

Uncertainty in the LCA of biofuels

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Hierarchy of Uncertainty

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Parametric

How do results in a particular model vary with uncertainty about parameter values?

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Model

How do results vary under competing models?

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Model

How do results vary under competing models?

Conceptualization

How well does the model answer the question at hand?

Possible questions

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I. What is the carbon intensity of fuel X?

Possible questions

1. What is the carbon intensity of fuel X?
2. What is the relative CI of fuel X vs fuel Y?

Possible questions

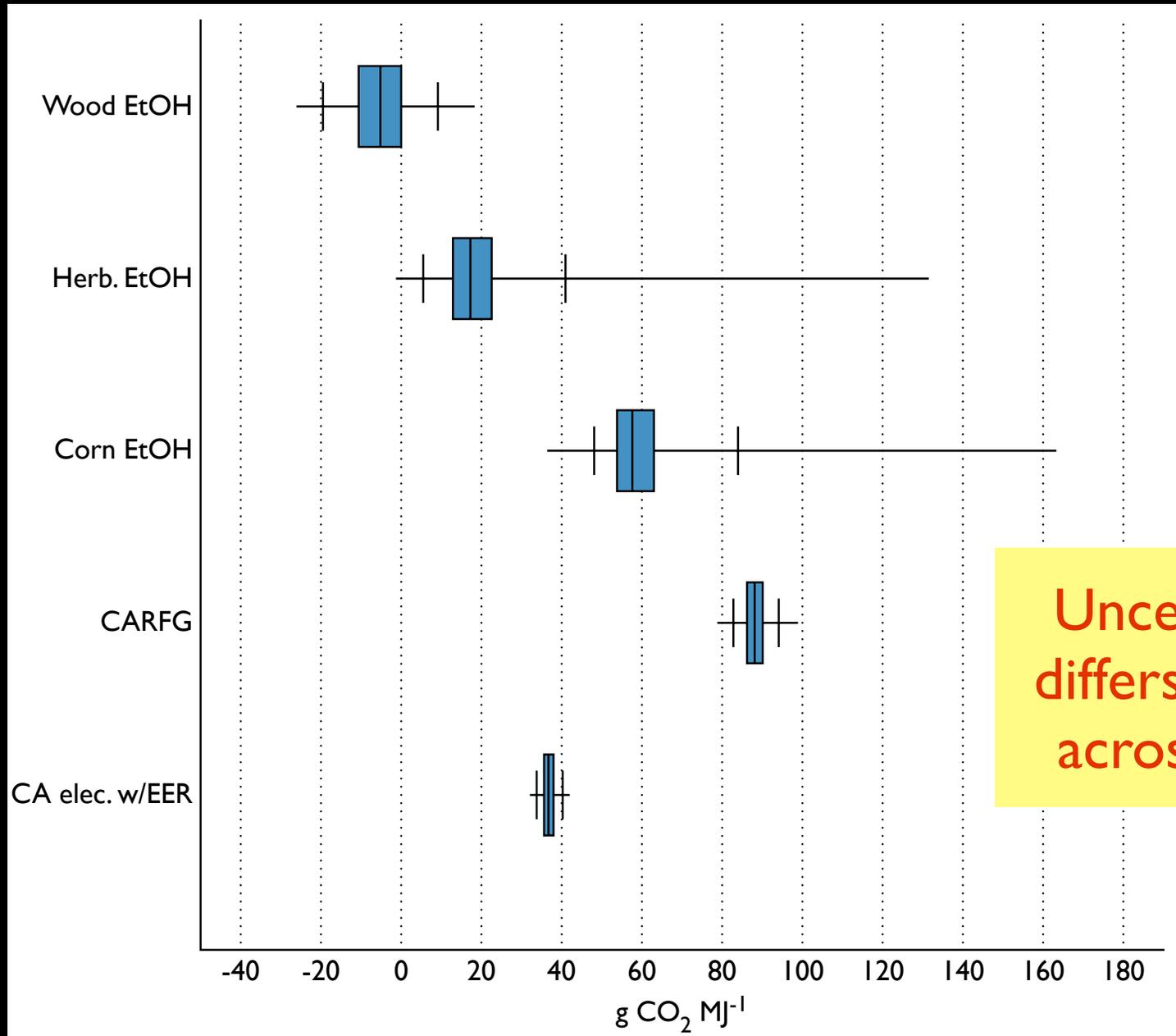
1. What is the carbon intensity of fuel X?
2. What is the relative CI of fuel X vs fuel Y?
3. What is the net global change in GHG emissions from producing more of fuel X?

Possible questions

1. What is the carbon intensity of fuel X?
2. What is the relative CI of fuel X vs fuel Y?
3. What is the net global change in GHG emissions from producing more of fuel X?
4. What is the probability that a world with policy X has a lower NPV of damages from climate change than a world without policy X?

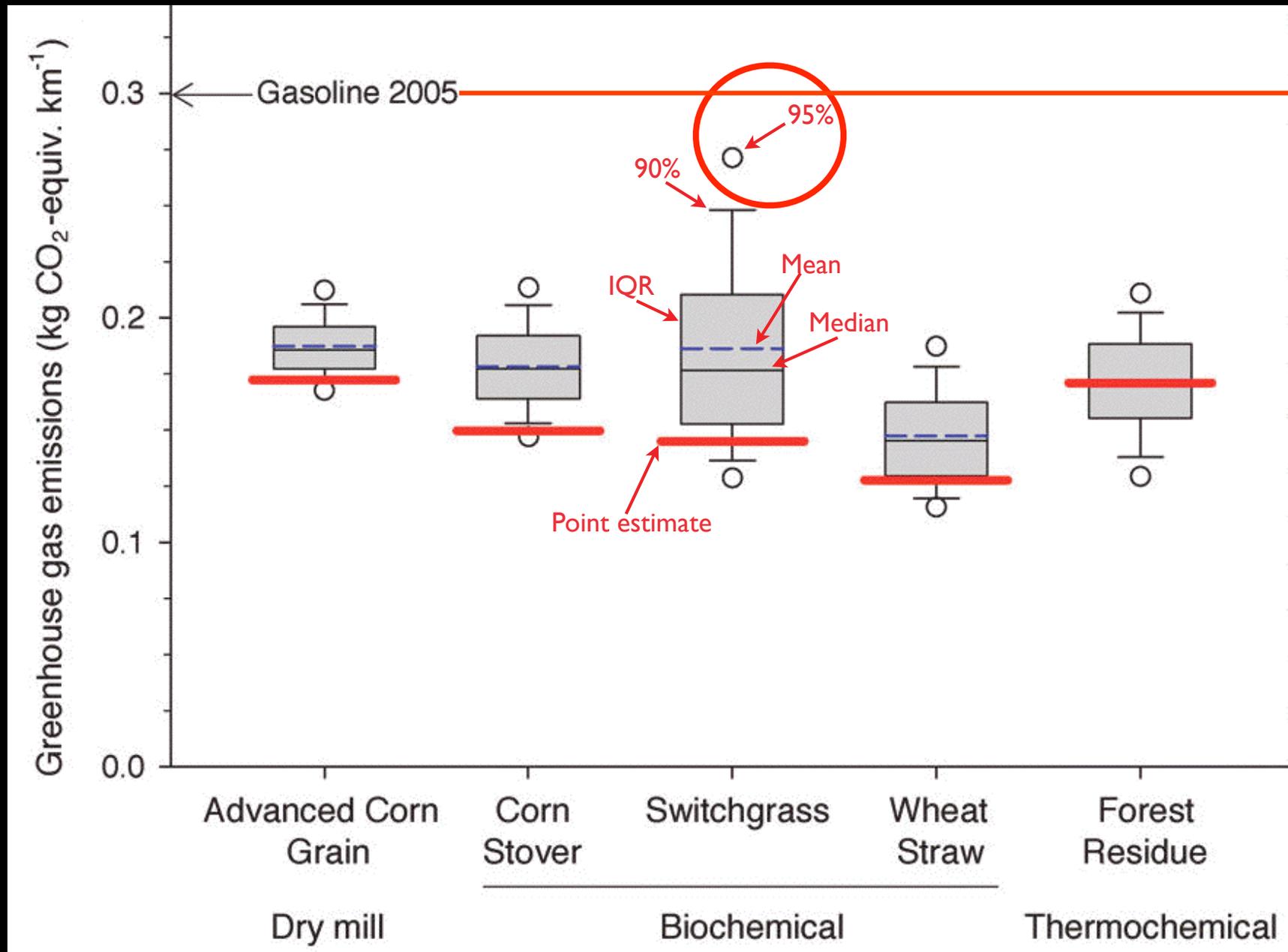
Parametric uncertainty

Attributional LCA uncertainty



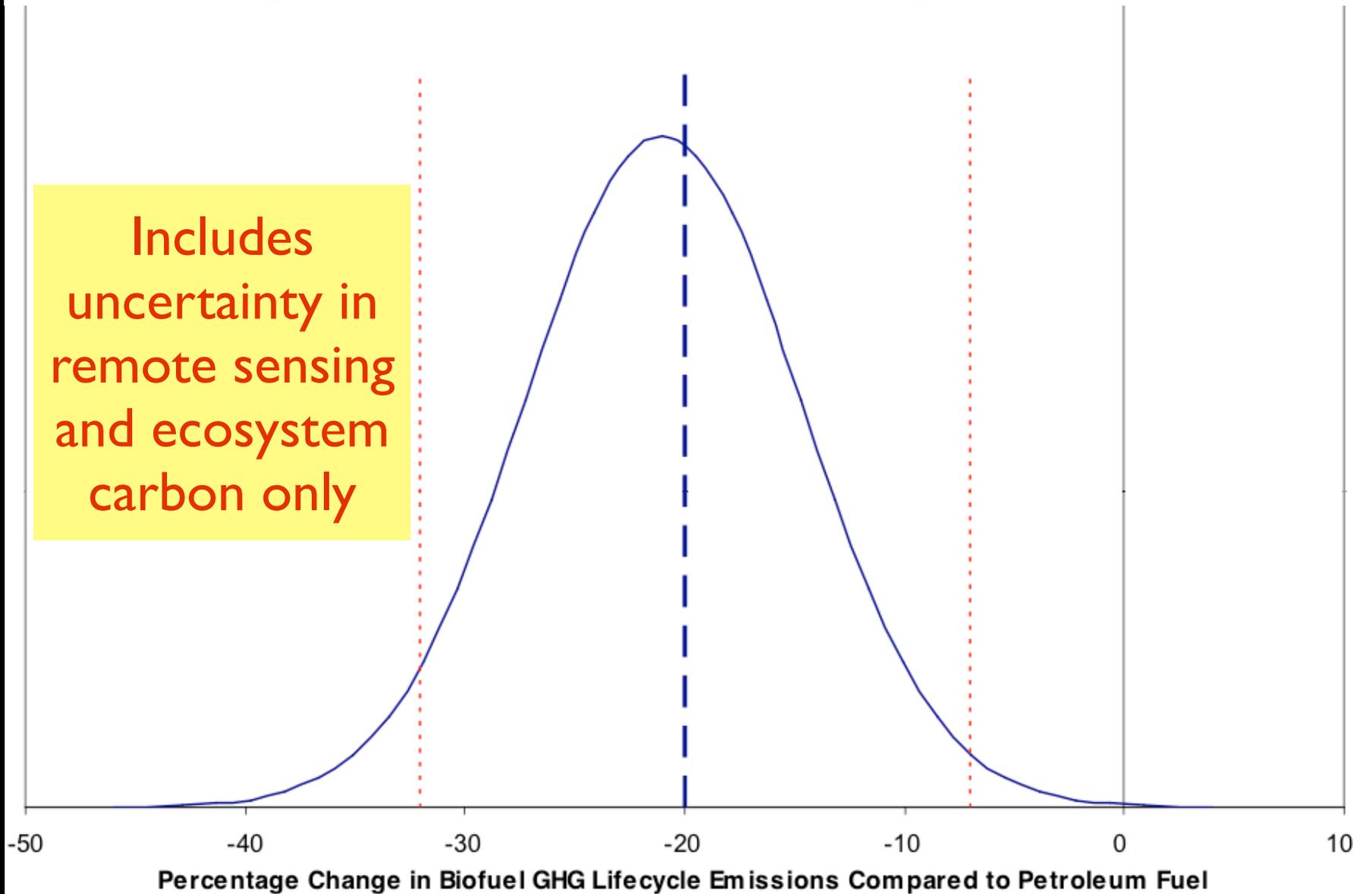
Uncertainty differs greatly across fuels

Attributional LCA uncertainty



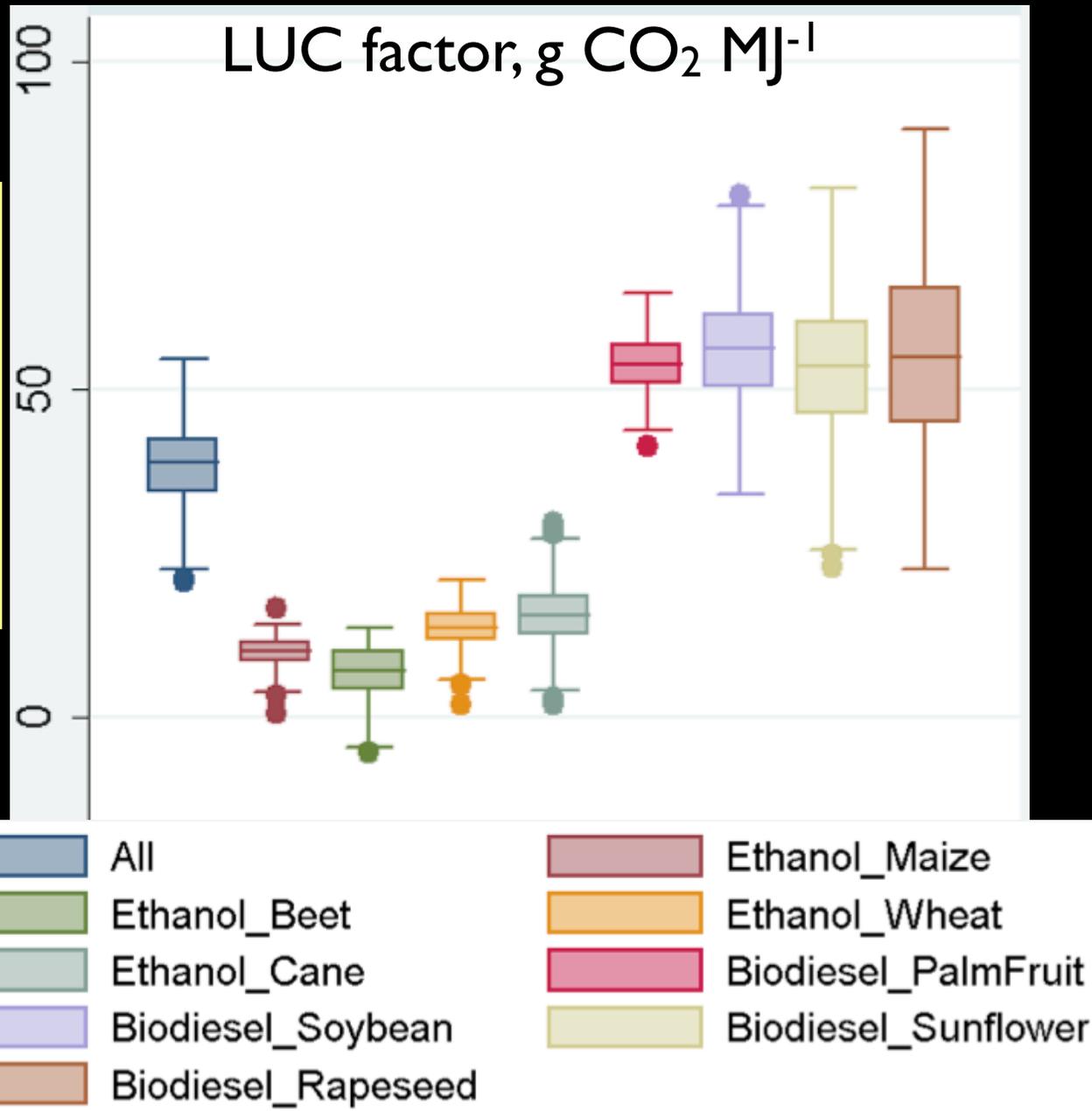
Partial ILUC uncertainty

2022 average corn ethanol, NG-fired dry mill, 37% wet DGs



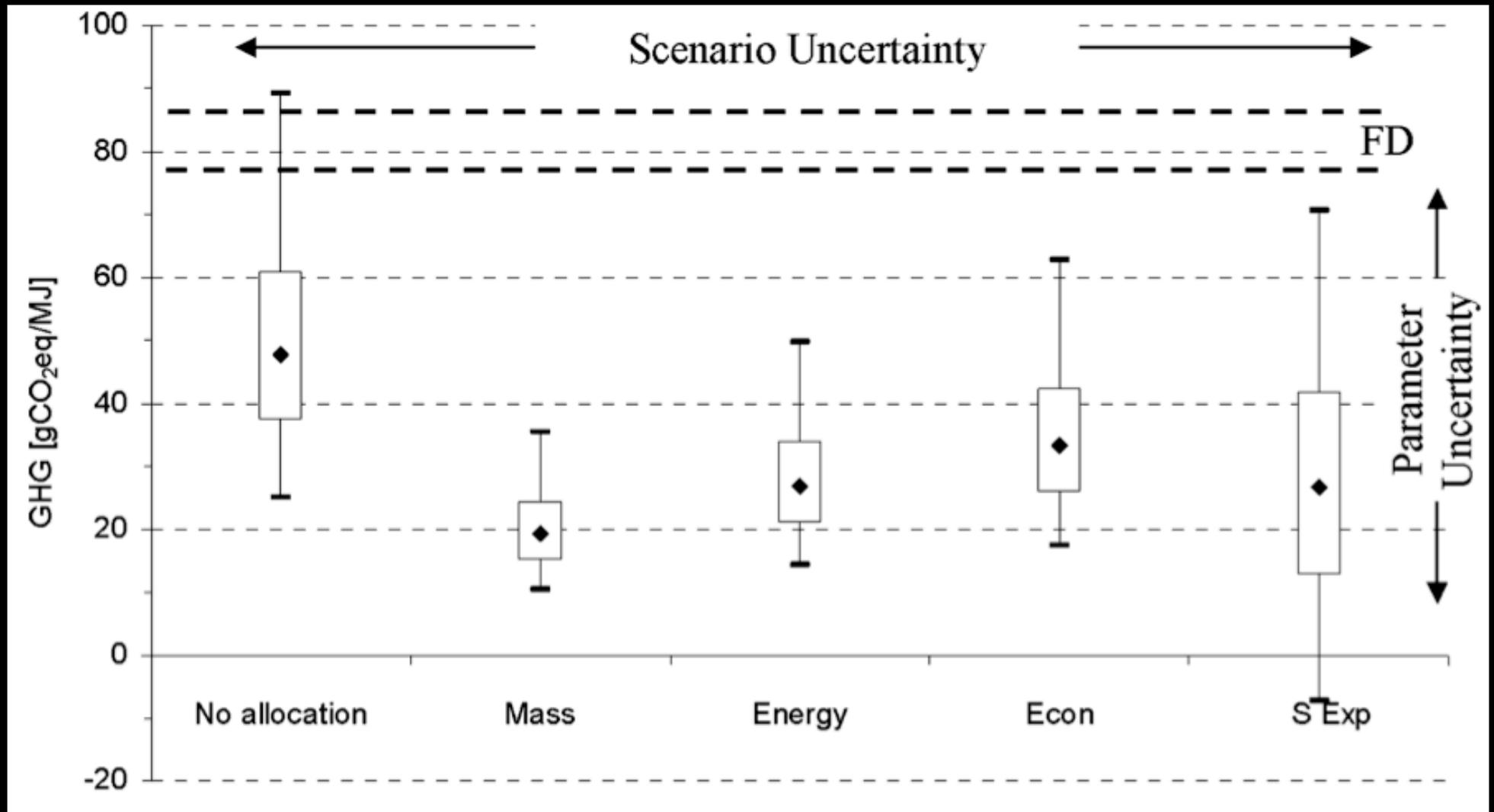
Partial ILUC uncertainty

Includes only
select
economic
model
parameters

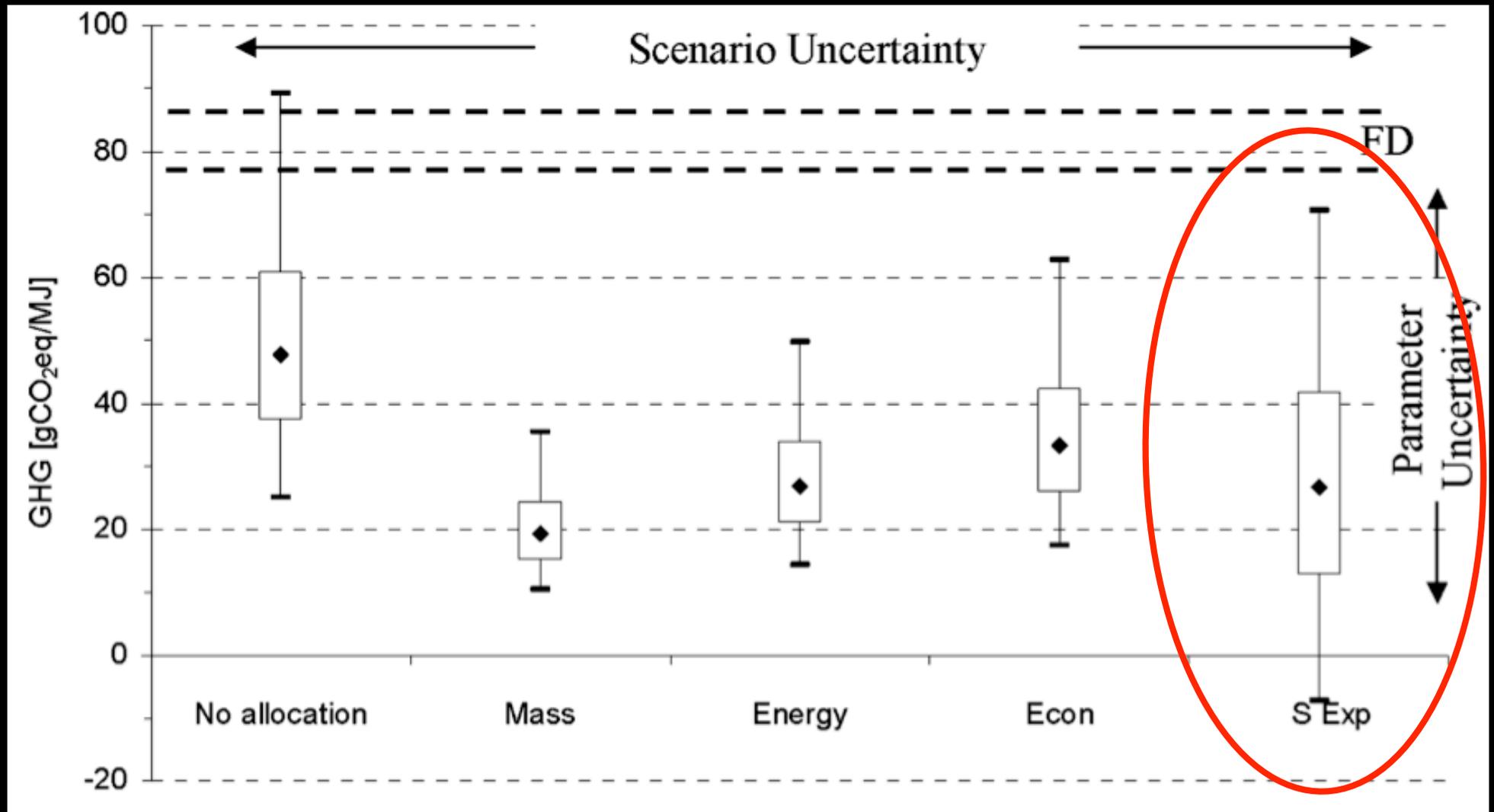


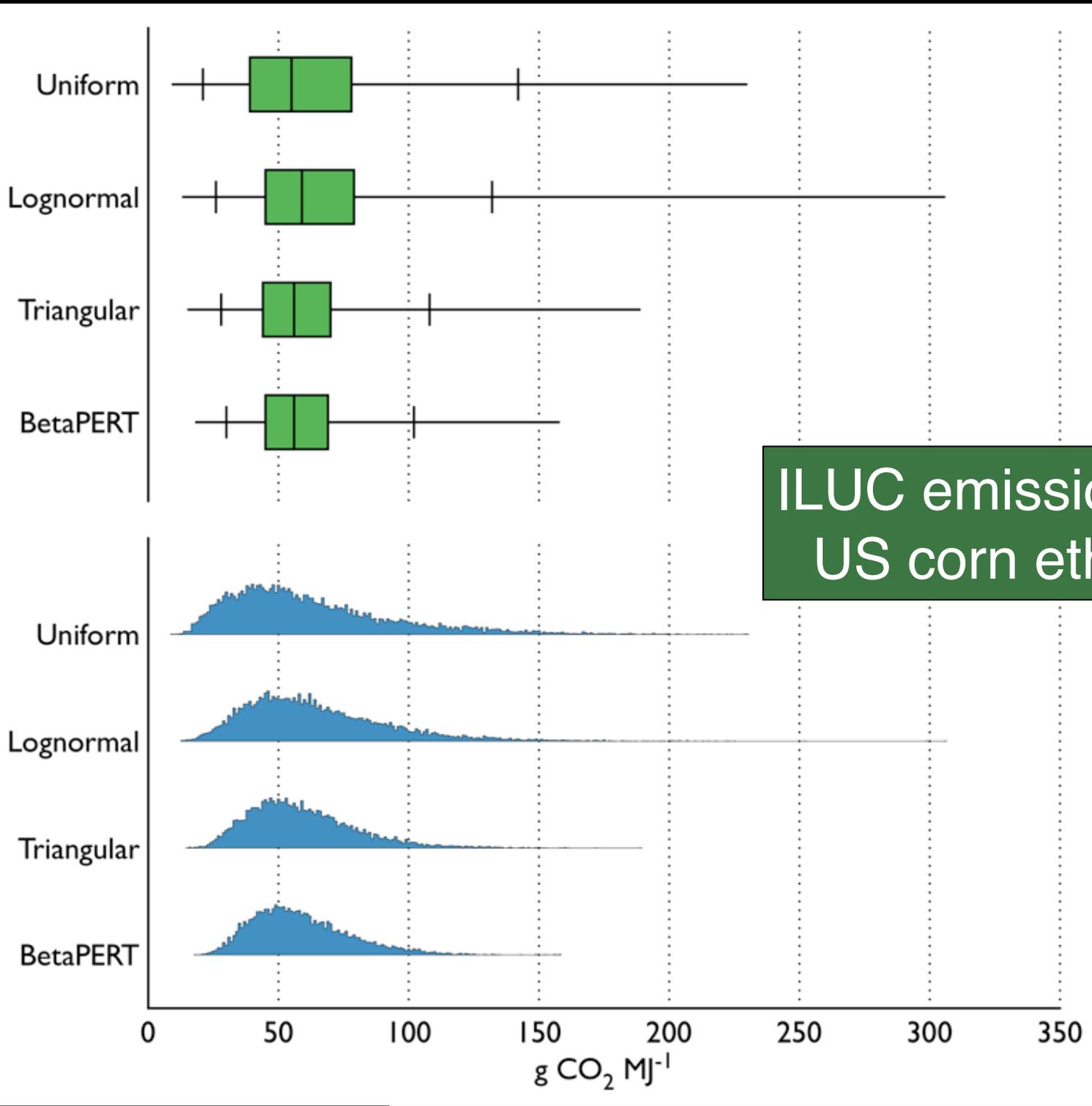
Model uncertainty

Rapeseed oil on set-aside land



Rapeseed oil on set-aside land





ILUC emissions for US corn ethanol

Ends of whiskers show max and min values; crossbars indicate 2.5 and 97.5 percentile values; green box indicates interquartile range; vertical line across box indicates median value.

Includes uncertainty in LUC emissions only

Source: Plevin et al. (2010)

Conceptualization uncertainty

How much GHG reduction?

CI of biofuel X is 20% lower than CI of gasoline



Biofuel X reduces GHG emissions by 20%

?

How much GHG reduction?

CI of biofuel X is 20% lower than CI of gasoline

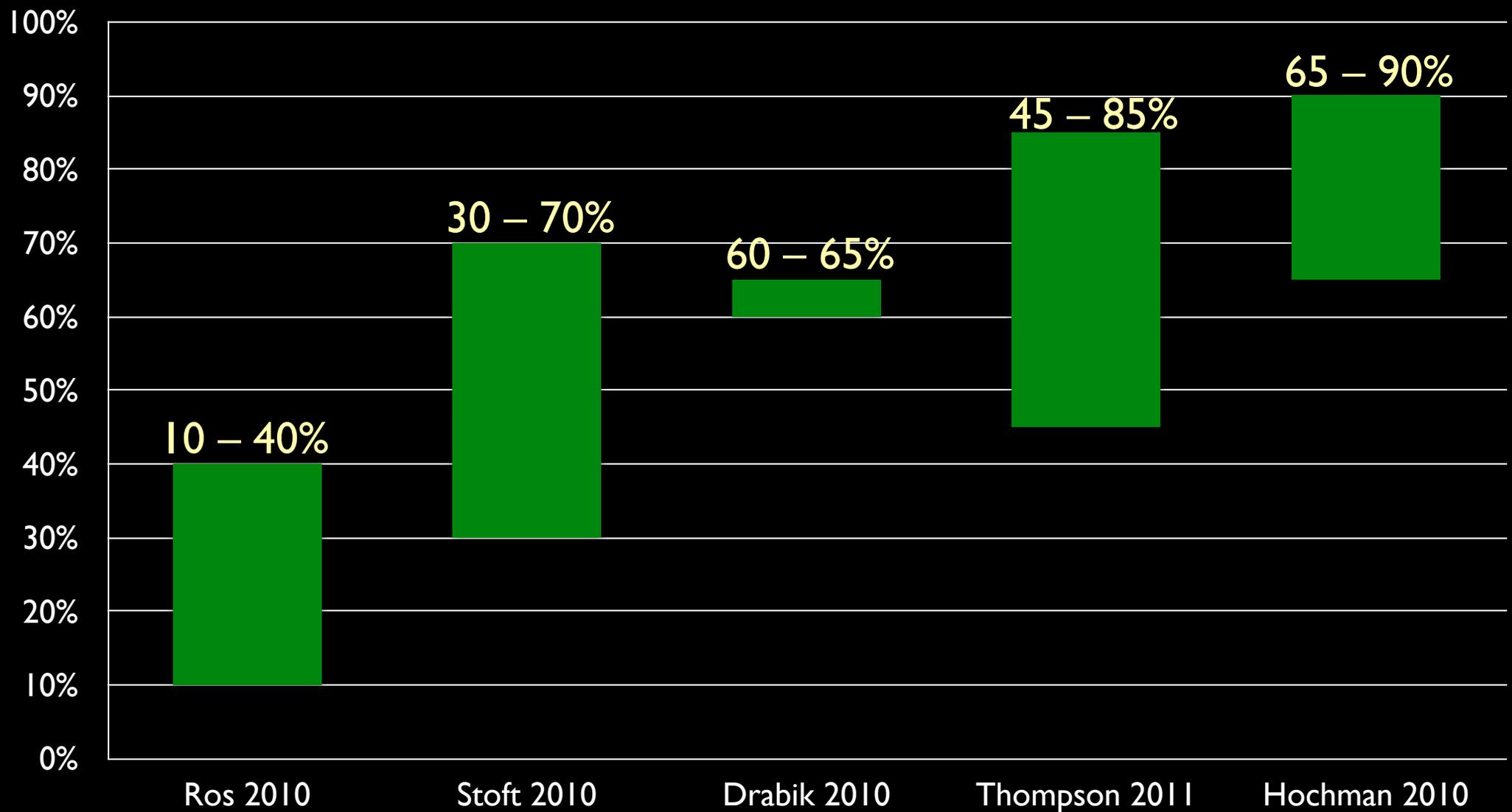


Biofuel X reduces GHG emissions by 20%

?

Only if there are no price effects in the fuel market

Recent estimates of rebound effect



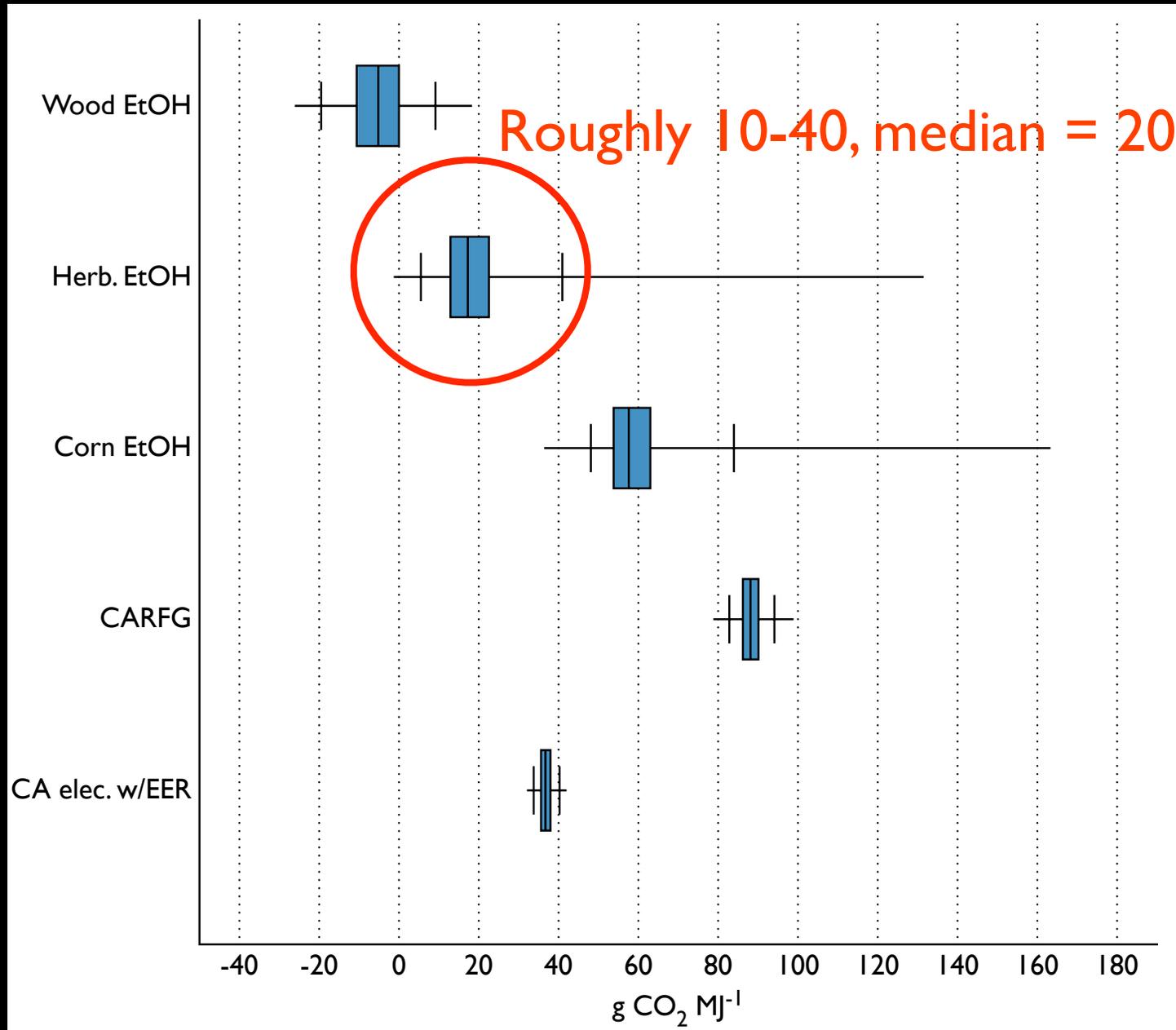
Large uncertainties

- Direct life cycle (mainly N₂O related)
- Indirect land use change
 - Magnitude and location
 - CO₂ from land conversion
 - GHG emissions from changes in production
- Quantity and type of fuel replaced by biofuels

Quick and dirty analysis

What are the global GHG consequences of producing switchgrass ethanol in the US?

Attributional LCA uncertainty



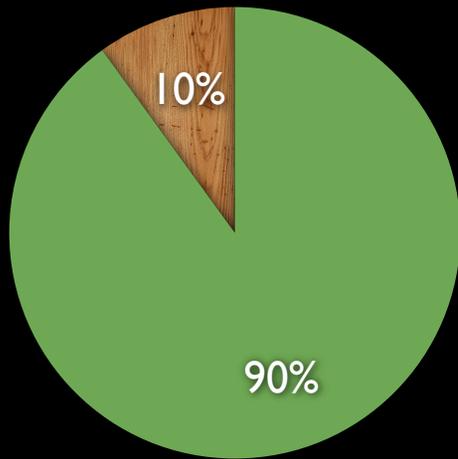
Switchgrass ILUC

Hectares of new cropland per 1000 gal



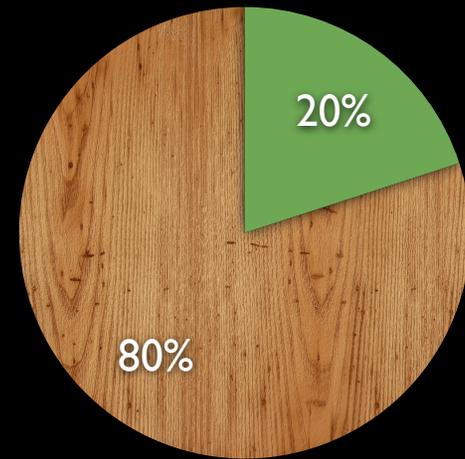
Switchgrass ILUC

Hectares of new cropland per 1000 gal



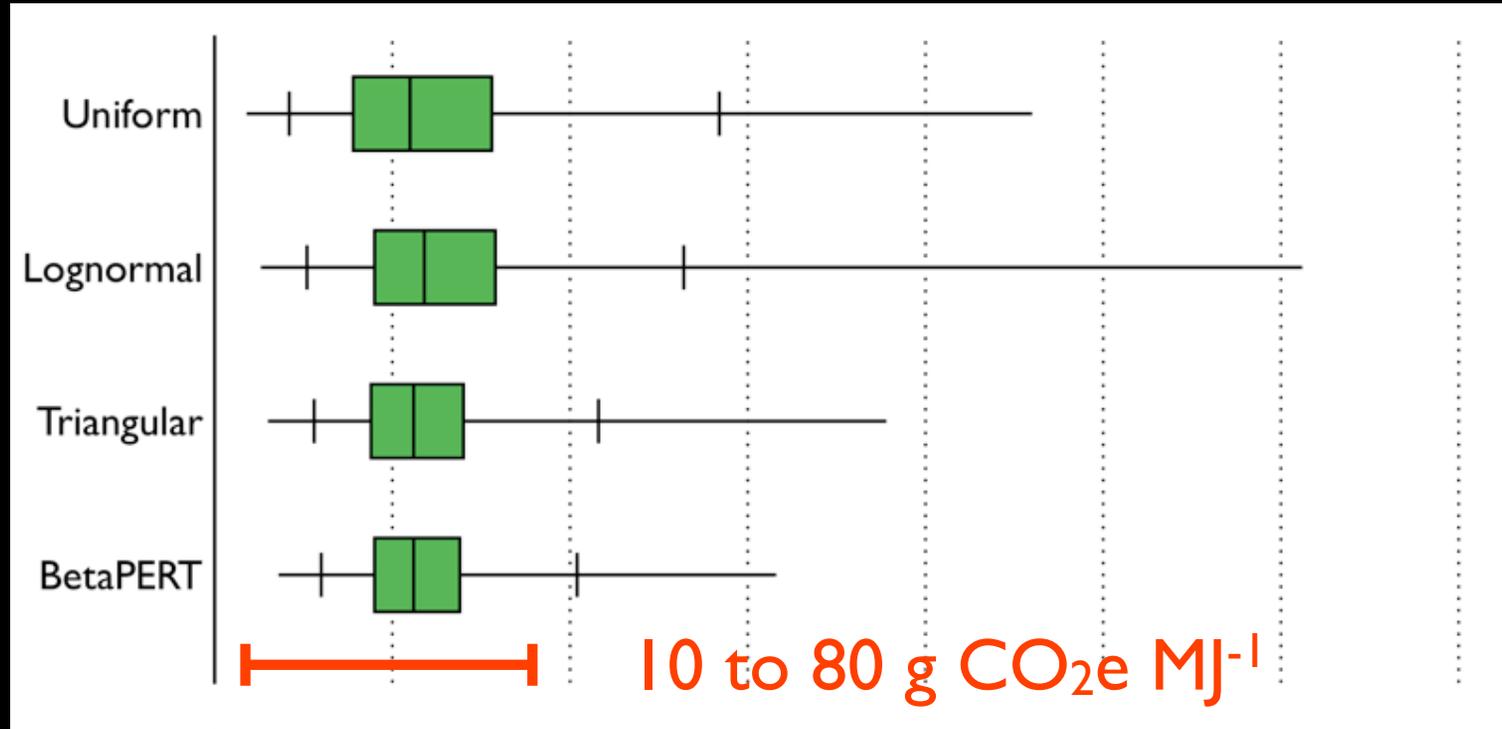
Corn Ethanol

● Pasture
● Forest

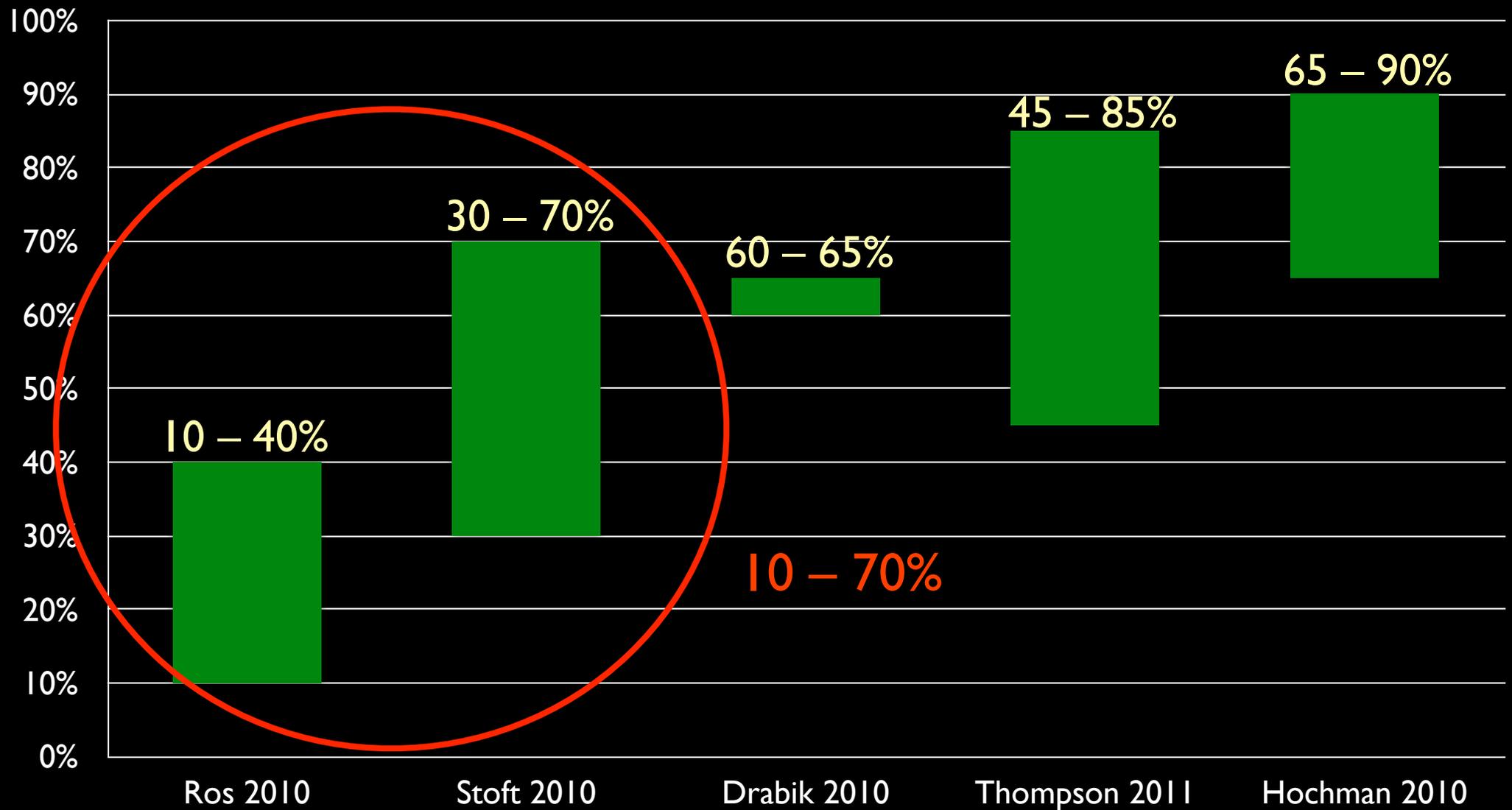


Switchgrass Ethanol

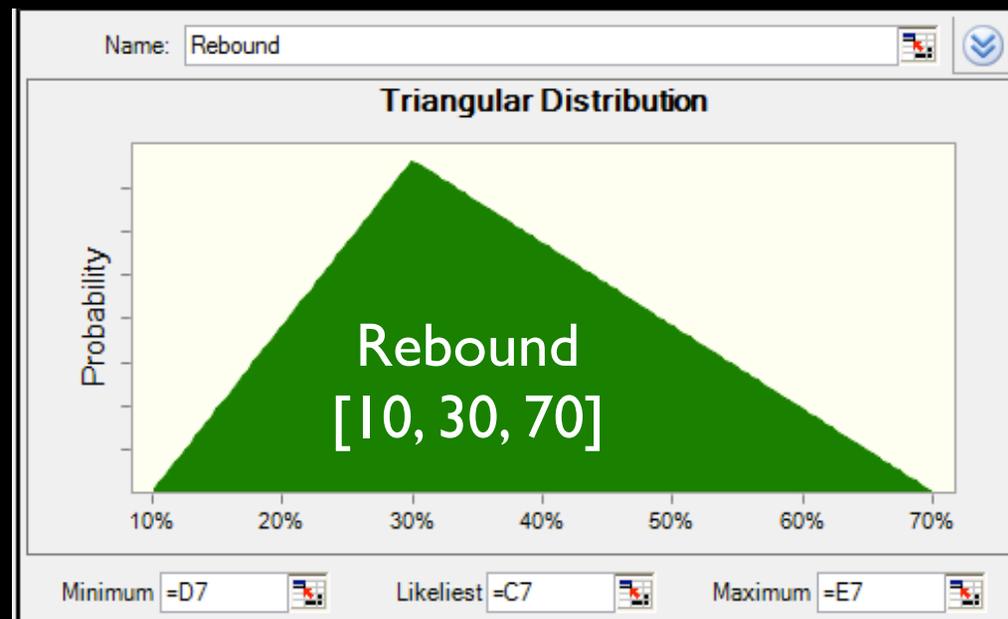
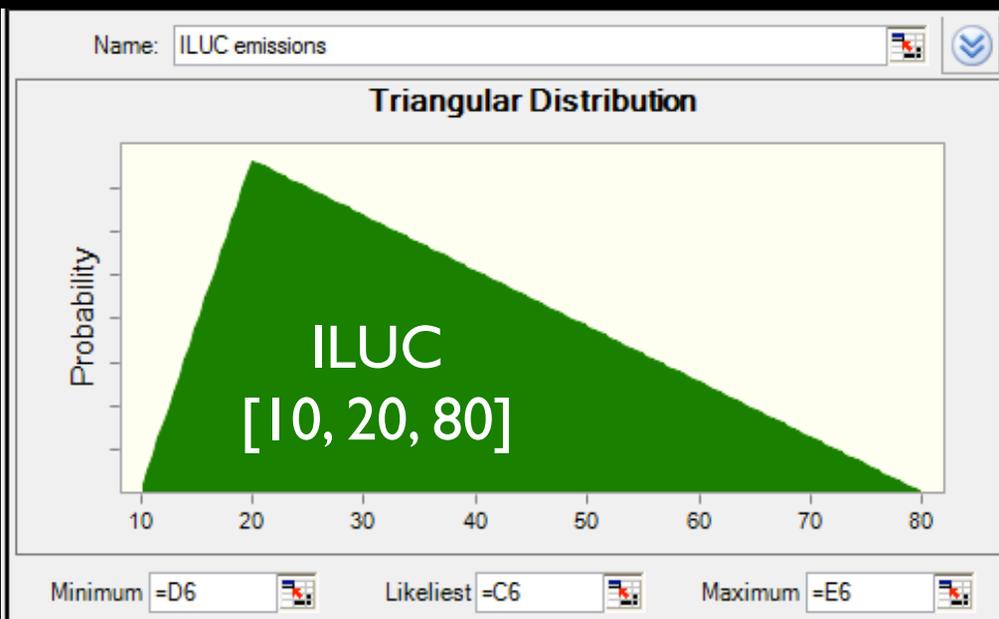
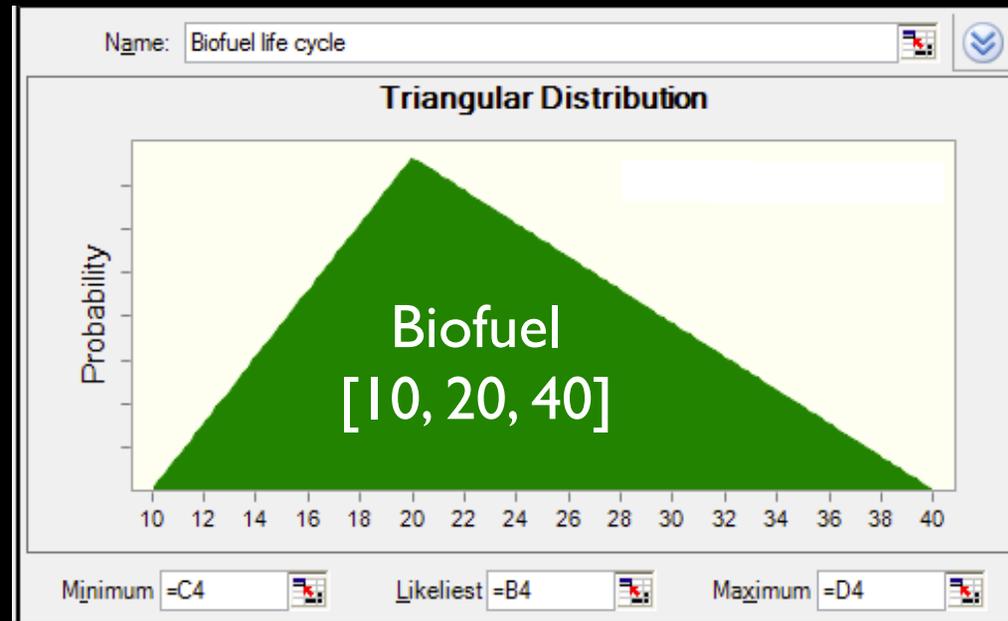
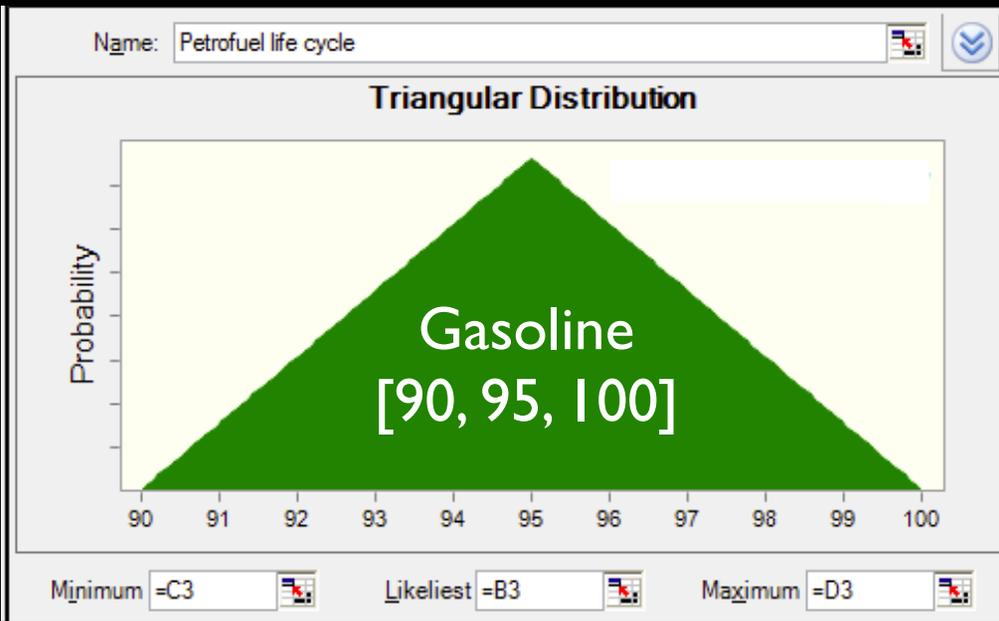
Switchgrass ILUC uncertainty



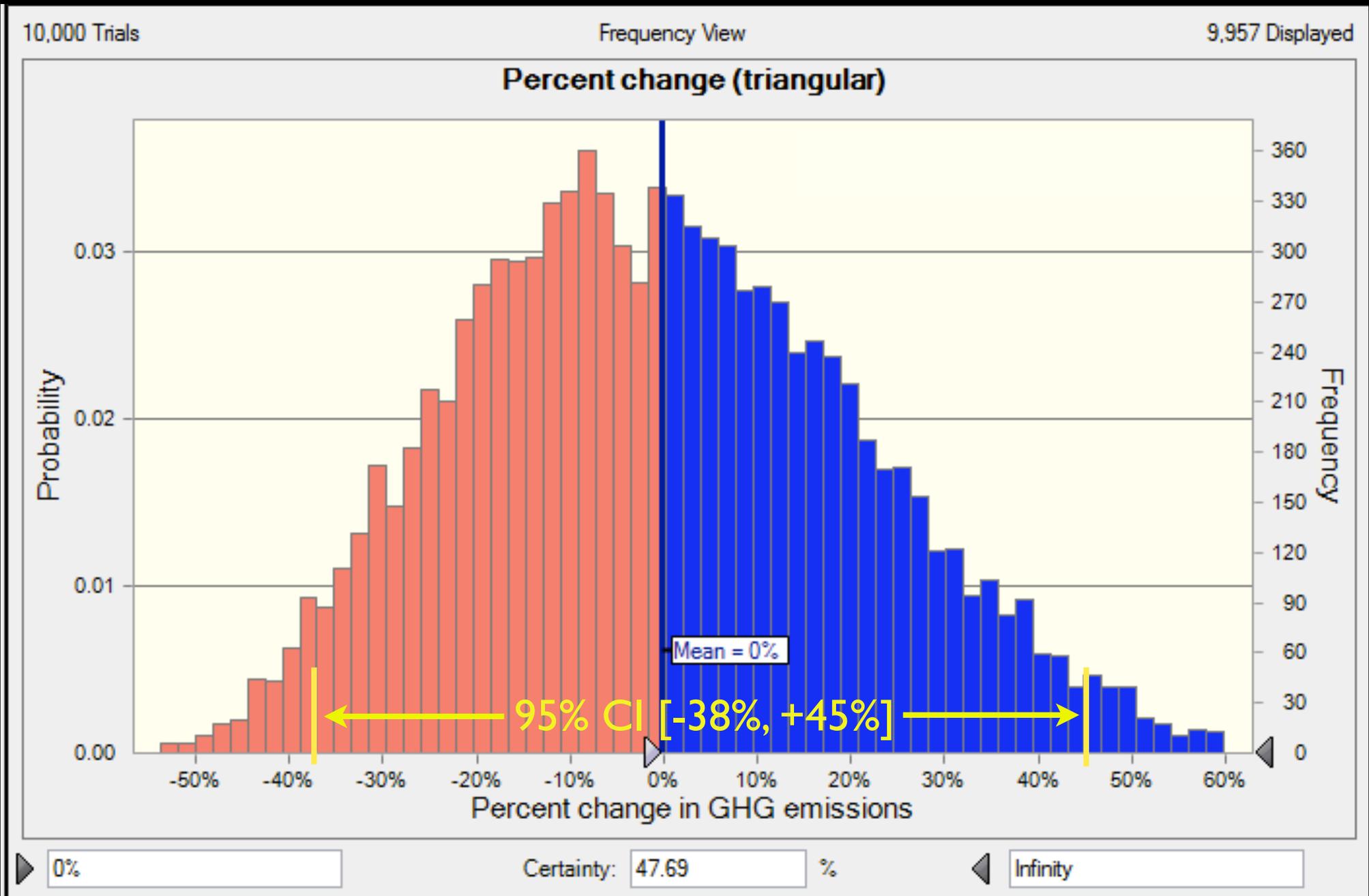
Rebound effect uncertainty



Direct + ILUC + rebound



Effect of cumulative uncertainty



Which definition to use for policy?

Analytical approach	Change in GHGs
Direct LCA	-79%
Incl. ILUC	-58%
Incl. ILUC and rebound	-28%
Stochastic mean (triangular)	0%
95% confidence interval	-38% to +45%

Challenges

- What is the right metric for a performance standard?
- How can we best incorporate uncertainty?
- What are the risks of over- versus under-counting emissions?

Thank you.

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