

Producing Ethanol for Low-Carbon Fuel Markets

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Richard Plevin
Energy and Resources Group
UC Berkeley
plevin@berkeley.edu

Steffen Mueller
Energy Resources Center
University of Illinois at
Chicago
muellers@uic.edu

Low-Carbon Fuel Standard

Reduce “carbon intensity”
of California’s
transportation fuels at least
10% by 2020

interpretation:

Reduce the life cycle **global
warming intensity** (GWI) of
all on- and off-road fuels
used in the state, at least
10% relative to 2004, by
2020



**What does this mean for ethanol
producers?**

Life Cycle GWI of Fuels

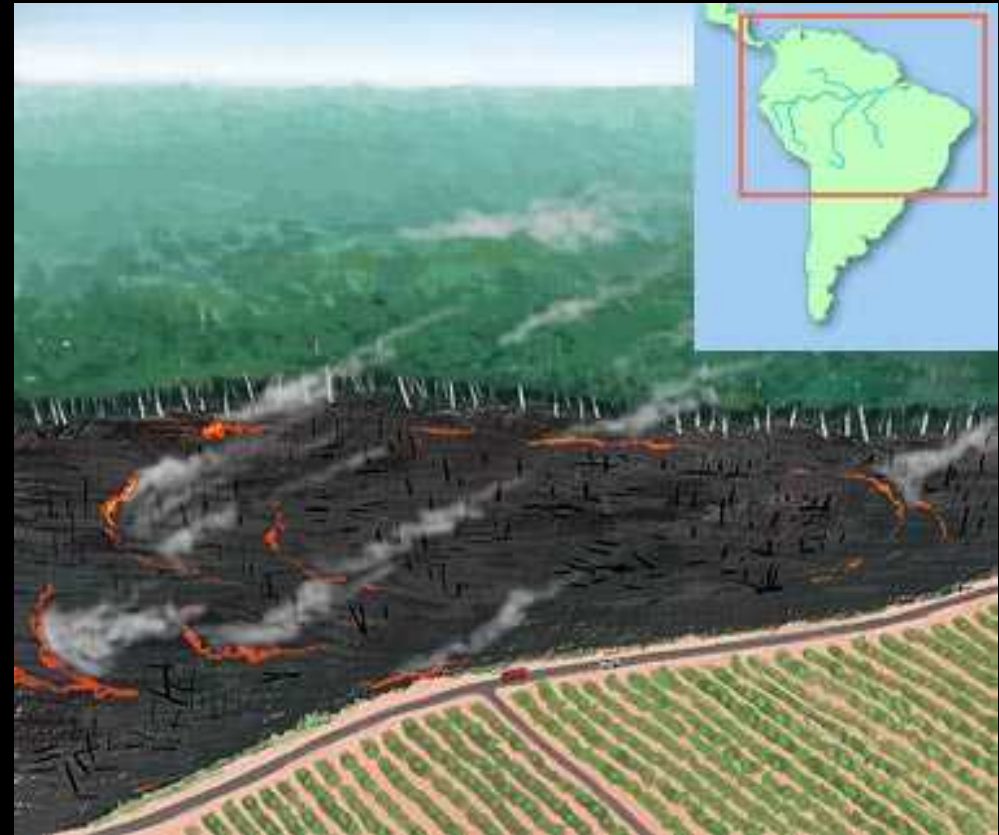
- Includes emissions from production and transport of feedstock, ag inputs, and ethanol
- Includes soil emissions of greenhouse gases
- Includes a small charge for domestic land use change
- Does not include food for workers or energy to build farm machinery or biorefineries

Factors Driving GWI

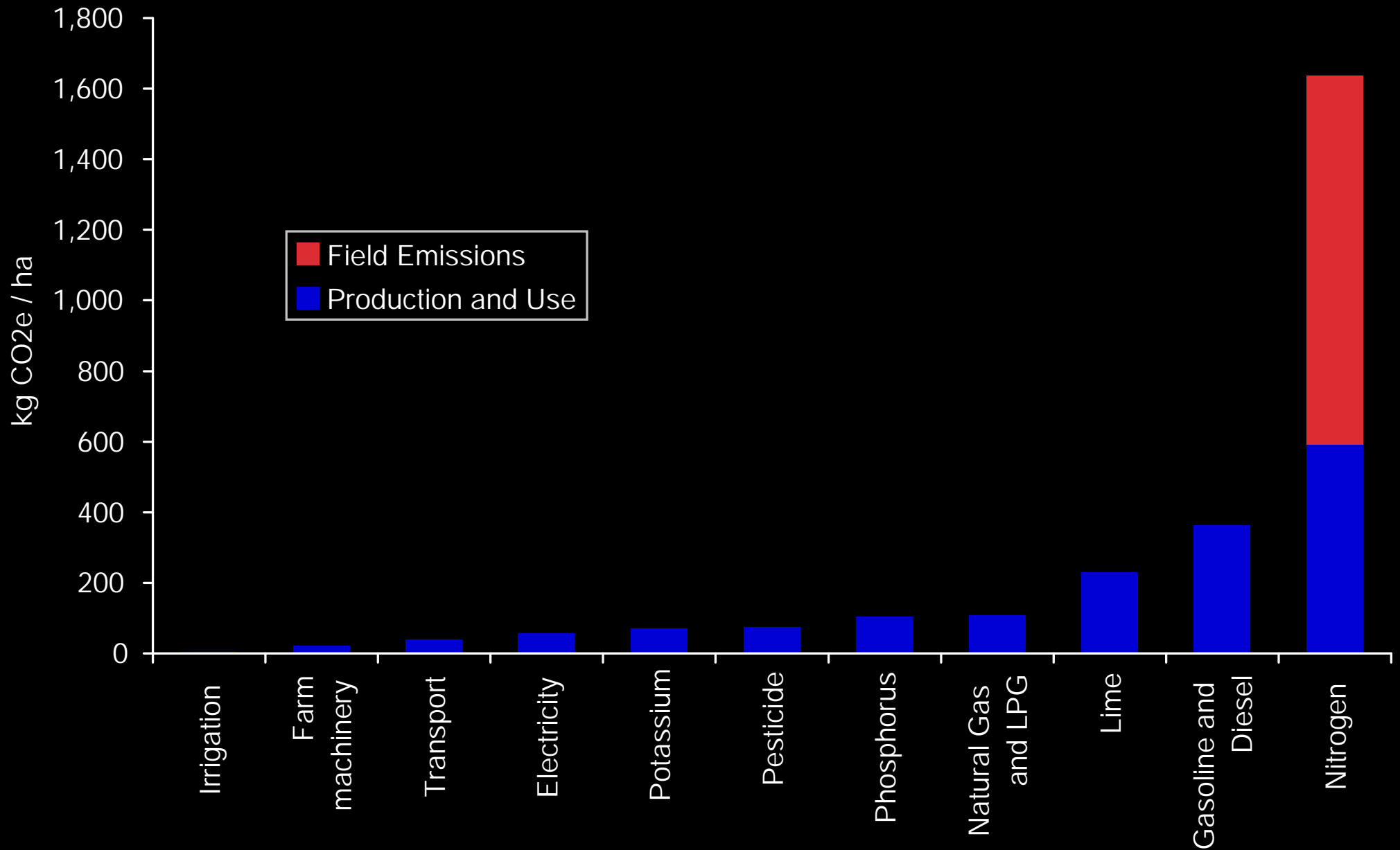
- Feedstock production
- Thermal energy source in biorefinery
- Energy system configuration
- Carbon intensity of purchased electricity
- Land use conversion

Land Use Conversion

- Increasing acreage dedicated to a new commodity causes conversion of lands from a natural to a managed state
- Released carbon can eliminate climate benefits of biofuels *for decades*
- Feed, fuels, and food markets are global, as are climate effects
- All crop-based biofuels are implicated
- Currently the cutting edge of biofuels life cycle assessment
- **Potentially game-changing**

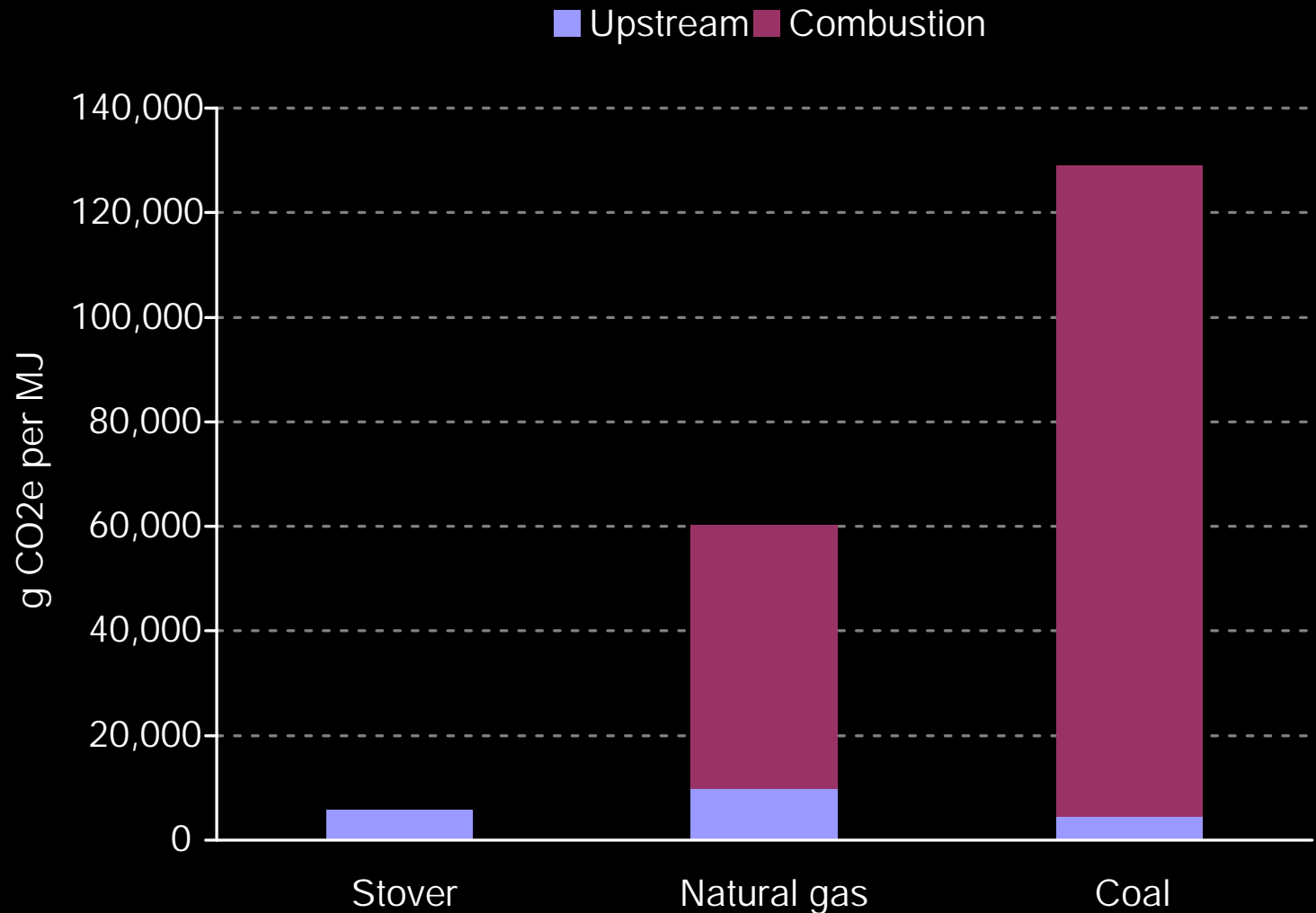


Greenhouse Gas Emissions from Corn Agriculture

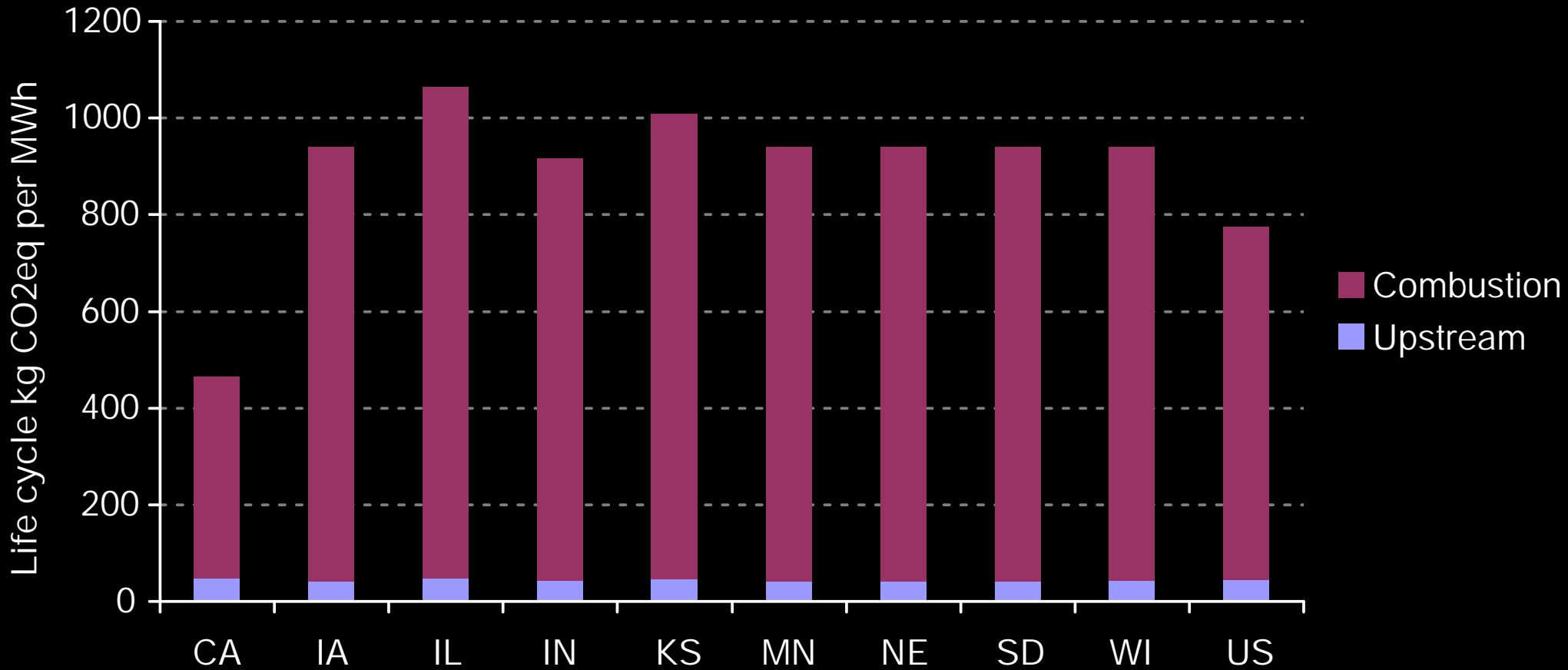


GWI of Primary Energy Sources

- Coal is > 2x as carbon-intensive as natural gas
- Biomass and coal systems are less efficient, so more Btus are required per gallon of ethanol.
- For biomass, only *production* GHGs are counted.

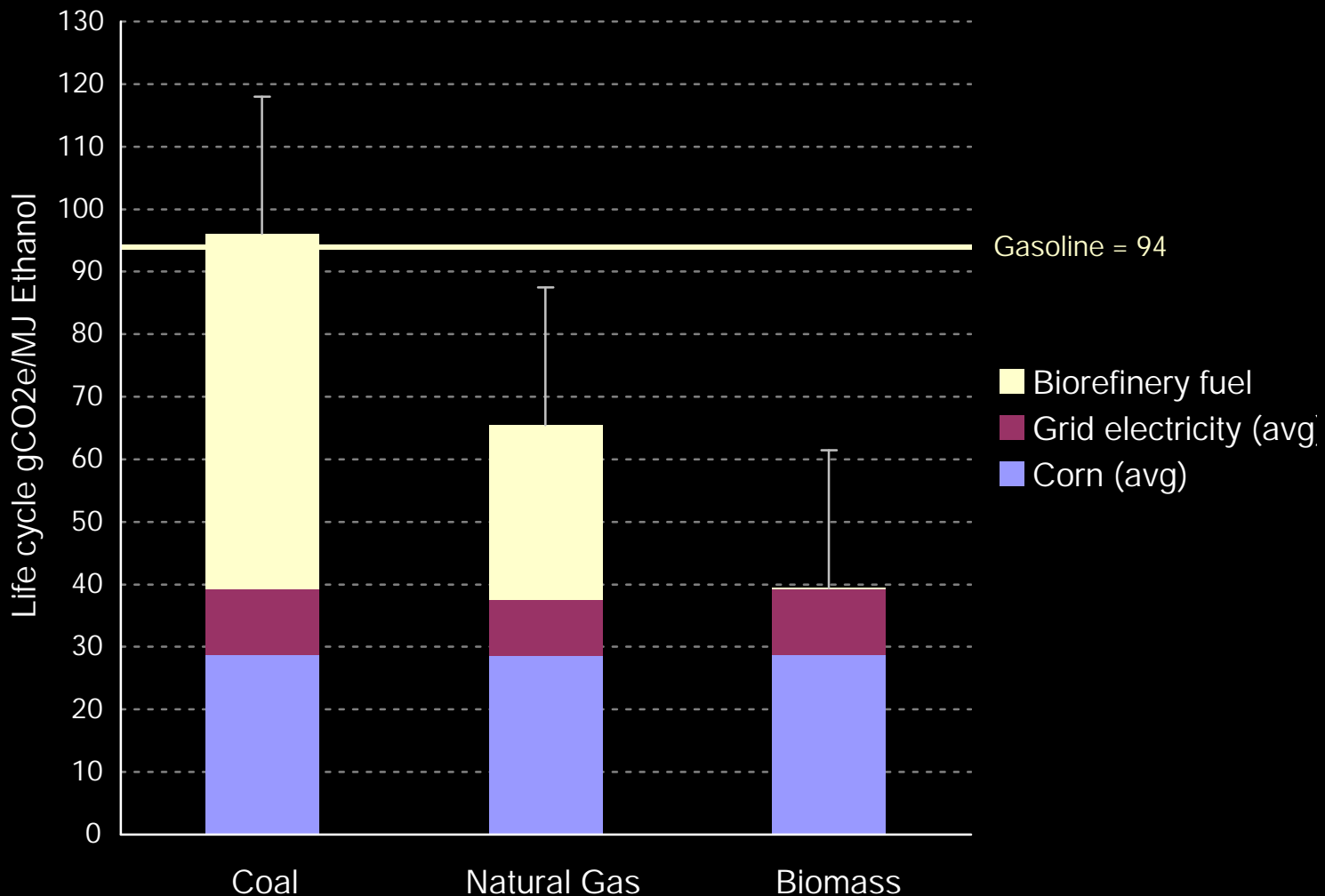


Life cycle GWI of Electricity by State



Based on eGRID regions defined by the US EPA

GWI of Corn Ethanol in Iowa



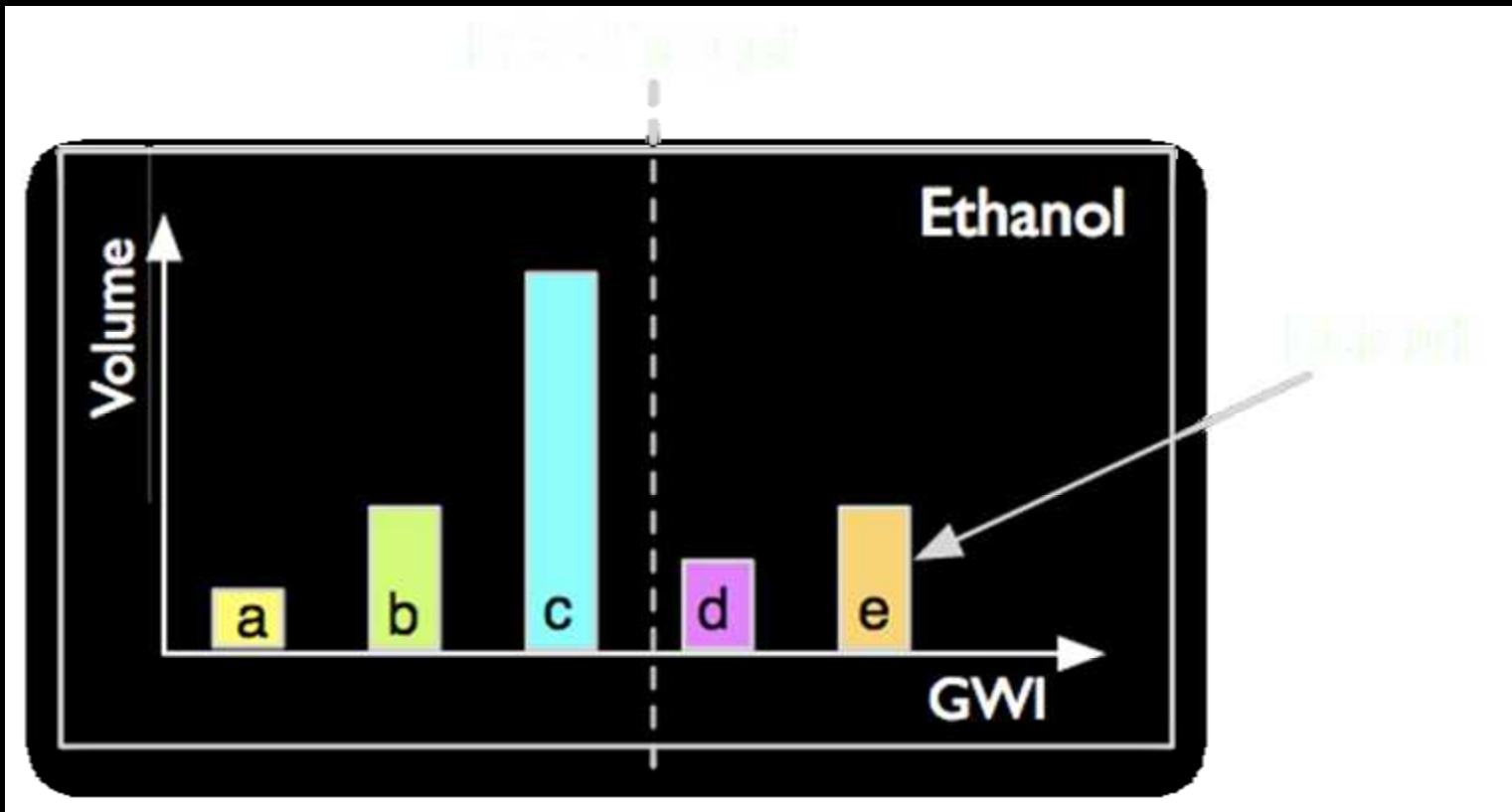
- Coal-fired ethanol is at least as greenhouse gas intensive as gasoline.
- With emissions from land-use change NG-fired ethanol isn't great

Plant Configuration

- Ethanol plants are good candidates for combined heat and power (CHP) applications.
- CHP systems can meet > 90% of electricity demand
- Carbon-intensity of purchased electricity is a minor component of life cycle global warming intensity.

Ethanol Certification

- Petroleum companies say blending low-GWI biofuels may be primary compliance strategy
- “Default and opt-in” for fuels and blendstocks
- GWI certification of ethanol sold into CA market avoids “worst-case” default



How does an ethanol
producer factor greenhouse
gas emissions into cost
estimates?

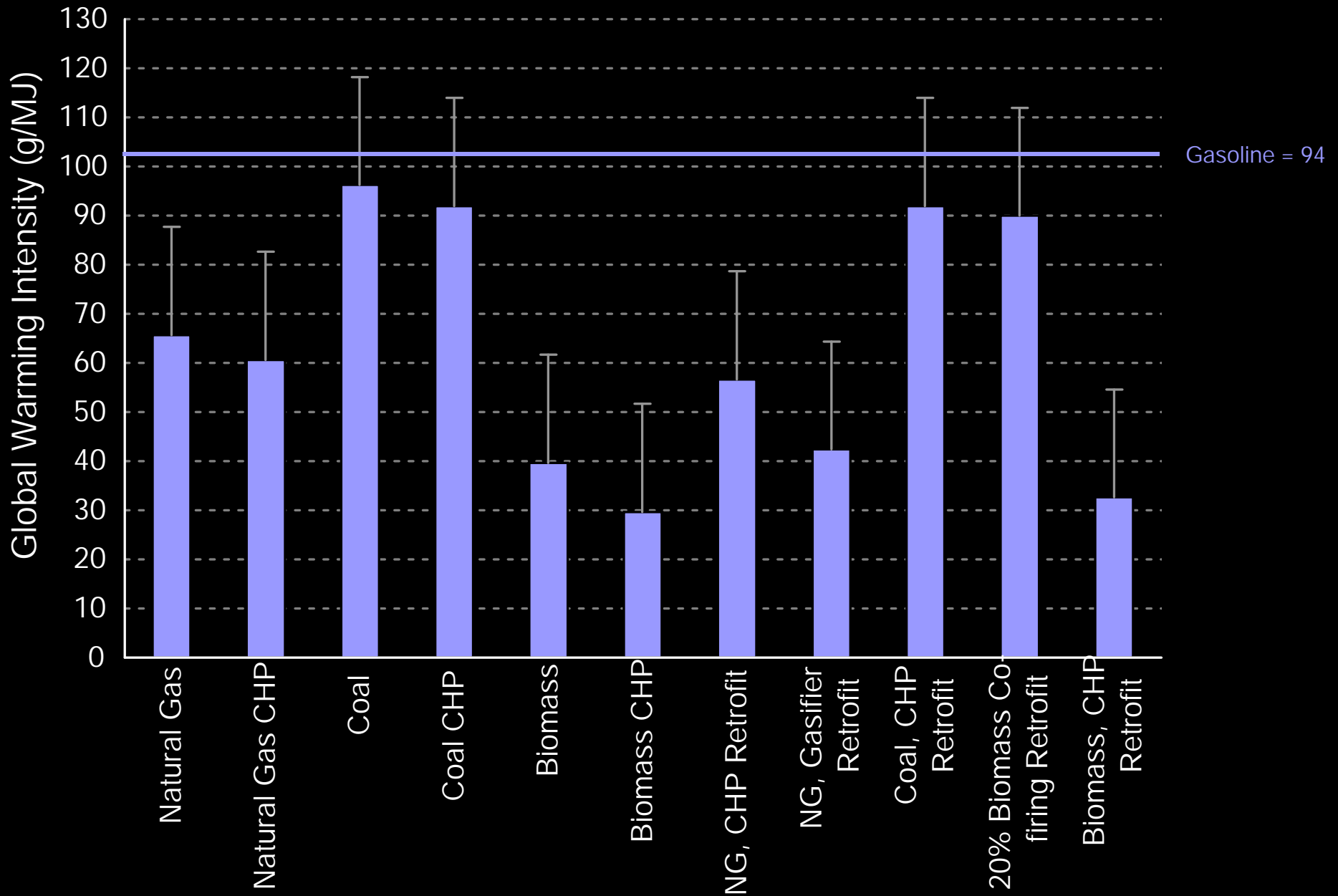
The BEACCON Model

- Biofuel Emissions And Cost CONnection
- Integrates economic and GHG accounting
- Compares 12 dry-mill configurations types
- Designed for customization
- Freely downloadable from LifeCycleAssociates.com

12 Plant Energy System Configurations

1. Natural gas
2. Natural gas with CHP
3. Coal
4. Coal with CHP
5. Biomass (corn stover)
6. Biomass with CHP
7. Natural gas CHP retrofit
8. Natural gas gasfication retrofit
9. Coal CHP retrofit
10. Coal co-firing 20% biomass
11. Biomass CHP retrofit
12. Nuclear steam, NG RTO

Global Warming Intensity by Pathway



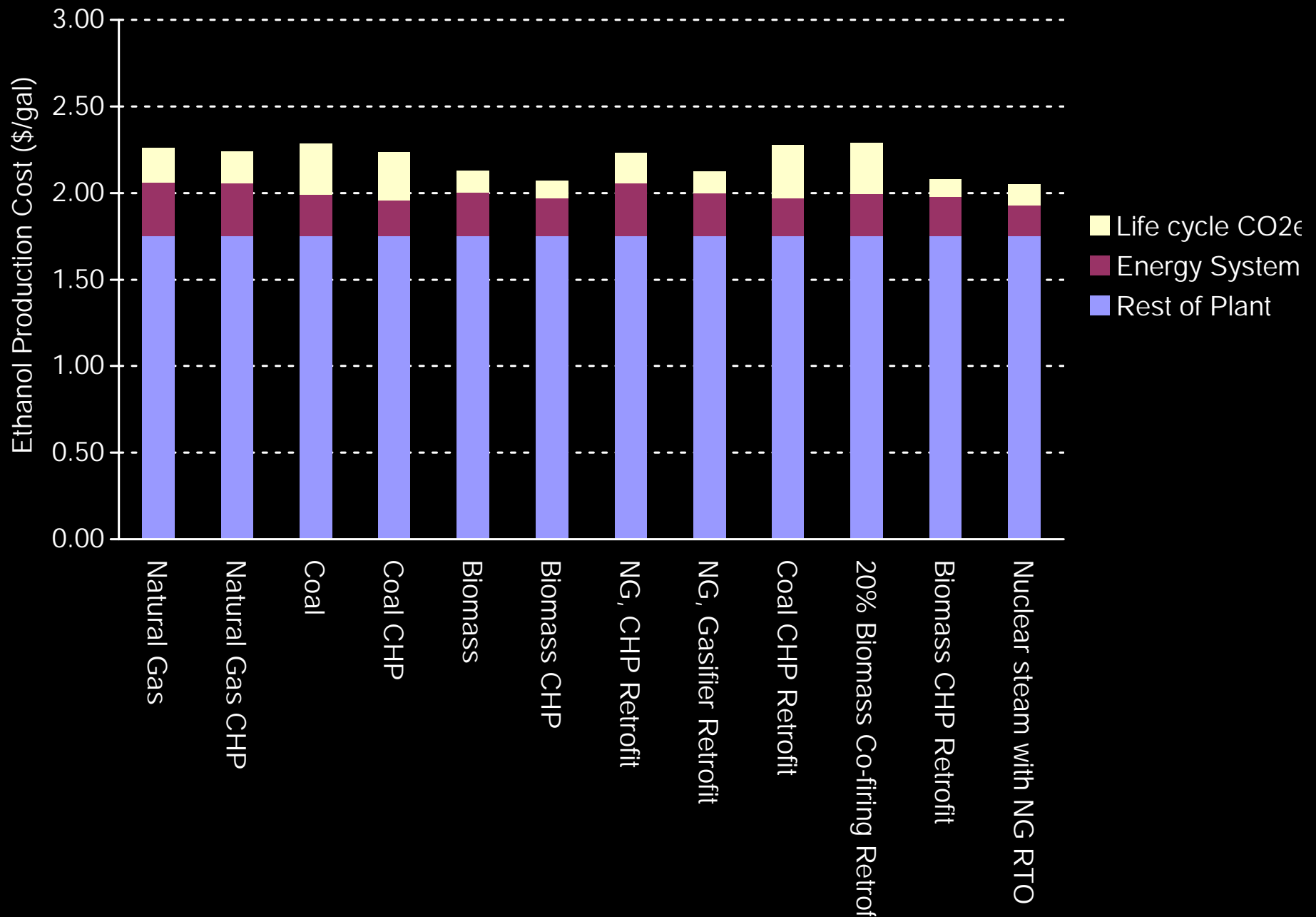
Corn farming

- Average corn production is used for all states
- Emissions actually vary by region and practices
- Corn farming and hauling emits about 29 g CO₂e/MJ
- Includes small factor for land use conversion, but it's too low.
- Model will soon include regional differentiation

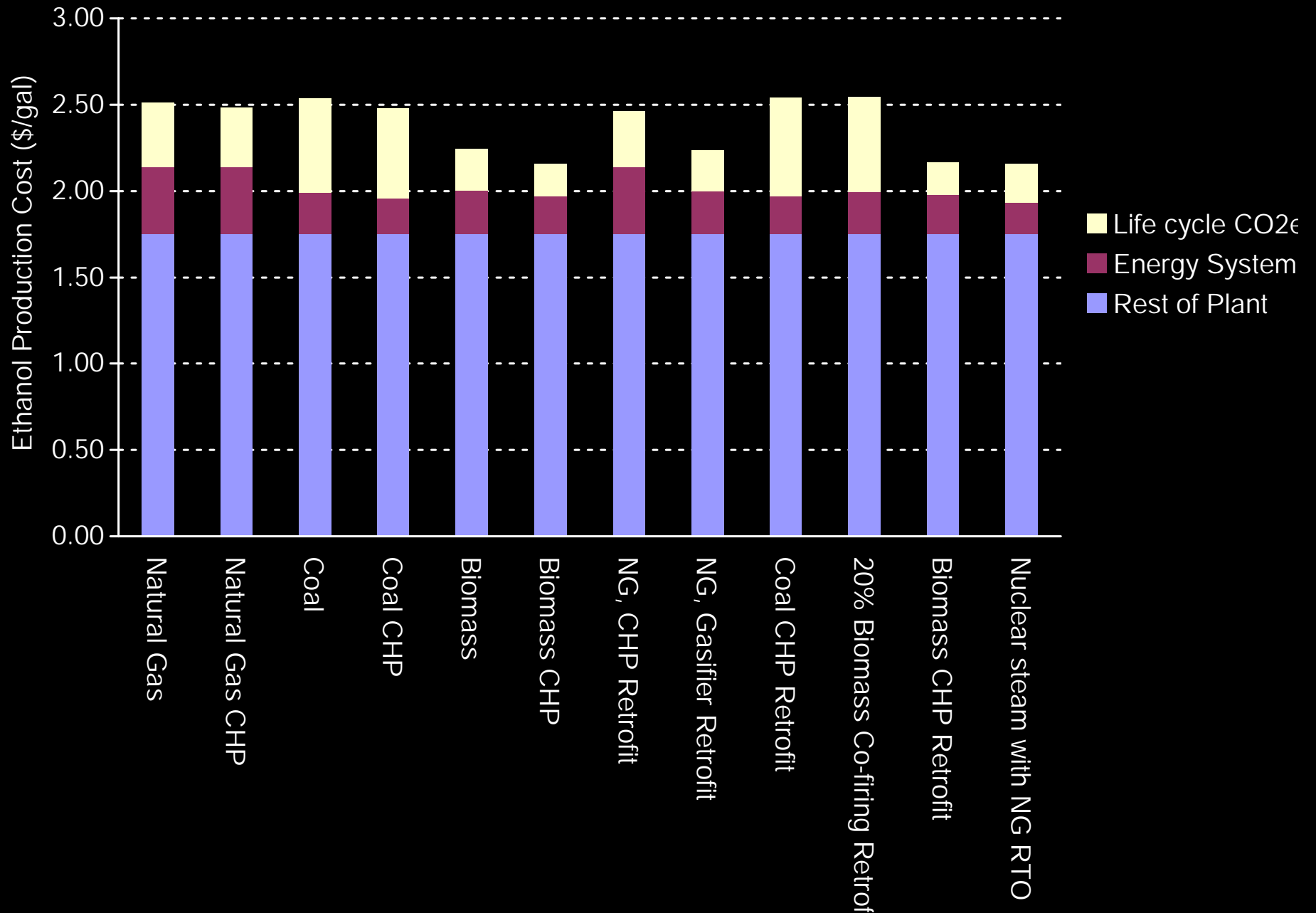
The Cost of GHG Emissions

- BEACCON computes life cycle GHG emissions
- Estimating affect of LCFS is very difficult
- Putting a price on CO₂ is very easy
- At what price of CO₂ is coal no longer cheaper than natural gas as an energy source?

Kansas: \$38/tonne CO₂e, \$7.44/MMBtu gas



Indiana: \$71/tonne CO₂e, \$9.82/MMBtu gas



Summary Findings

- Primary fuel choice is the main driver of GWI
- Location (electric grid) differences are minor
- Combined heat and power lowers GWI and cost
- Coal-fired ethanol is at a significant disadvantage
- Biomass-fired ethanol offers lowest GWI



BEACCON: Next Steps

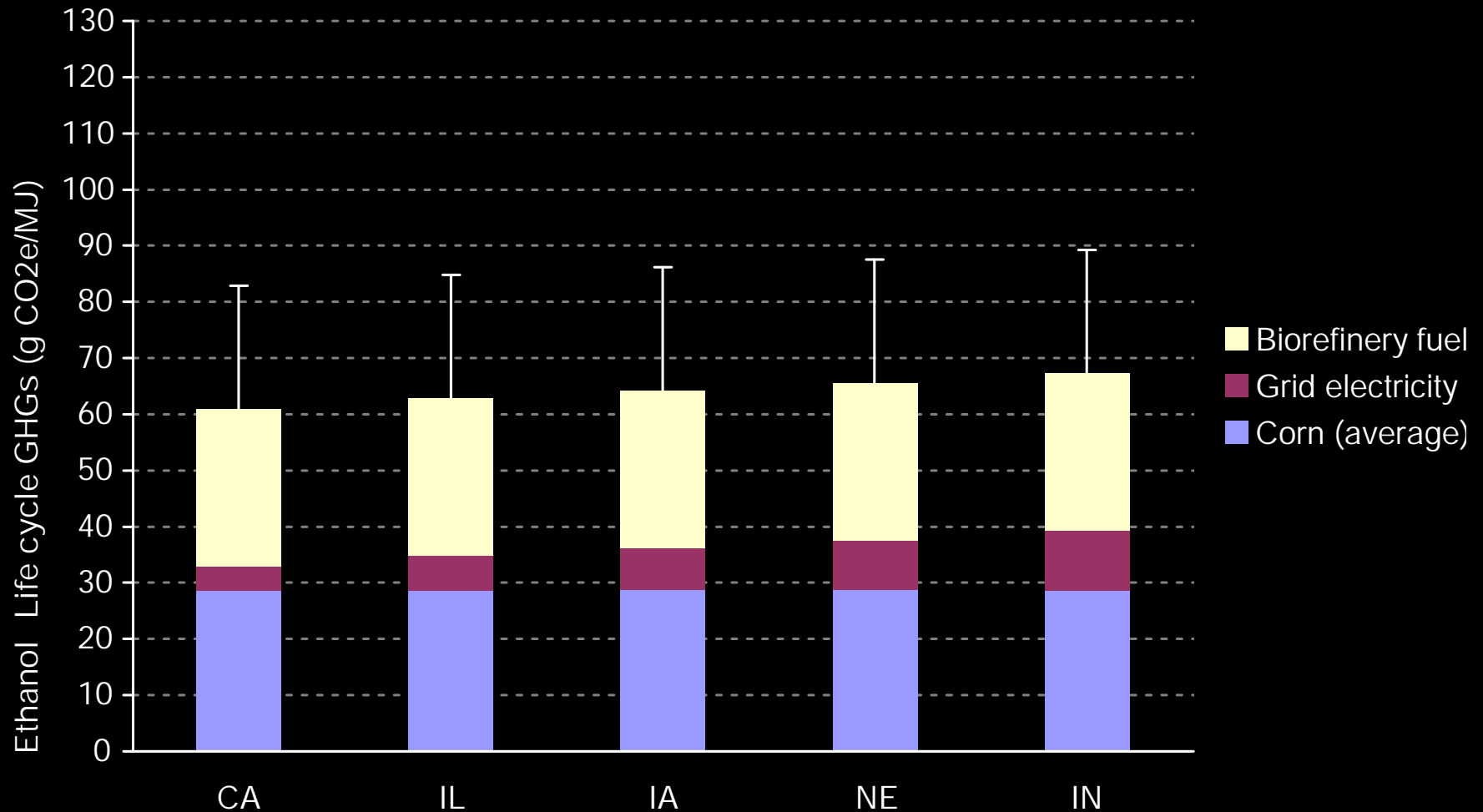
- Greater regional differentiation
- Direct versus life cycle emissions
- Uncertainty analysis using Crystal Ball
- Prototype certification tool for LCFS?

LifeCycleAssociates.com

- Download the spreadsheet model
- Download this presentation
- Links to related studies and models
- Consulting services

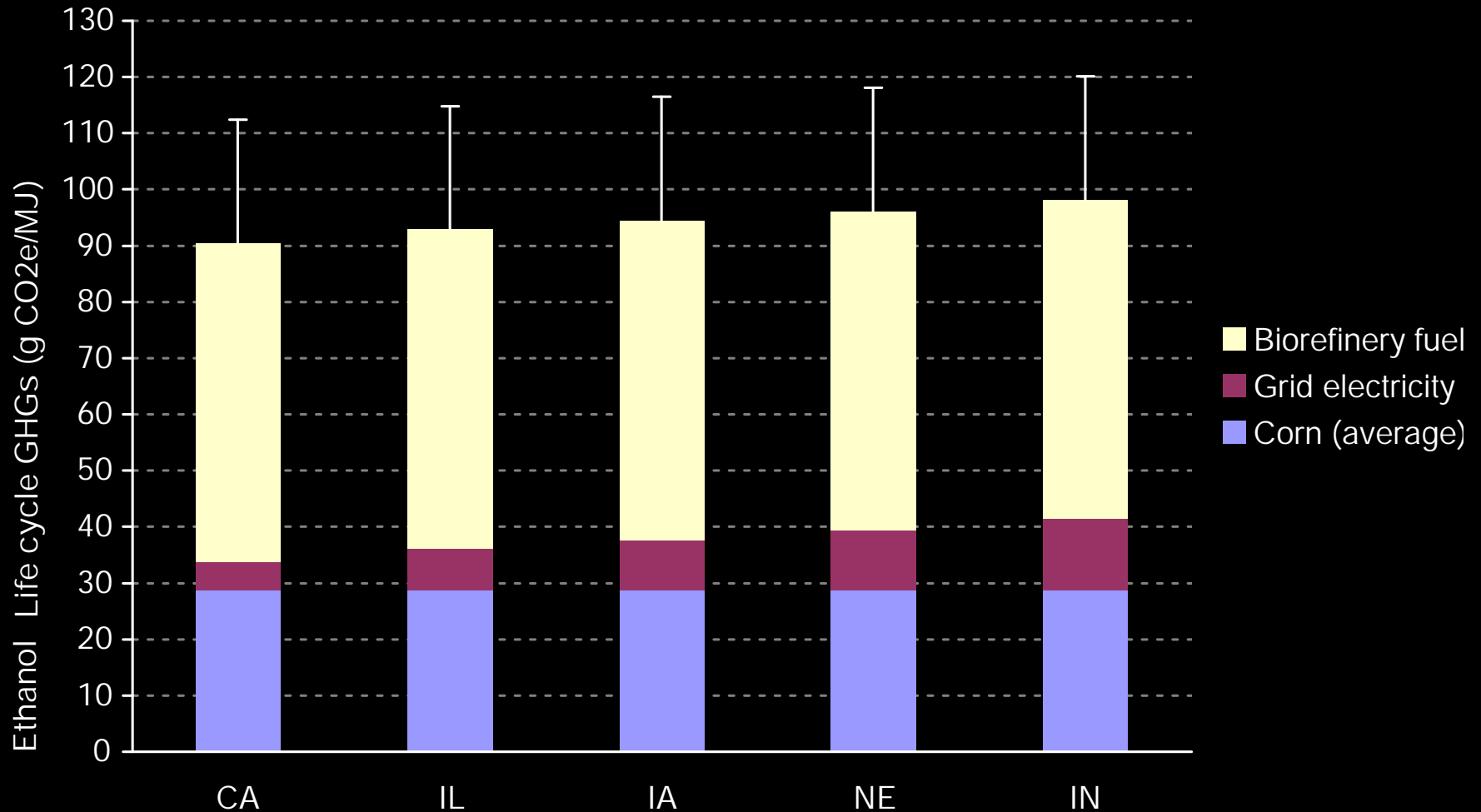
The End

Natural Gas-fired Ethanol



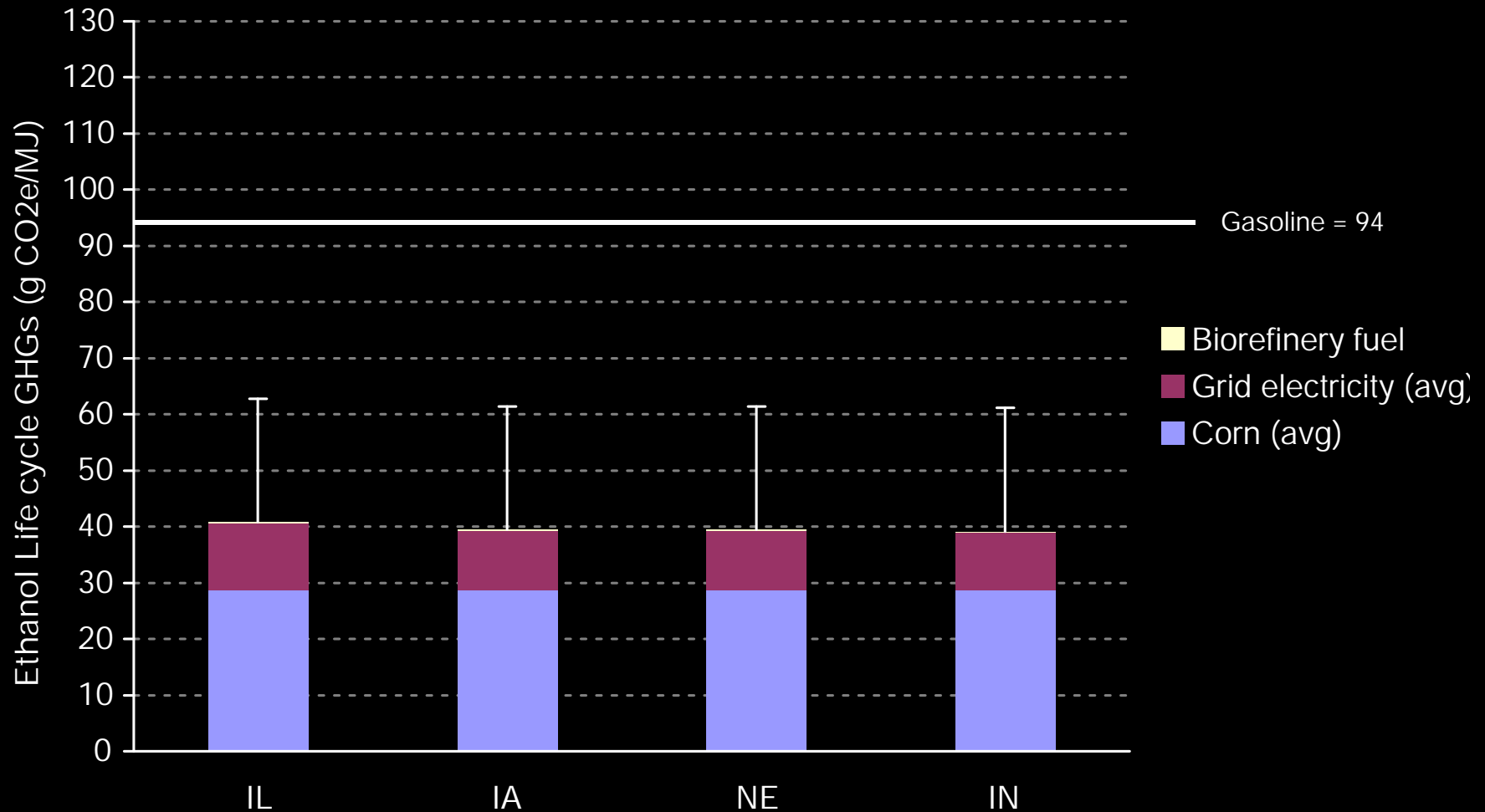
- NG-fired corn ethanol offers GHG reductions of 1/3 to 1/2
- With emissions from land-use change it approaches the GWI of gasoline.

Coal-fired Ethanol



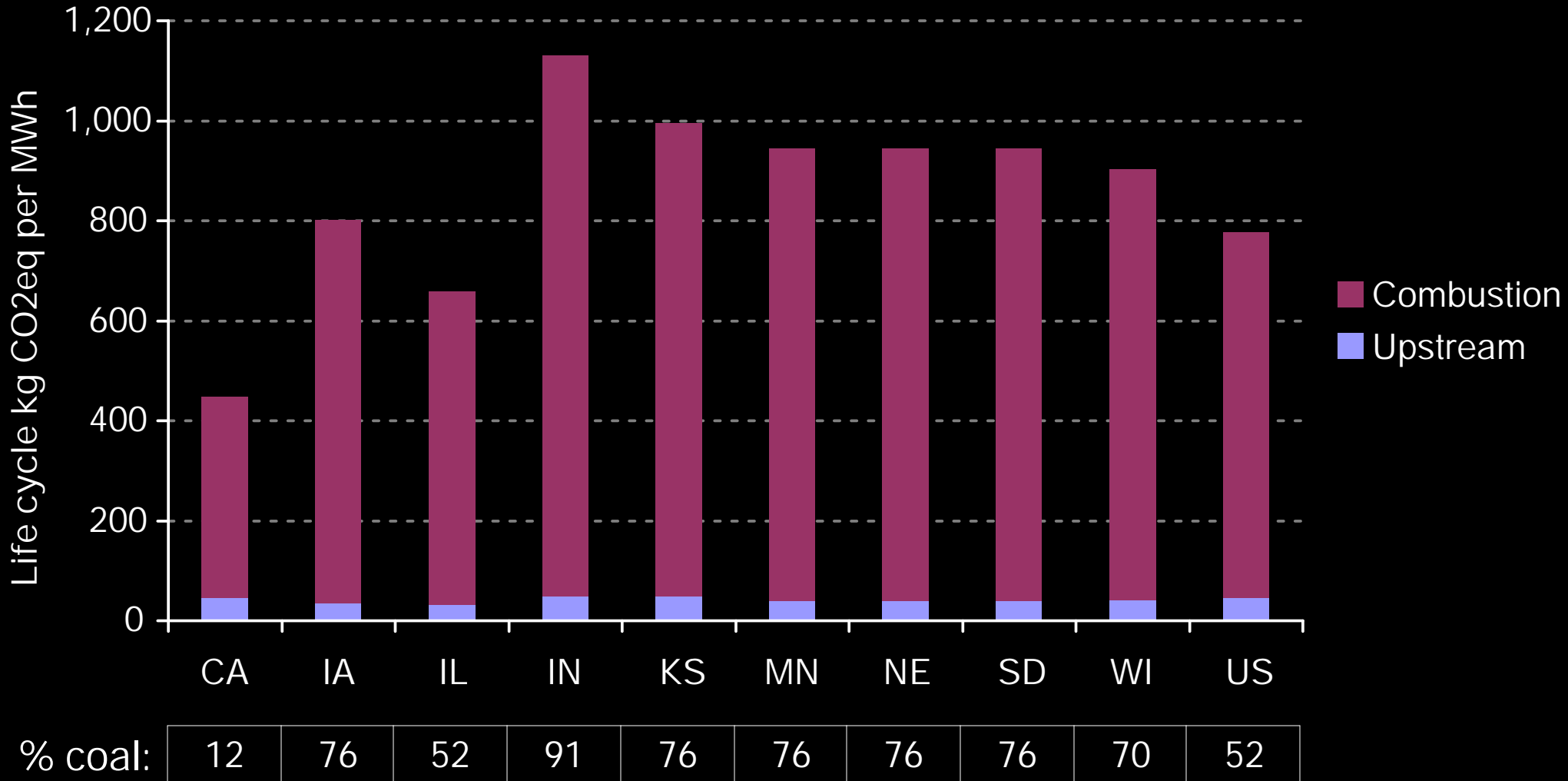
- Coal-fired corn ethanol rates about the same as gasoline
- Emissions from land use change may make it *much worse* than gasoline
- In low-carbon fuel markets, it offers no advantage to regulated

Primary Fuel: Biomass

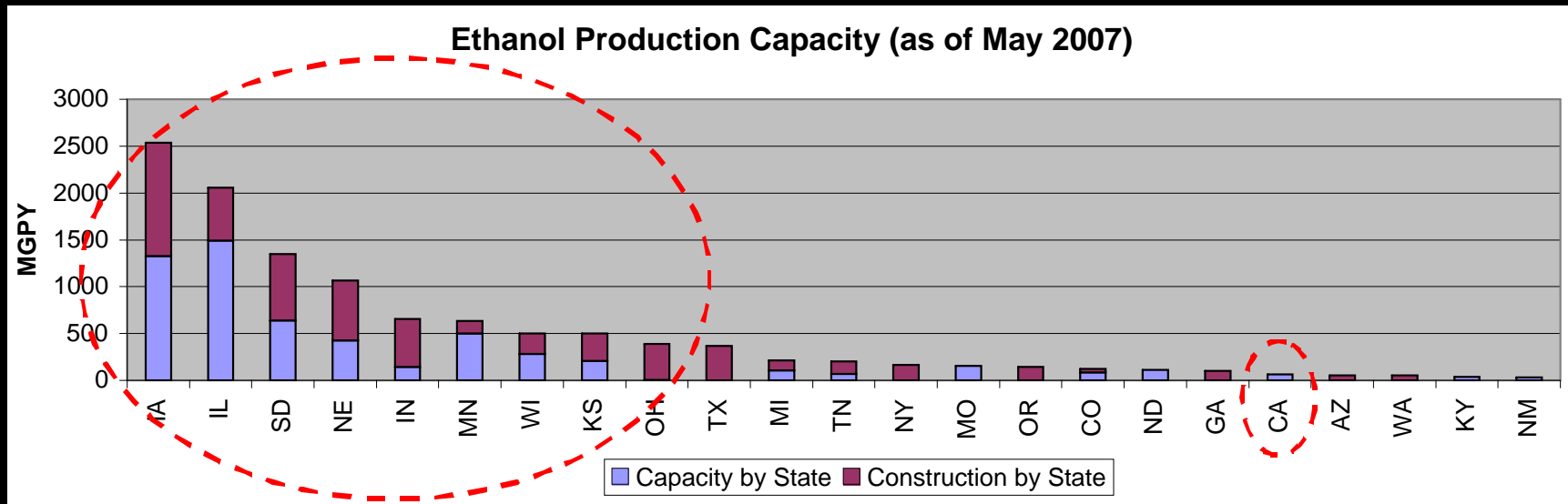


- Biomass-fired corn ethanol offers large reductions in GWI
- With emissions from land-use change it's still better than gasoline
- These fuels are ensured a premium to low-carbon markets

Life cycle GWI of Electricity by State



States Covered in the Model



- Top 9 states account for 80% of the ethanol capacity