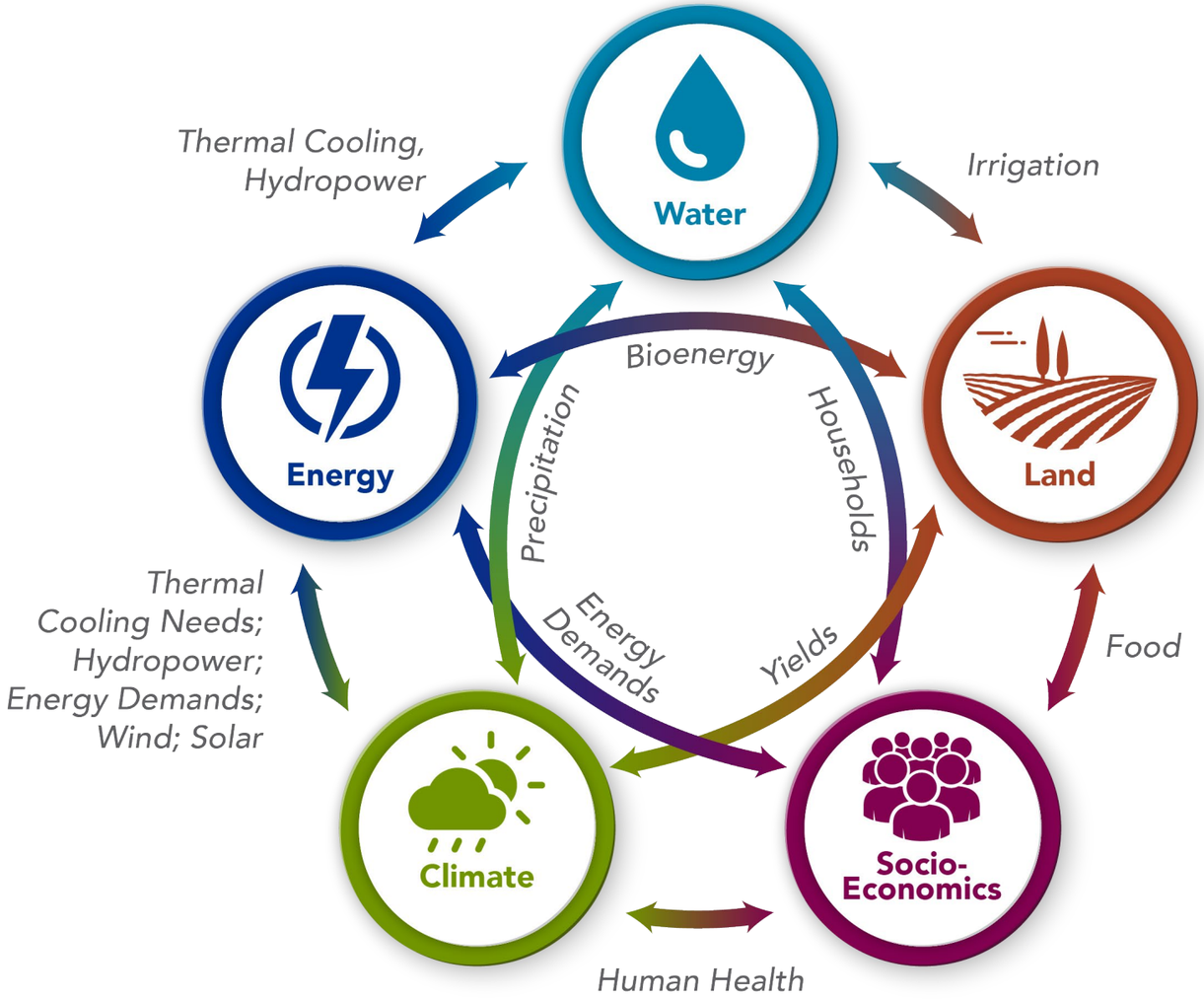
GCAM explores the interactions between multiple systems



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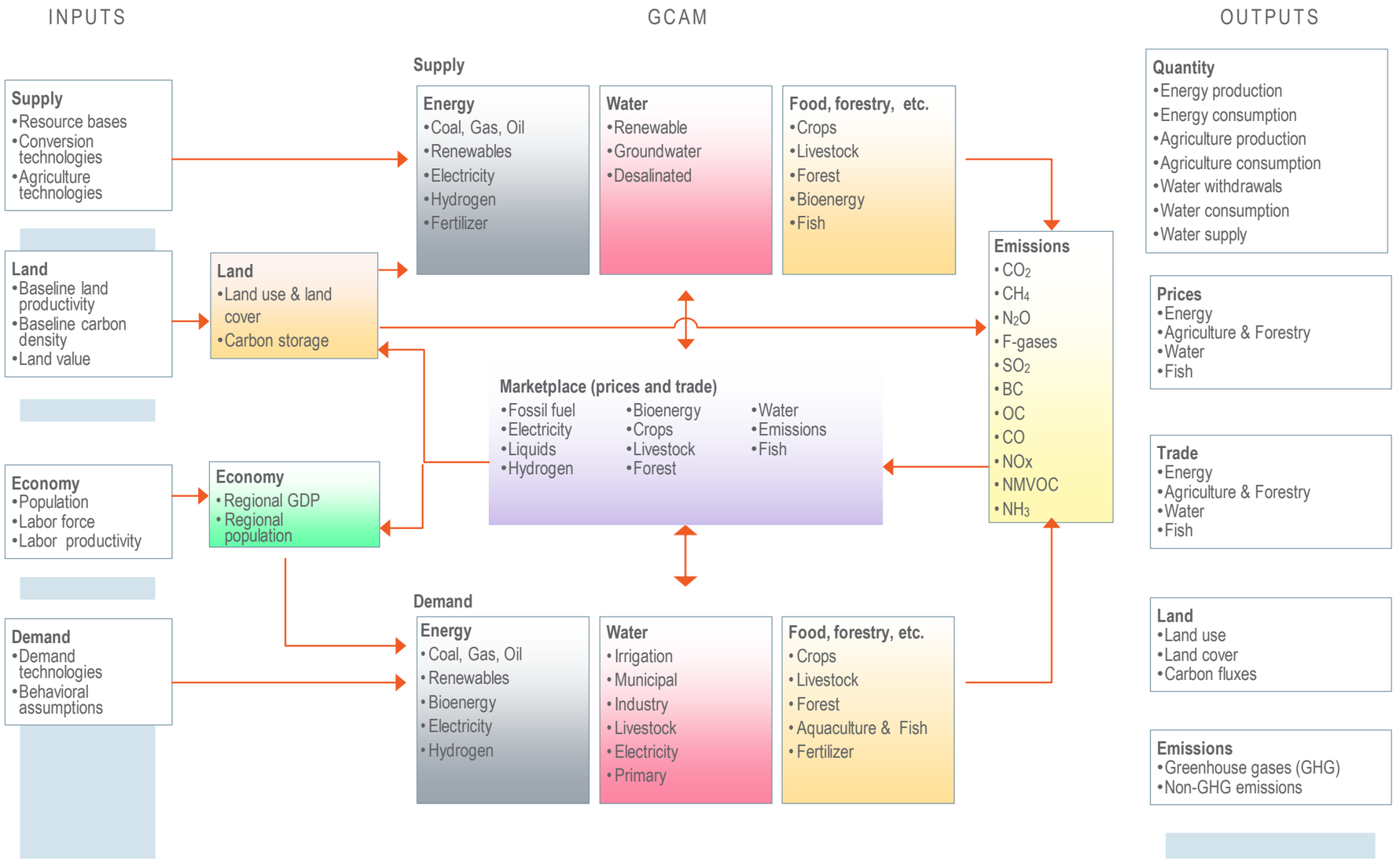


Key Features of GCAM

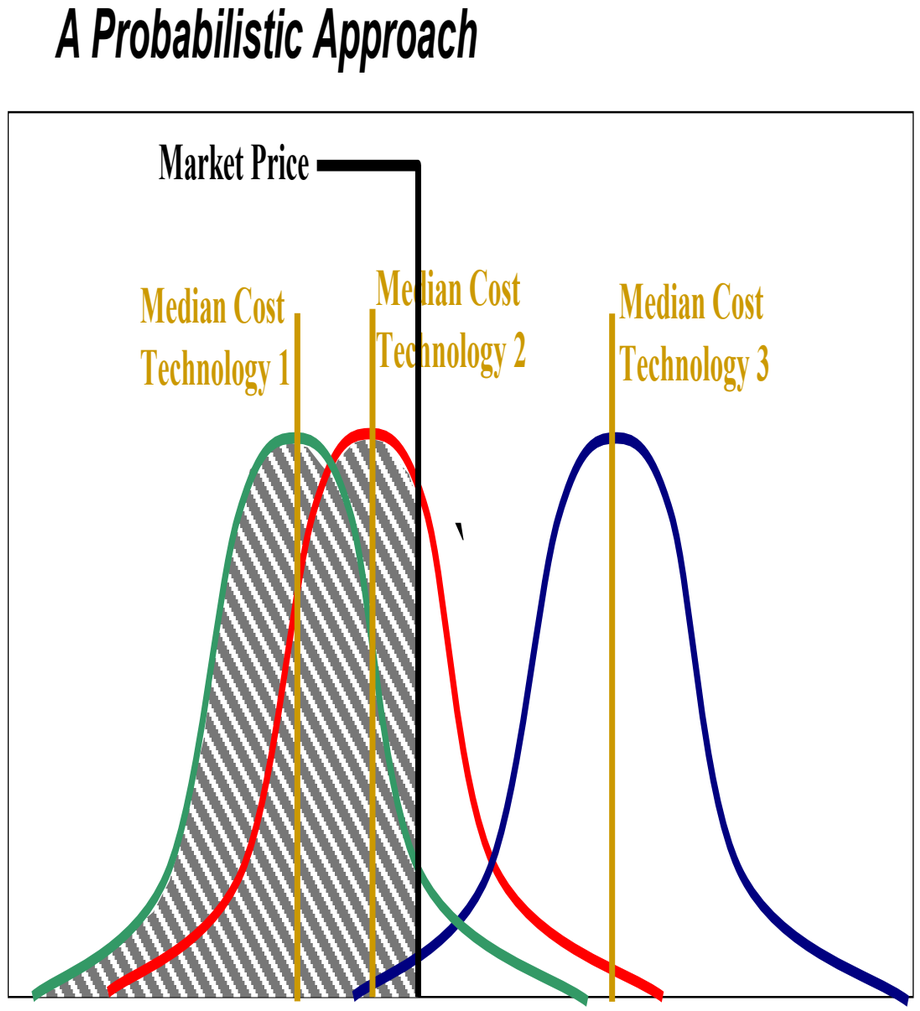
- Full global coverage in 5-year timesteps: 2015 to 2100

- Dynamic-recursive: decisions reflect present/historical knowledge, not future

- Partial equilibrium
  - Population and GDP are exogenous
  - Focal markets include energy and agricultural commodities, emissions, water
  - Final energy demands: buildings, industry, transportation
  - Labor, capital, and most materials markets are implicit

- Relative strengths
  - System interactions
  - Physical-based representations
  - Technology-rich

Logit Choice Mechanism for Decision Making



- Calibrated logit approach assumes a distribution of realized costs due to heterogeneous conditions.
- Market share based on probability that a technology has the least cost for an application.
  - Avoids a “winner take all” result.
- Historical calibration influences future competition through the “share-weight” (α)

$$s_i = \frac{\alpha_i c_i^{\ \sigma}}{\sum_j \alpha_j c_j^{\ \sigma}}$$

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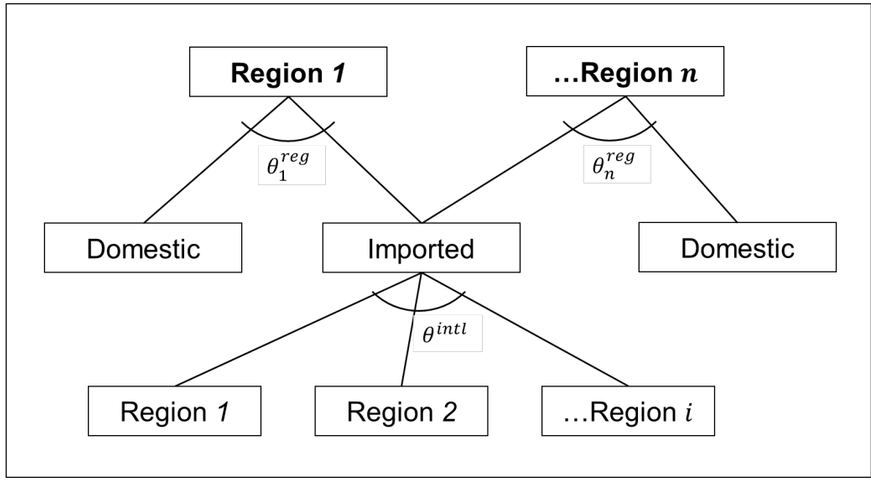
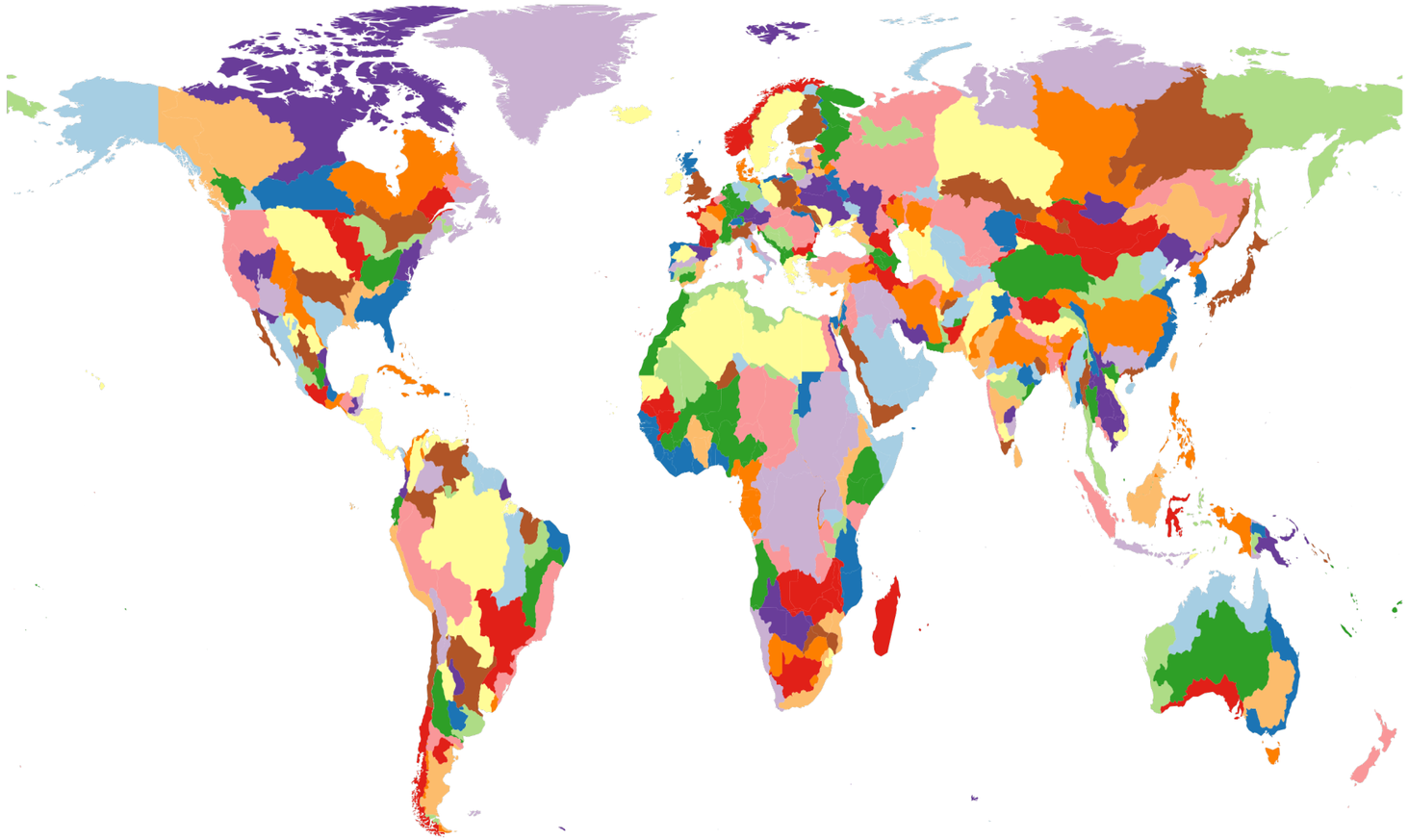
Logit-based Armington Trade

- Instead of CES-Armington trade, we use calibrated logit-based Armington representation:
  - Each region has discrete choice between domestic & imported sourcing of any given commodity
  - Global trade center has discrete choice between different exporting regions
  - Competition based on physical quantities (Mt, not $)
  - In the figure, θ values regulate the competition



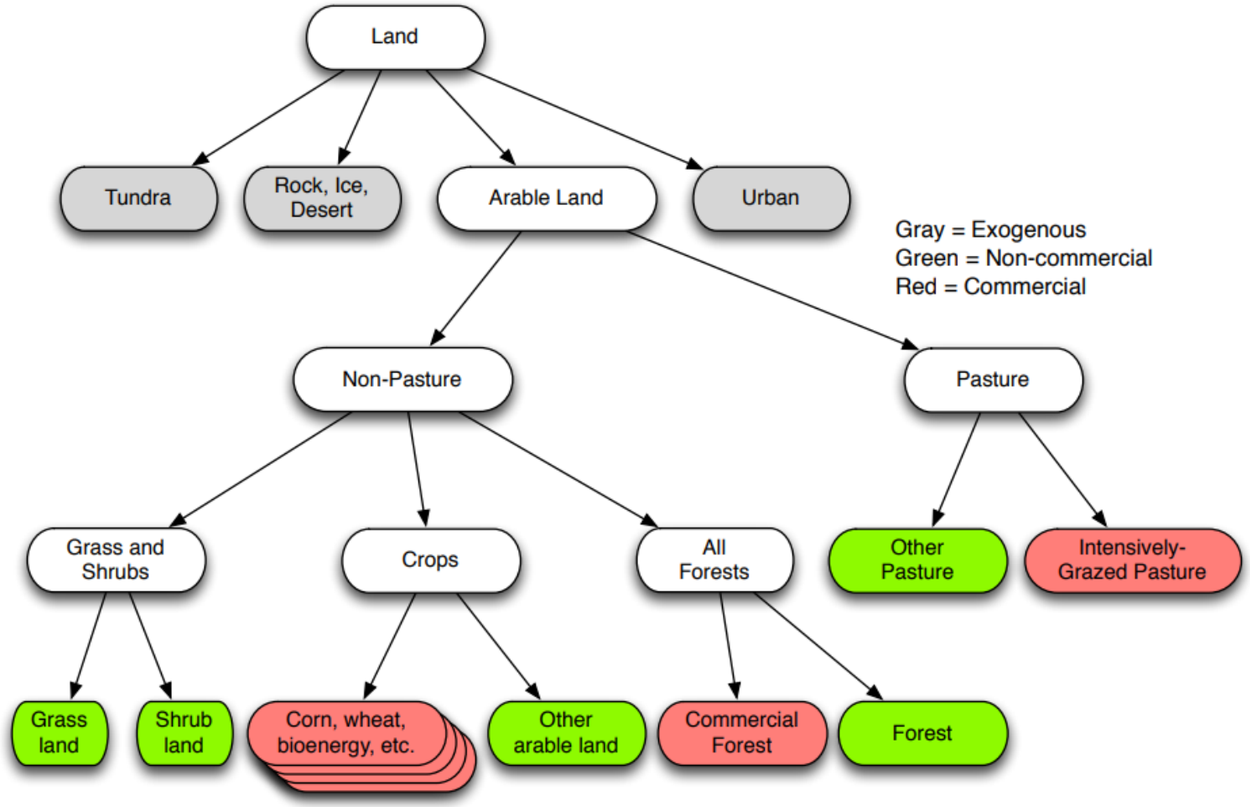
- Nested structure
  - Aggregated international trade center
  - Gross trade flows are represented

Land Use Regions



- 384 land use regions, formed by the intersection of 32 geopolitical regions and 235 global water basins

Land Allocation



- Nested competition for allocation of land to different uses
- Crop production: additional levels for irrigated/rainfed, low/high fertilizer application rates

Land Use and Land Use Change

- The world is divided into **384** regions, each of which independently allocates land to a number of potential modeled uses
  - The profit-rate ($/m2/yr) of each potential land use is estimated
  - Non-commercial land profit-rates are imputed
  - Future allocation is driven by base-year allocation, and relative profitability over time
- Terrestrial carbon is explicitly tracked using a simple carbon cycle model
  - Each potential land use is assigned terminal carbon densities for soils and vegetation
  - Carbon uptake/emissions and stocks are tracked for each land use type over time
  - The land use change footprint of cropland expansion is unique to each region and time period

GCAM Additional Features for Biofuel CI Analysis

- Biodiesel and ethanol represented individually, not as technologies within the liquid fuels sector
  - Biodiesel and ethanol are further differentiated by feedstock types (e.g., corn ethanol, sugar ethanol)
  - Trade of each type of ethanol and biodiesel

- Oil seed crushing explicitly represented
  - Crop-derived oils, feedcake secondary outputs
  - Trade of vegetable oil and feedcake commodities

- Key upstream linkages added
  - Agricultural energy use driven by crop production
  - Energy used for oil, gas, and coal production driven by these activities
  - Freight and maritime shipping requirements of all energy and agricultural commodities

GCAM and Biofuel CI Estimation

- Includes dynamic changes to components of system that are static in standard LCA
  - E.g., changes in transportation technologies
- Equilibrium impacts on markets not directly affected by a biofuel policy
  - E.g., price-driven increases in oil consumption internationally
- Land use change emissions from explicit land use model

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Thank you