Decarbonization Technologies in GCAM

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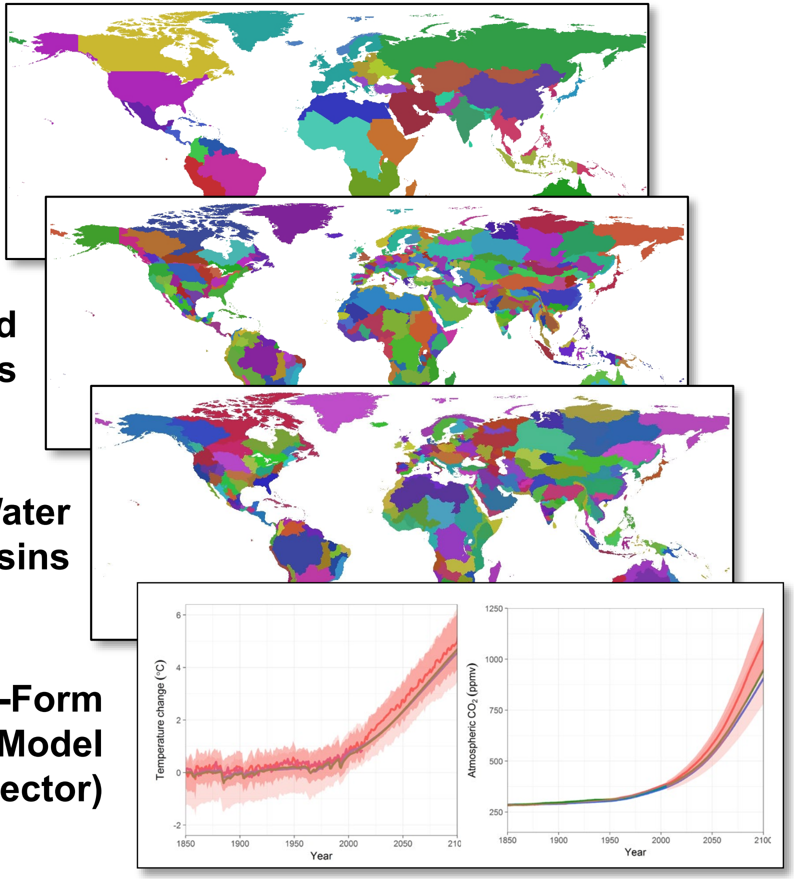
Workshop on Modeling Energy-related CO_2 Mitigation Pathways in the National Energy Modeling System

DRAFT PRESENTATION—COMMENTS WELCOME

The Global Change Analysis Model (GCAM)



32 Energy & Economy Regions

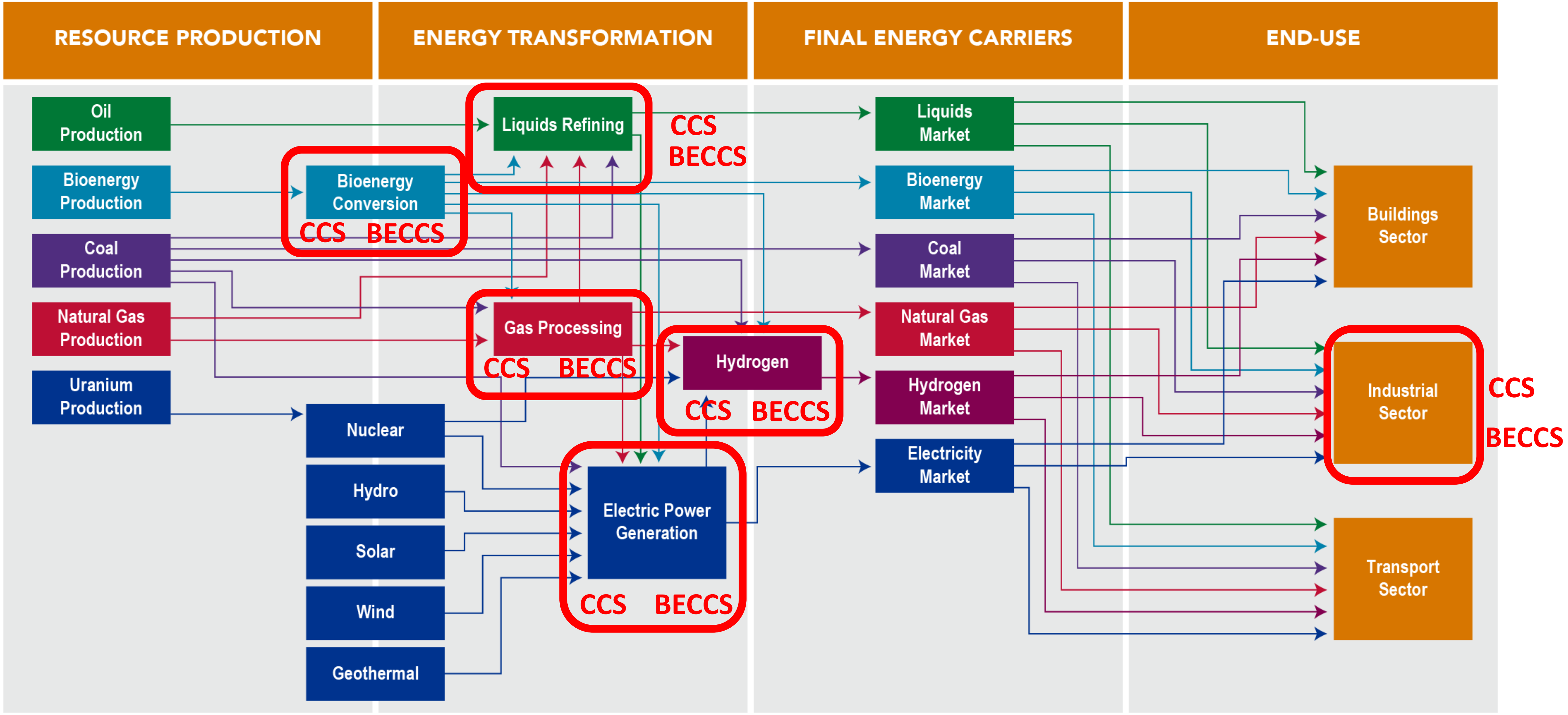
384 Land Regions

235 Water Basins

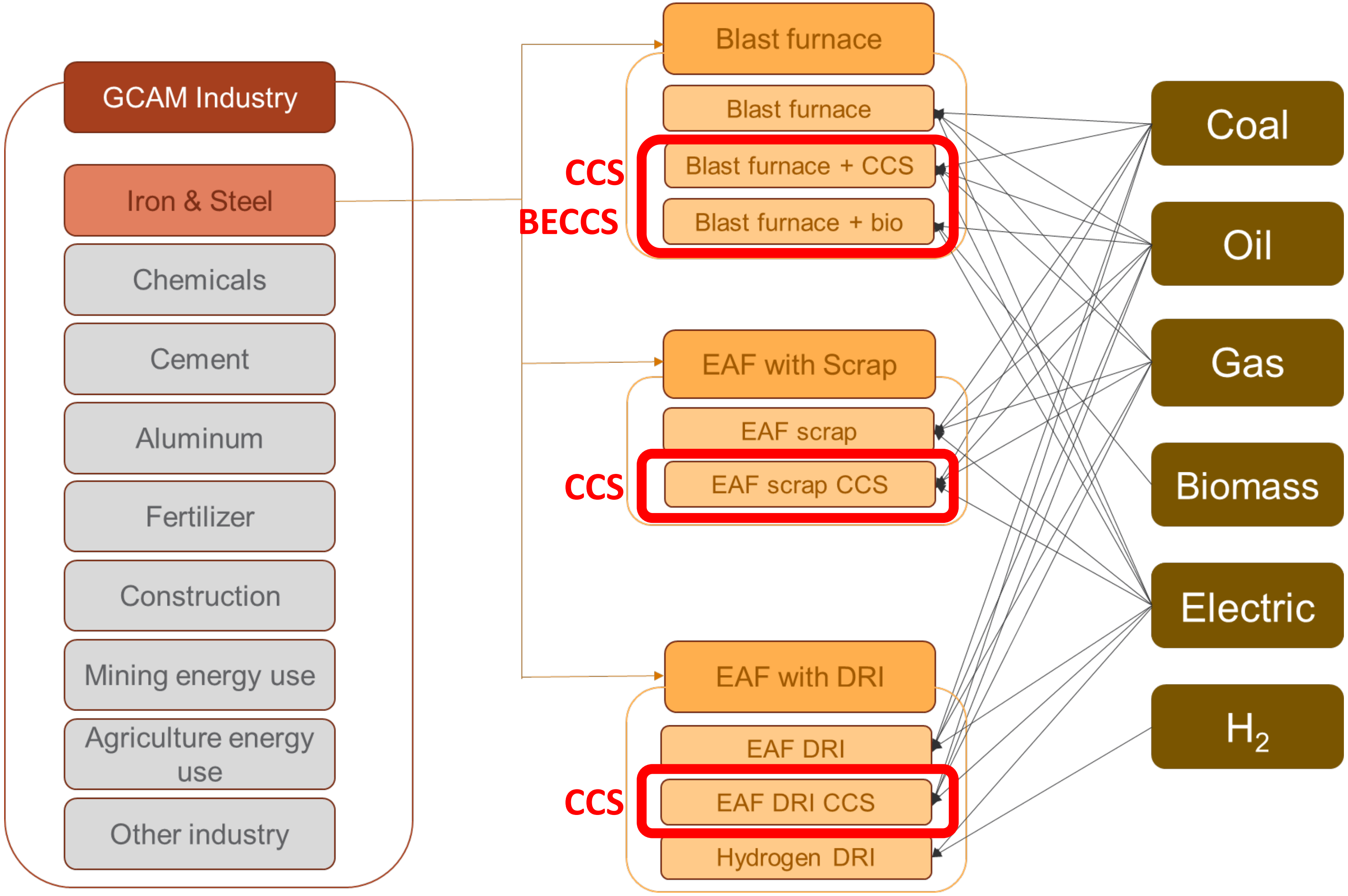
Reduced-Form Climate Model (Hector)

- Global model that integrates energy, water, land, economic, and climate systems in an integrated platform.
- Dynamic-recursive, economic market equilibrium
- Inputs include assumptions
  - Technology, national and international policies, socioeconomic development pathways
- Provides information about key outcomes
  - E.g., energy prices, fossil and other resource utilization, fossil trade, energy technology deployment, water use and scarcity, irrigation, agricultural production & trade.
  - KP gases, aerosols and short-lived species
- **Five-year time steps** can run one-year time steps.
- **Time horizon: 2100**
- **Community model** (https://github.com/JGCRI/gcam-core/releases)

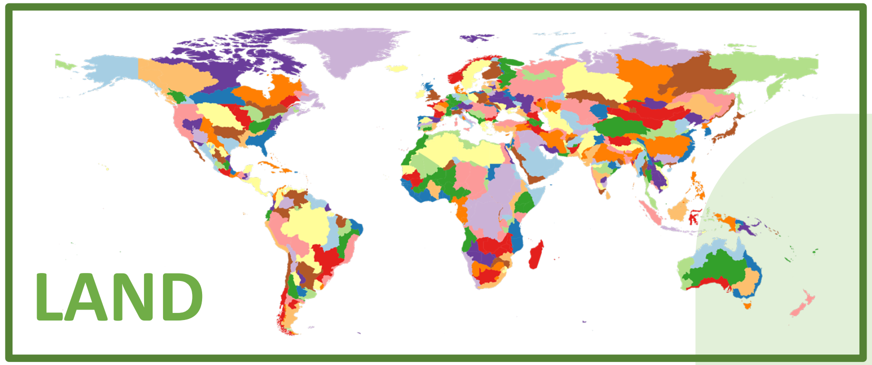
Multiple points at which decarbonization can occur in GCAM



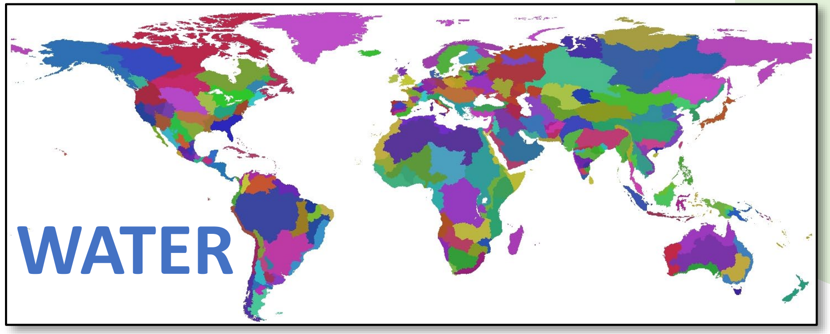
GCAM Detailed Industry Model Structure

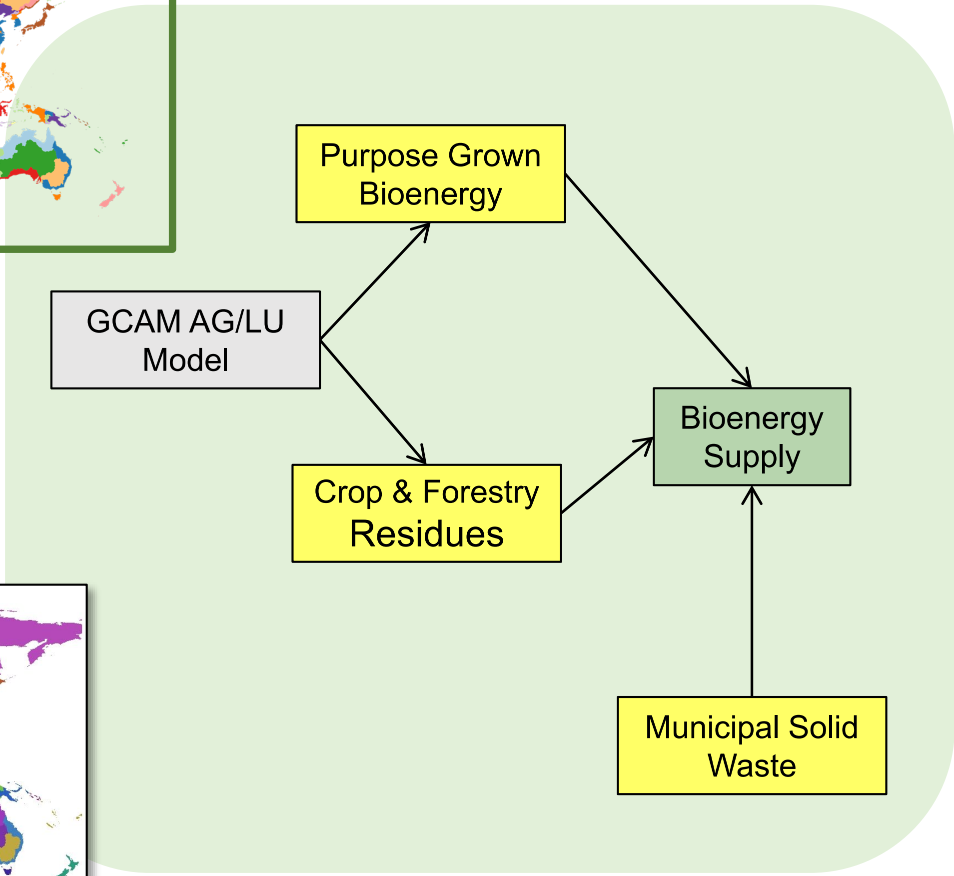


Bioenergy: Produced as part of the larger energy-water-land system



384 land use regions, formed by the intersection of geopolitical regions and water basins.





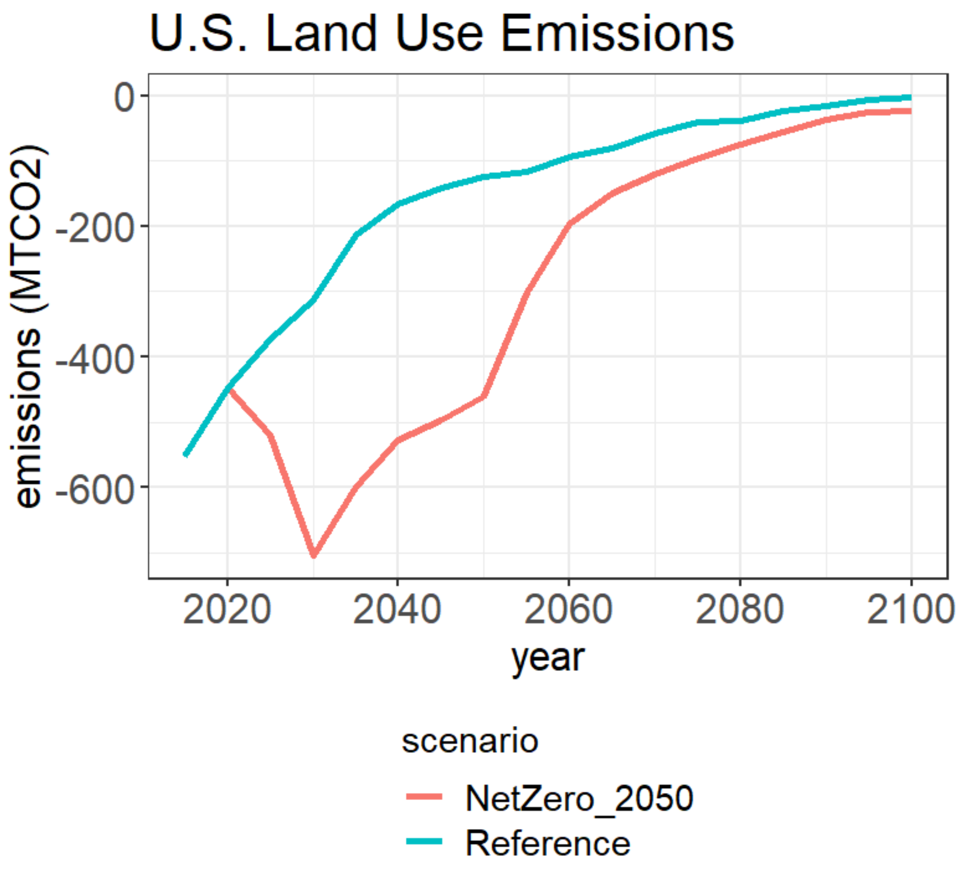
Purpose Grown Bioenergy:
- Production depends on land allocation and regional yield from Ag model
- Land allocation depends on the profit rate of biomass AND all competing land uses
- Includes 1st and 2nd generation crops

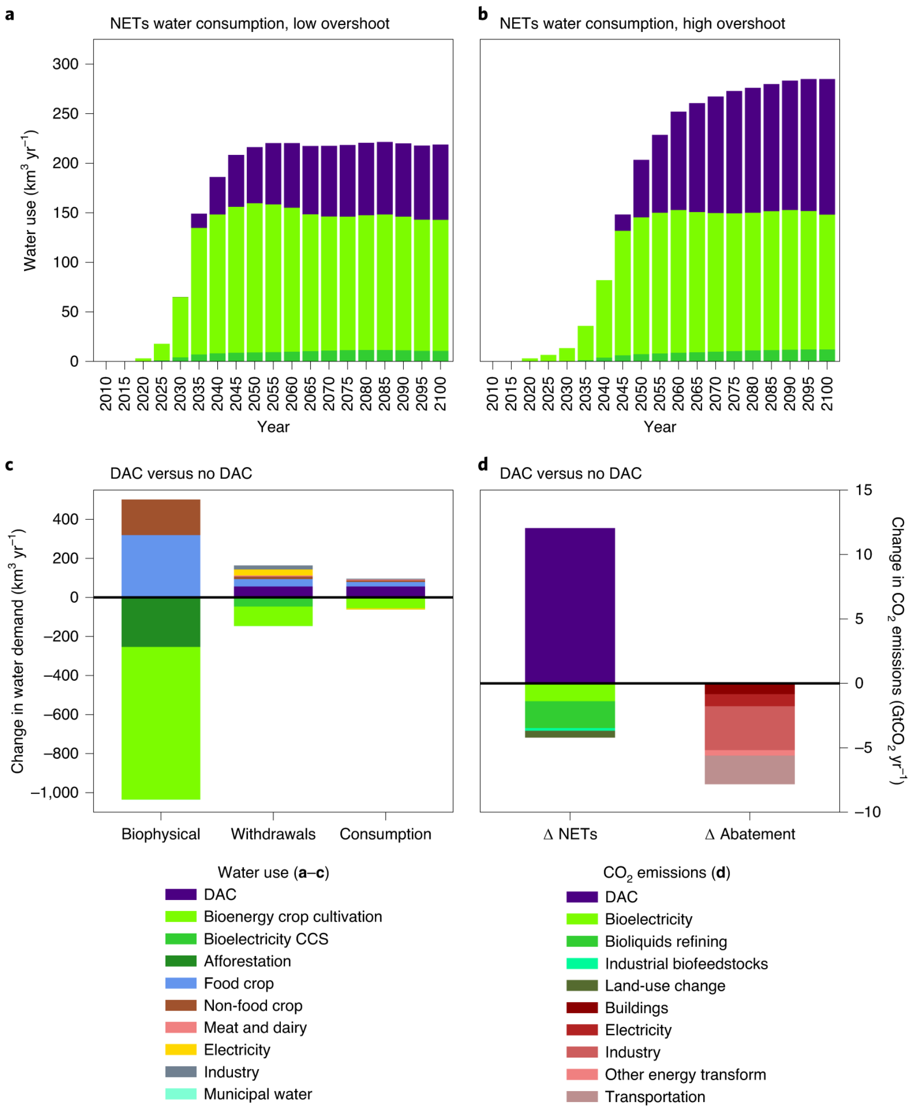
Crop & Forestry Residues:
- Potential production depends on crop production in ag model
- Fraction harvested depends on the price of bioenergy; higher prices lead to more production
- Some amount of residue must remain on the field for erosion control

Municipal Solid Waste:
- Potential production depends population and income
- Fraction used for bioenergy depends on the price of bioenergy; higher prices lead to more production

Note: We also model traditional bioenergy. However, it is not added to the bioenergy resource pool and is instead consumed directly by the buildings sector. Similarly, we model 1st generation bioenergy (corn, sugar, oil crops), but it is converted directly to ethanol or diesel and not added to the bioenergy resource pool.

Land-use Emissions & Water Use





a,**b**, Global consumptive water use for BECCS and DAC under low (**a**) and high (**b**) overshoot of the 1.5 °C temperature target. **c**, Differences in the year 2050 for biophysical water demand, withdrawals and consumption by sector for low-overshoot scenarios in which DAC is and is not available. The availability of DAC decreases evapotranspiration related to human activities but increases overall withdrawals and consumption. **d**, Effect of DAC on NET deployments and abatement effort. Decreased abatement effort indicates increased gross positive CO_2 emissions.

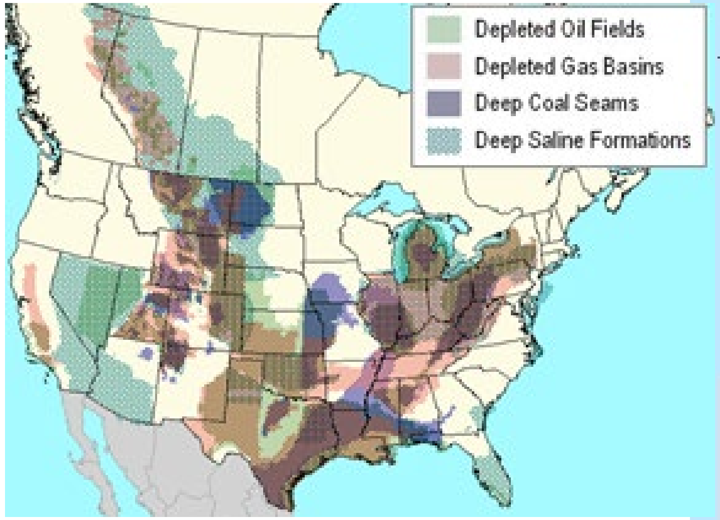
Direct air capture

- Aqueous or amine-based chemical processes to separate CO_2 from ambient air
- Receiving increasing interest from IAM community

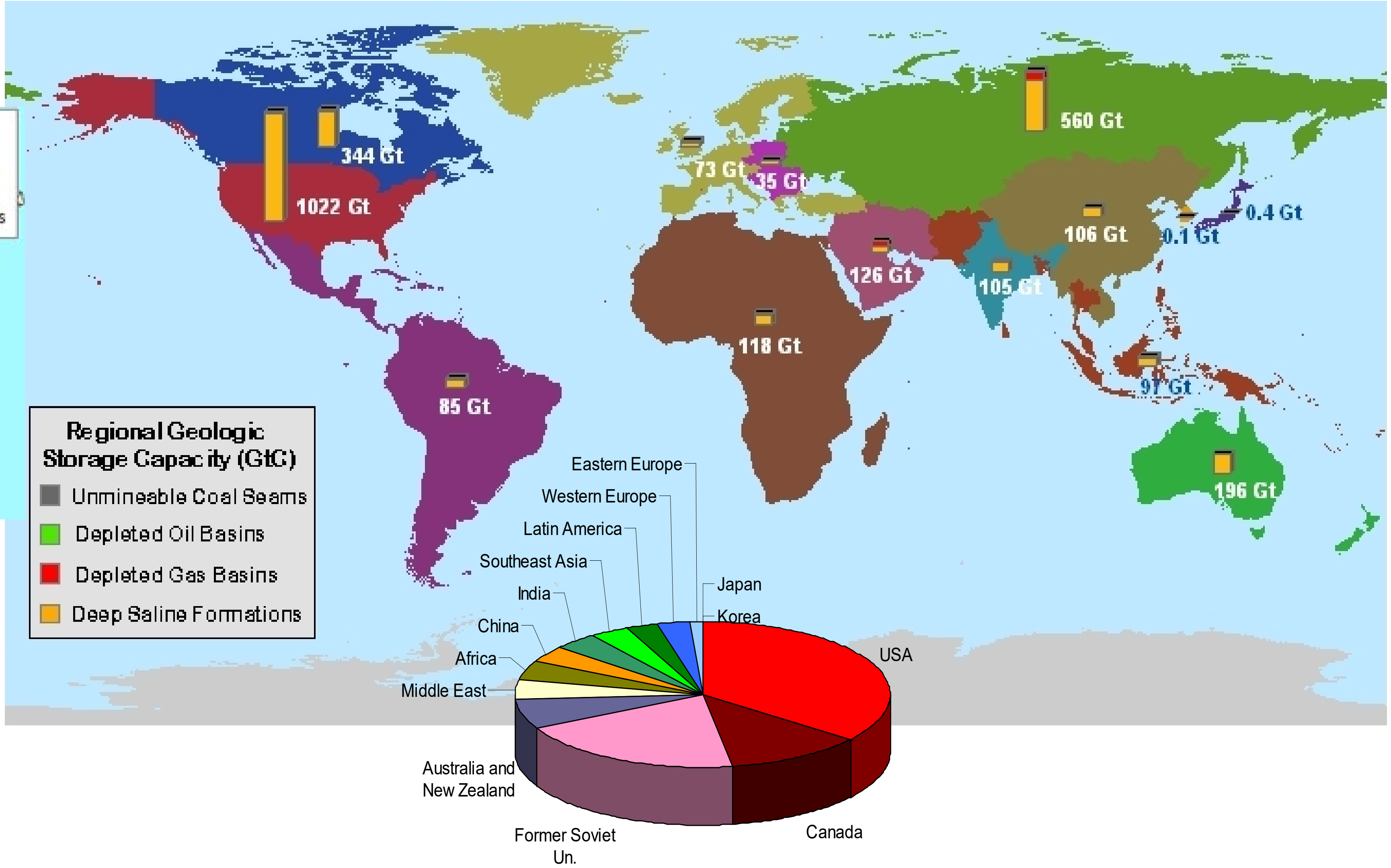
Image source: Tollefson, J. Sucking carbon dioxide from air is cheaper than scientists thought. *Nature* **558**, 173 (2018).

Global CO_2 Storage Capacity

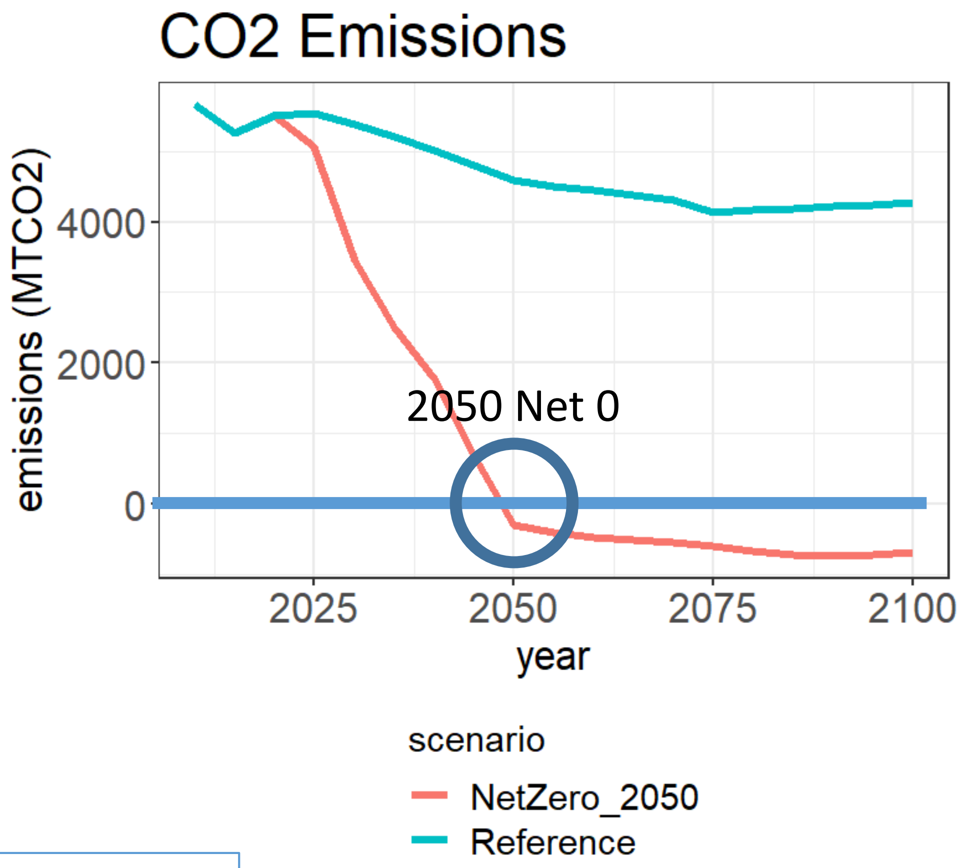
Modeled as a graded resource



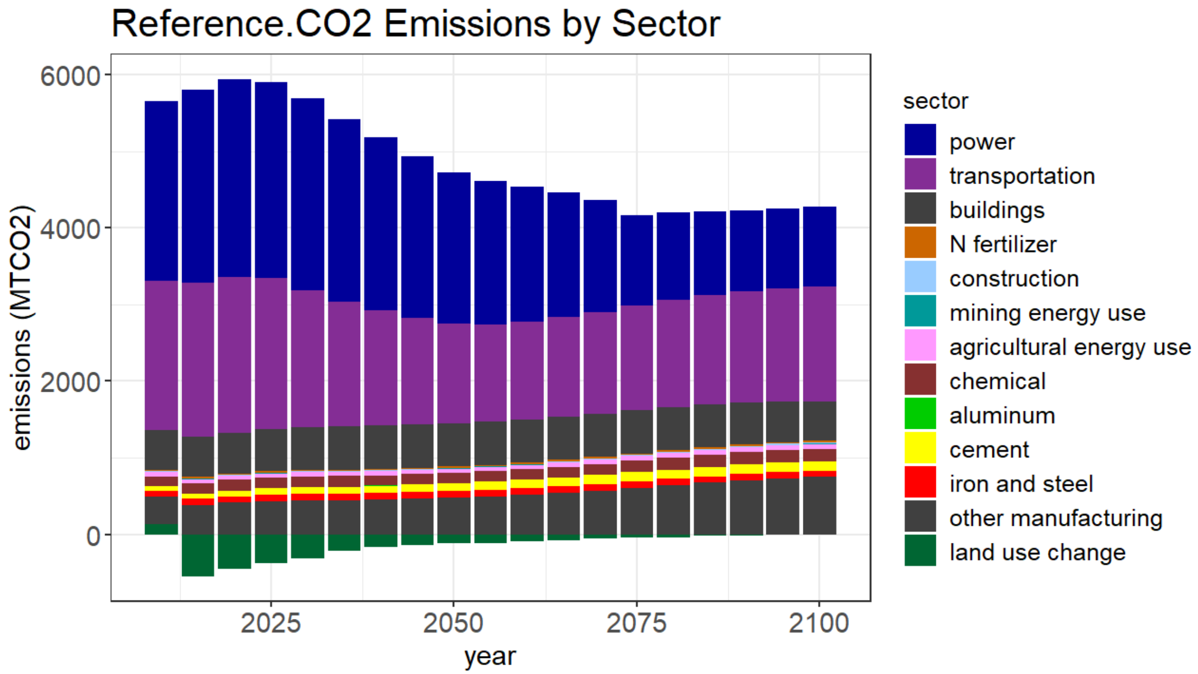
Gigatons of Carbon

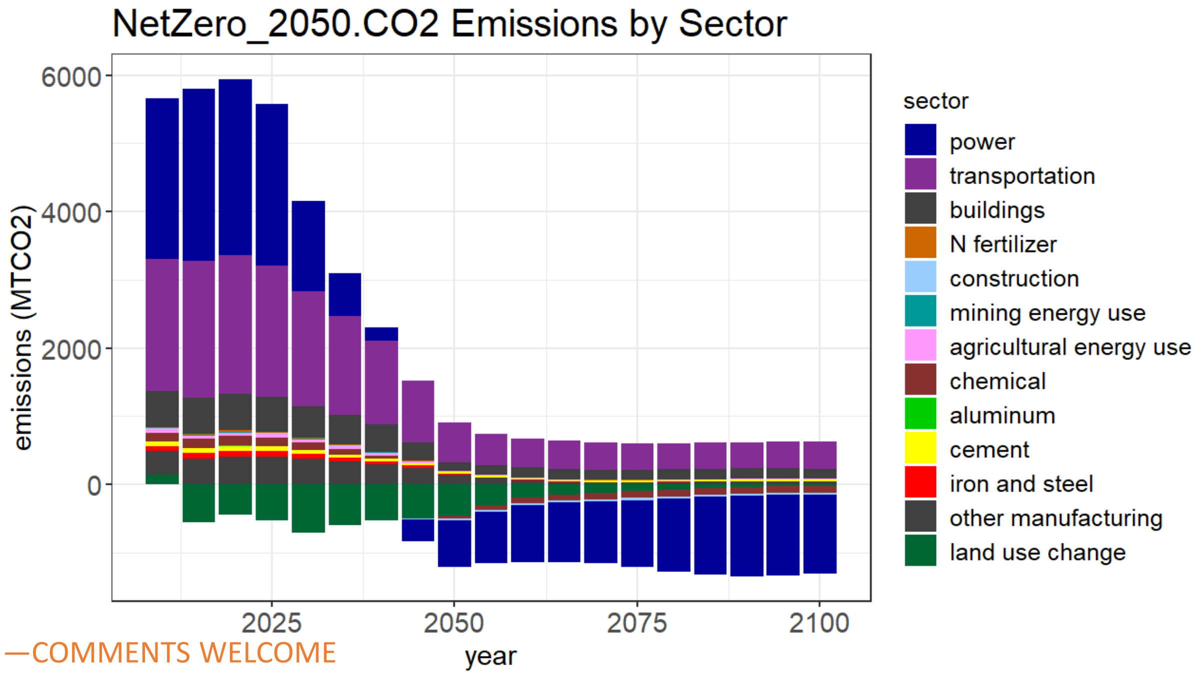


U.S Net-Zero Pathway



Note: Does not include retrofit CCS technology.





Discussion