

# Role of Uncertainty in LCA: Evaluation of Corn Ethanol and Biodiesel GHG Emissions

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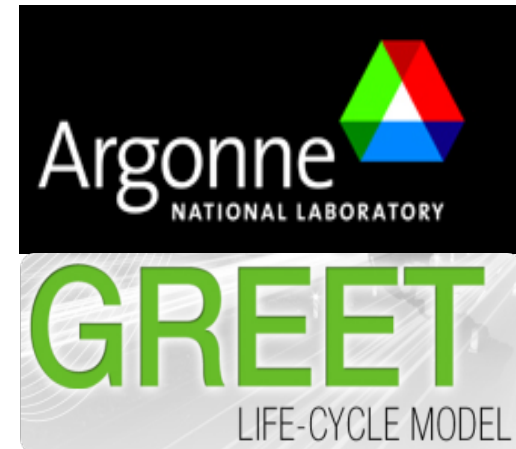
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# Goals

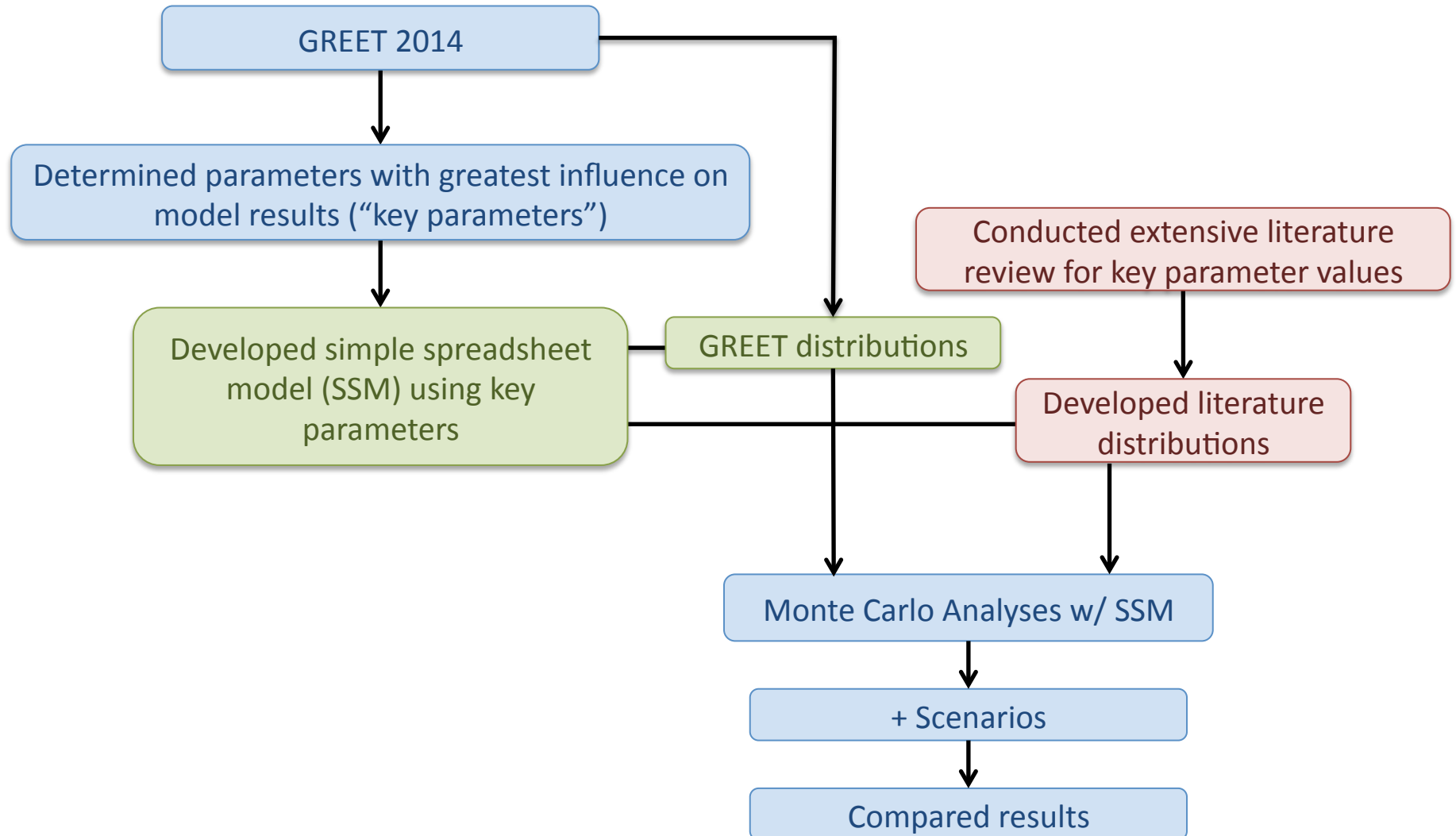
- Use a standard, accepted model structure to compare results for a biofuels pathway versus plausible values for important parameters from the peer reviewed literature.
- Determine the overall uncertainty related to “key parameters” using this structure and plausible parameter values.

# Framework

- GREET: The *defacto* gold standard
- Basis for decision-making in the US (RFS2, CARB LCFS)
- Updated frequently - GREET 2014
- Most often used deterministically, although has a stochastic module



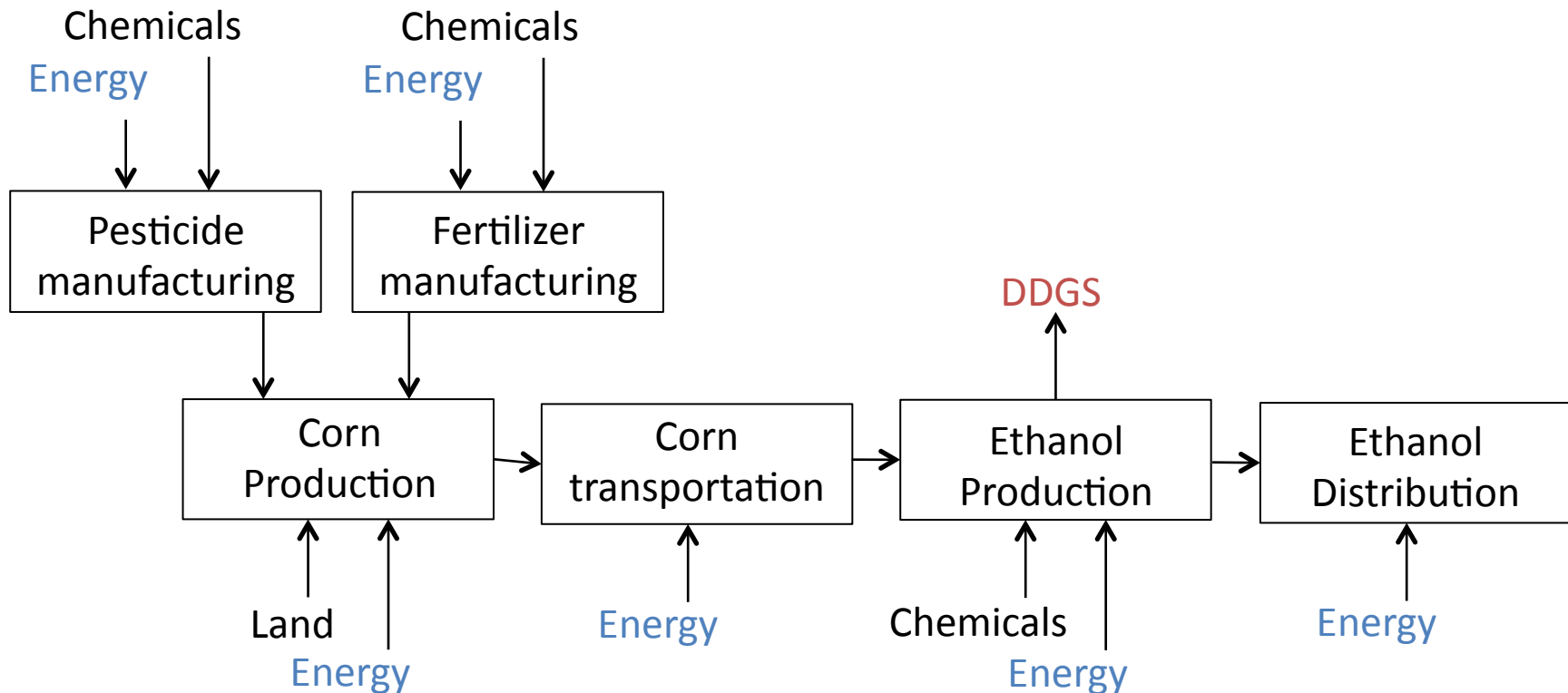
# Approach



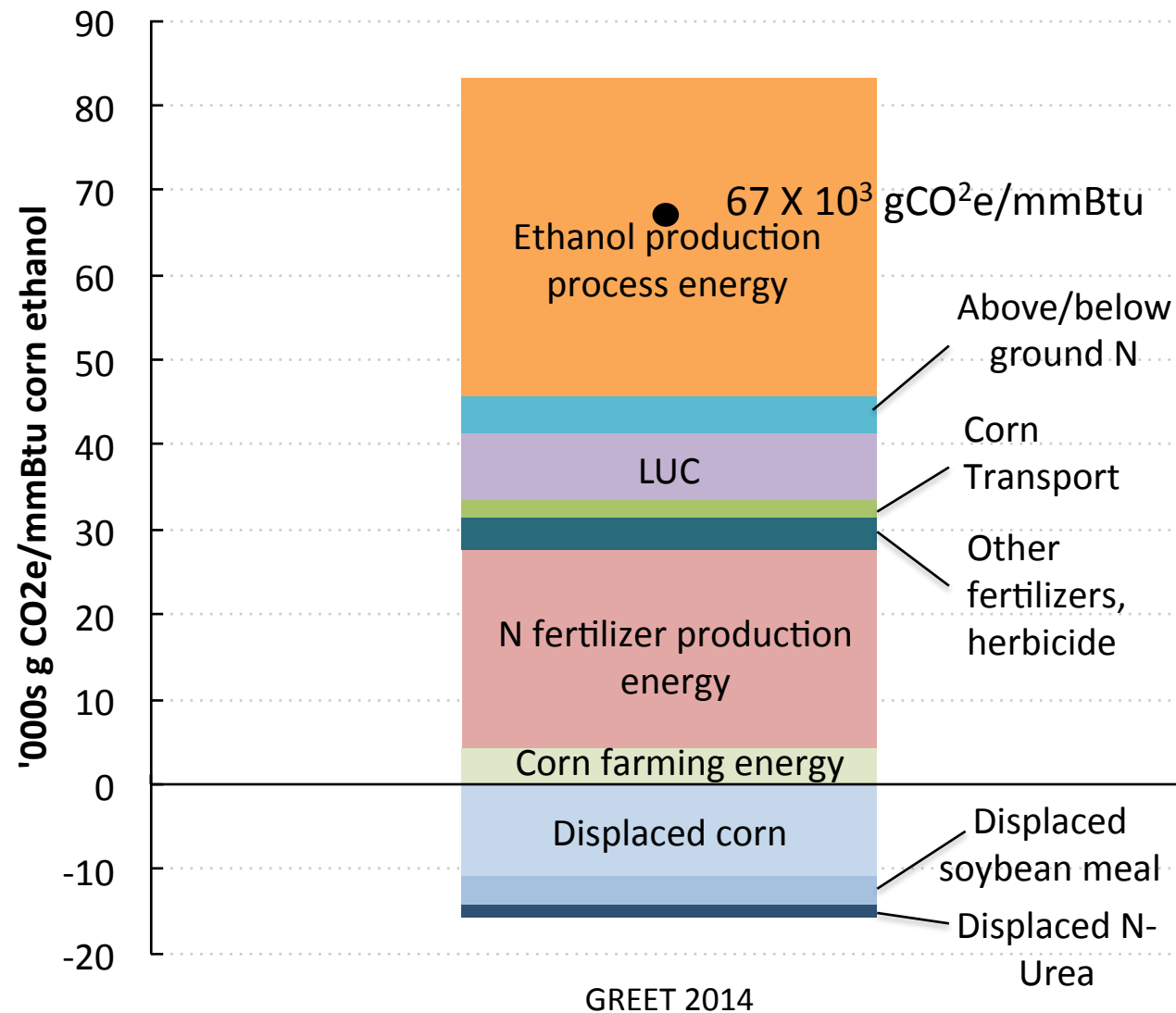
# Corn Ethanol Process

- Dry mill corn ethanol plant with DDGS as sole co-product
- Process fuel - natural gas
- Grid-supplied electricity; Midwest Reliability Organization (MRO)
- 2010 base year for simulation (GREET default)
- Co-product credits allocated by displacement method (displacement of corn grain animal feed with DDGS)

# Corn Ethanol Production (WTP)



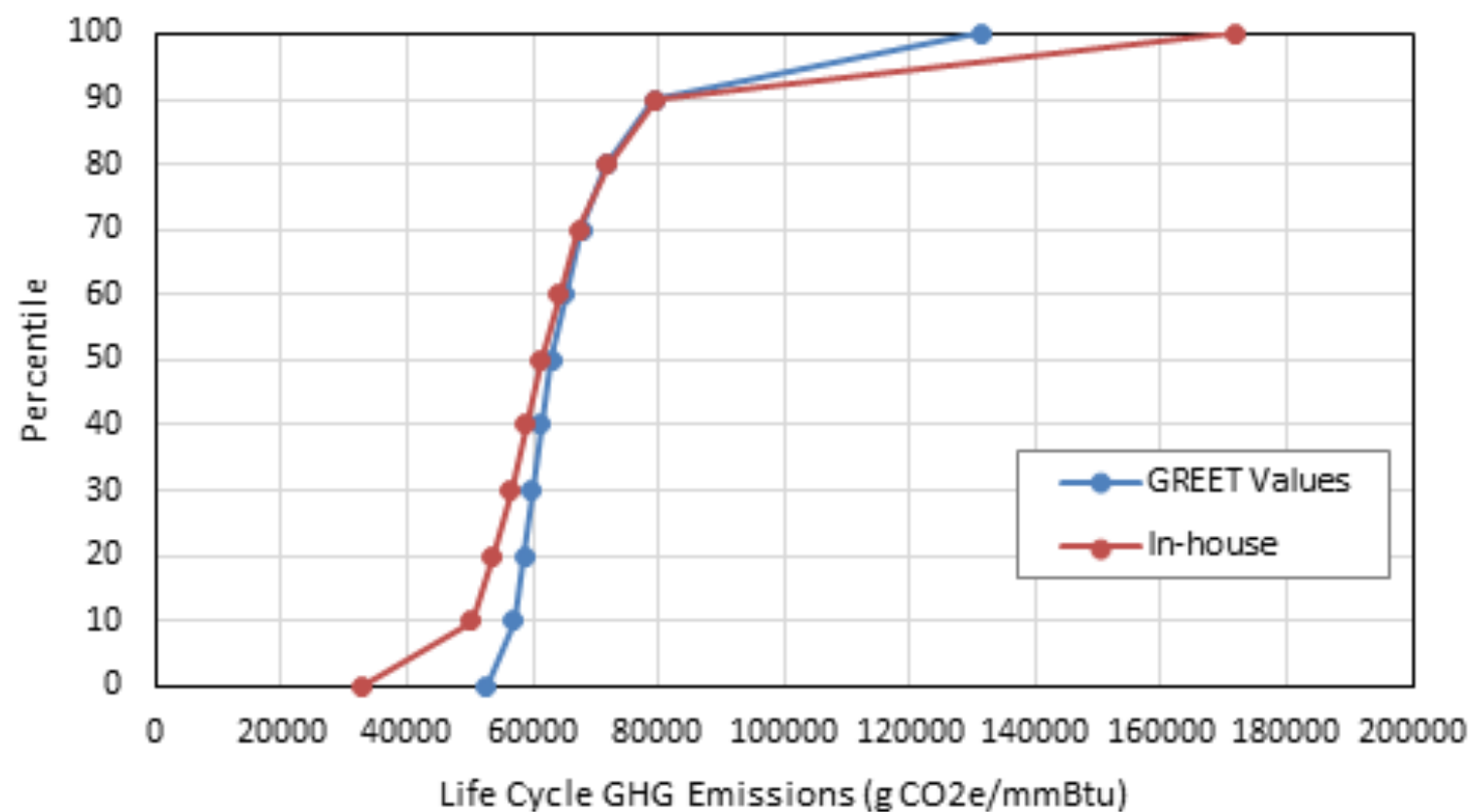
# Contribution of Parameters and Key Parameters – Corn Ethanol



## Key Parameters:

1. Corn farming energy
2. Application rate of N fertilizer
3. N<sub>2</sub>O emission rate
4. Ethanol production process energy
5. Process yield
6. LUC\*

GREET 2014 Distribution, WTP EtOH, Cumulative

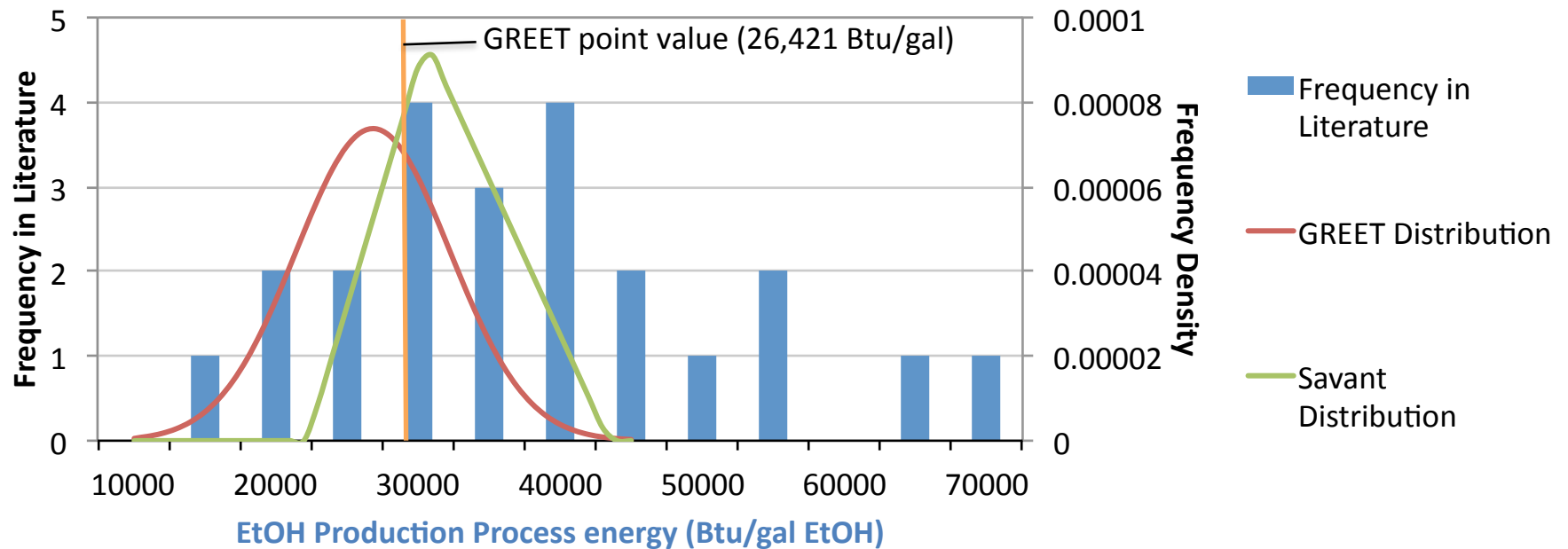




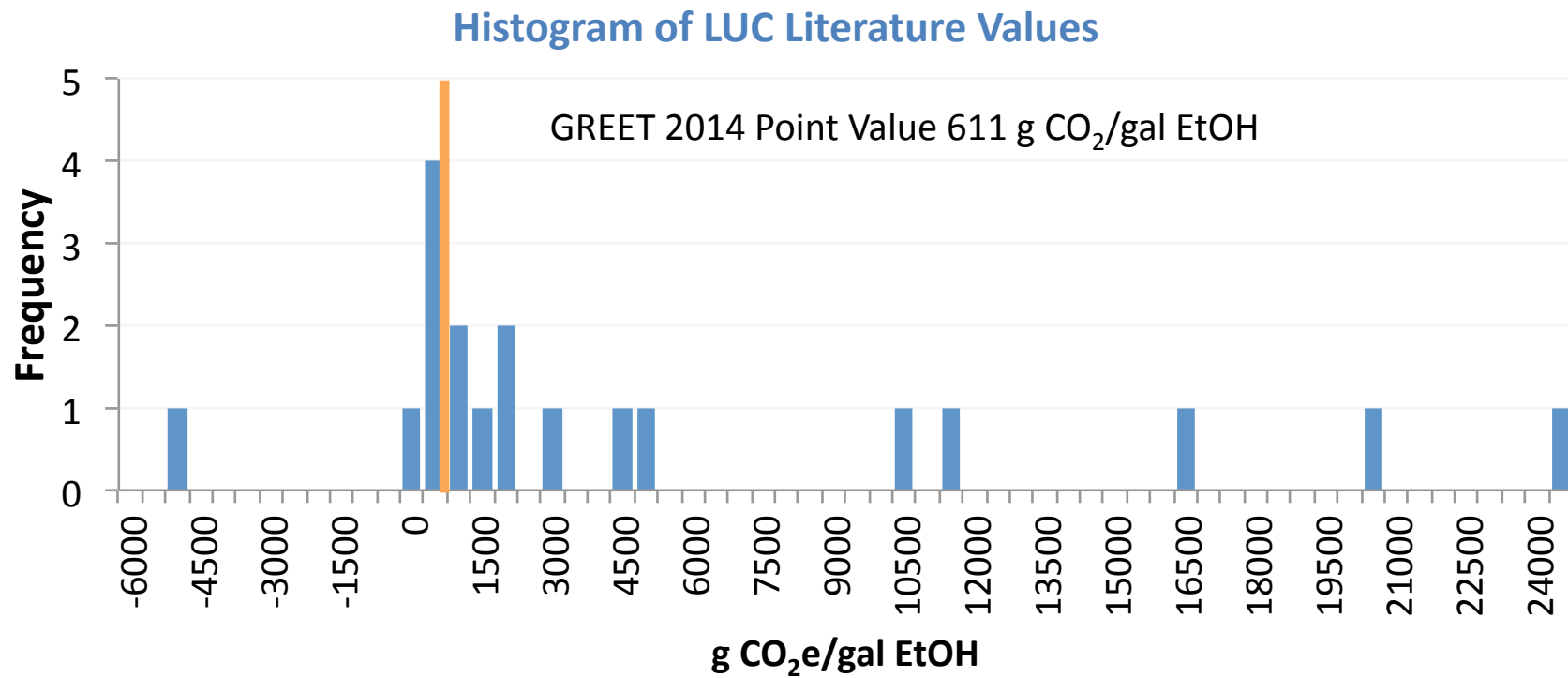
# Summary of Literature

Parameter	Total Relevant Literature
N-Fertilizer	24
N <sub>2</sub> O-N	21
Corn Yield	24
Corn Farm Energy	22
LUC	11
Ethanol Yield	27
Process Energy	20
DDGS Yield	19

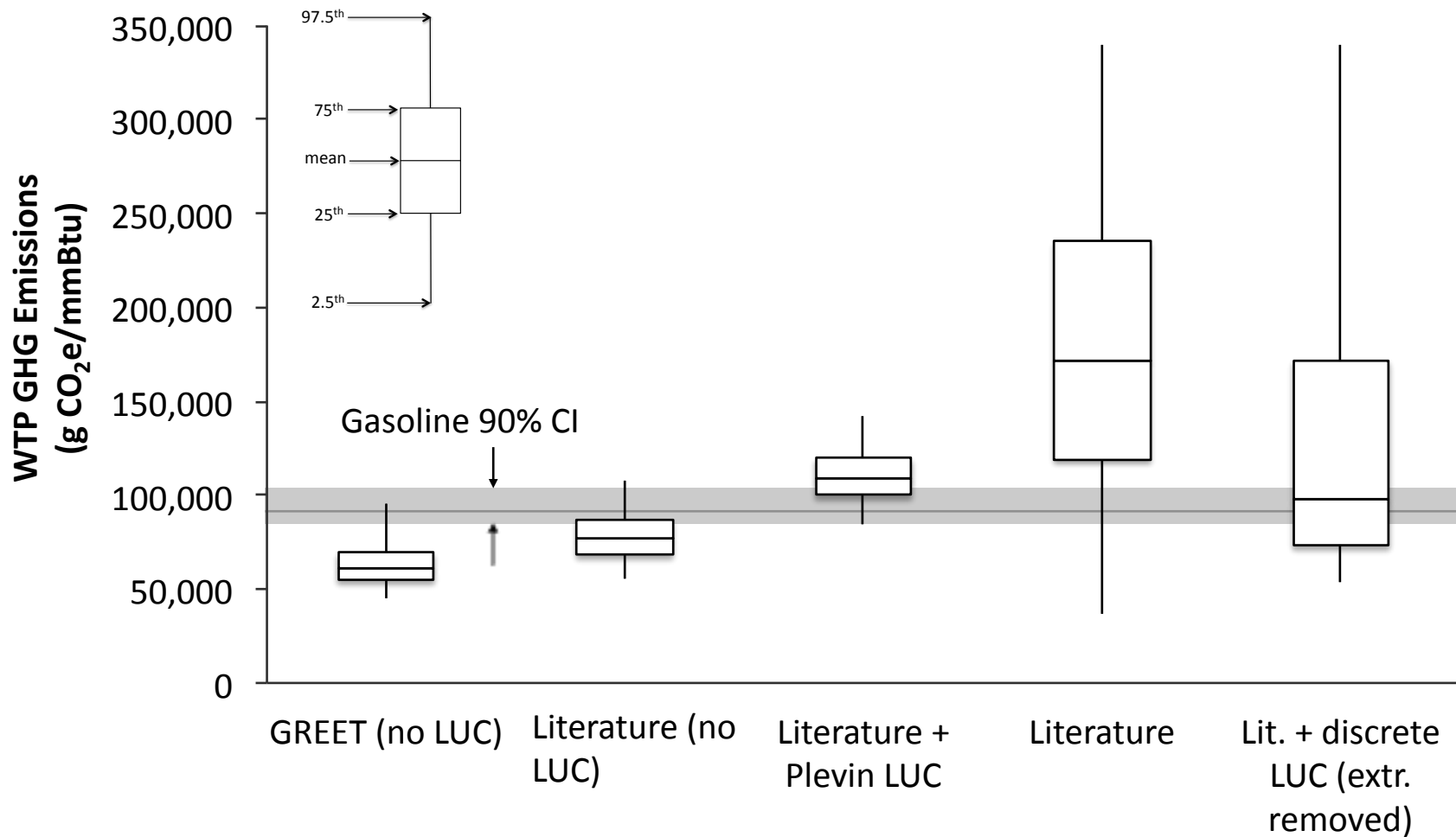
# Sample Parameter Distributions – Corn Ethanol



# LUC – Corn Ethanol



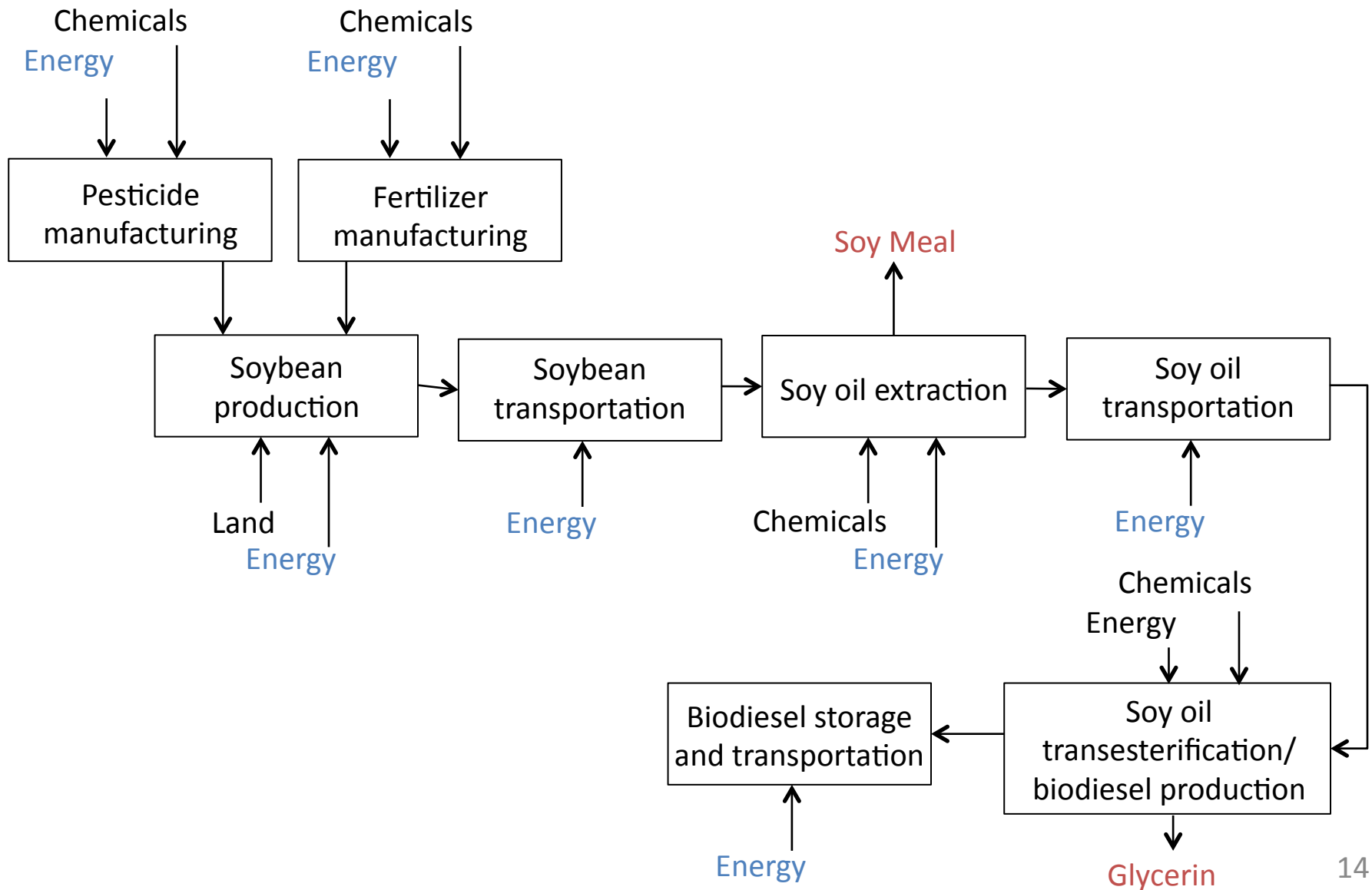
# Monte Carlo Analysis – Corn Ethanol



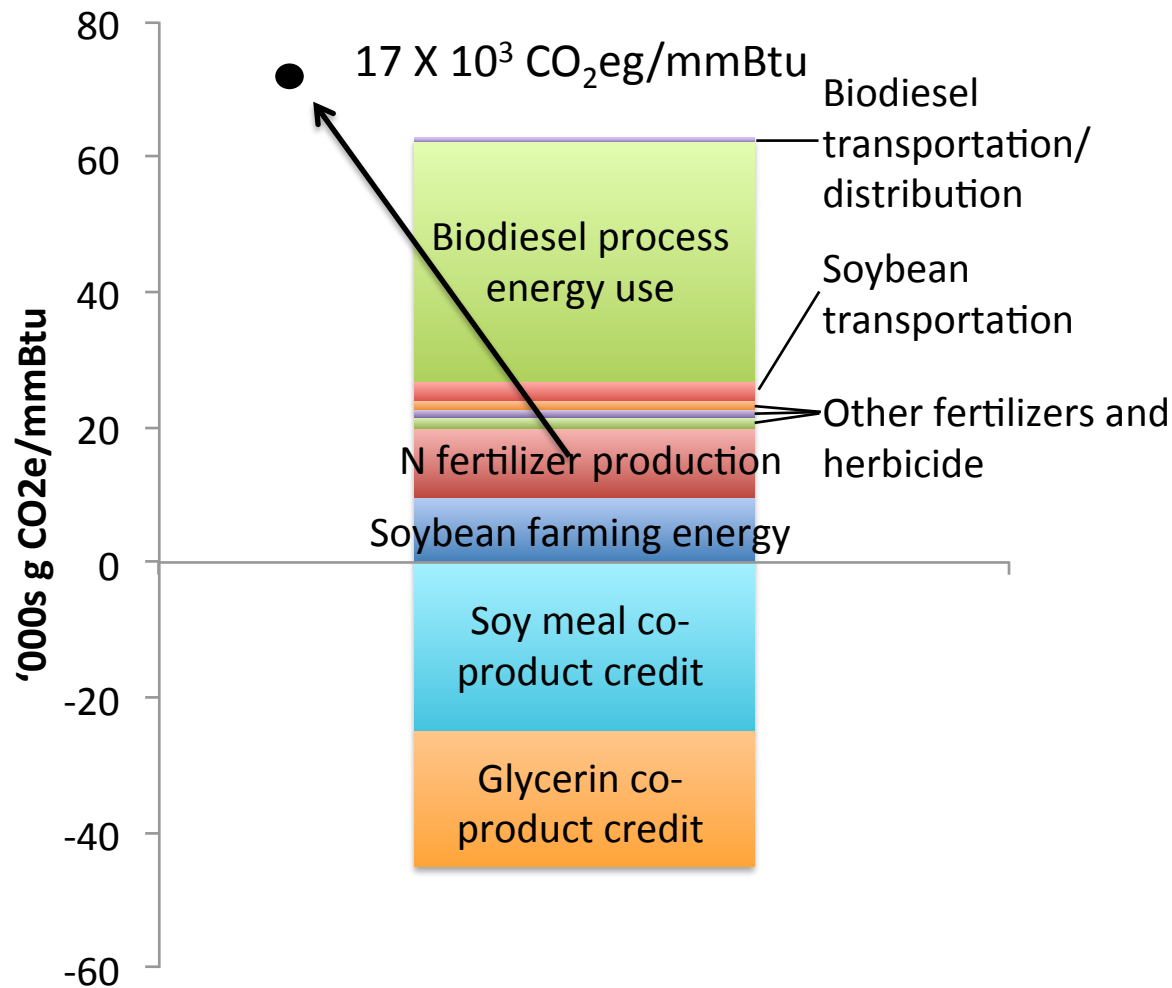
# Soybean Biodiesel Process

- Soybean feedstock
- Grid-supplied Midwest Reliability Organization (MRO) electricity used for process energy
- 2010 was selected as the base year of simulation
- Co-products are soymeal and glycerin
- Co-product credits allocated using displacement method
  - Some question of which product is being displaced, particularly in the case of glycerin
  - Used RFO per EPA RIA (2010)

# Soybean Biodiesel Production



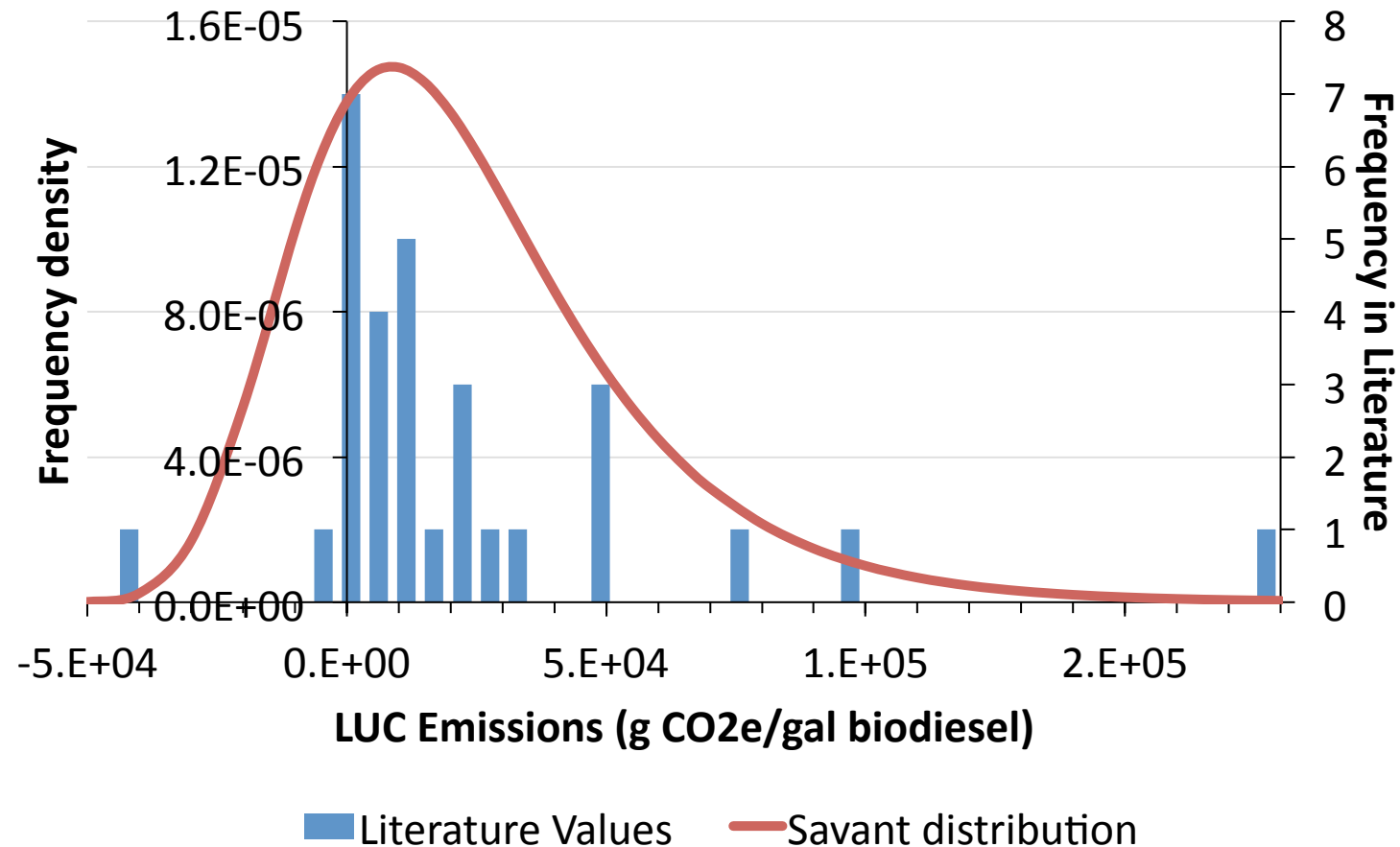
# Contribution of Parameters and Key Parameters – Soybean Biodiesel



## Key Parameters:

1. Soybean farming energy use
2. Application rate of N fertilizer
3. N<sub>2</sub>O emission rate
4. Biodiesel process energy (soy oil extraction, transesterification)
5. Process yield
6. LUC\*
7. Co-product yield

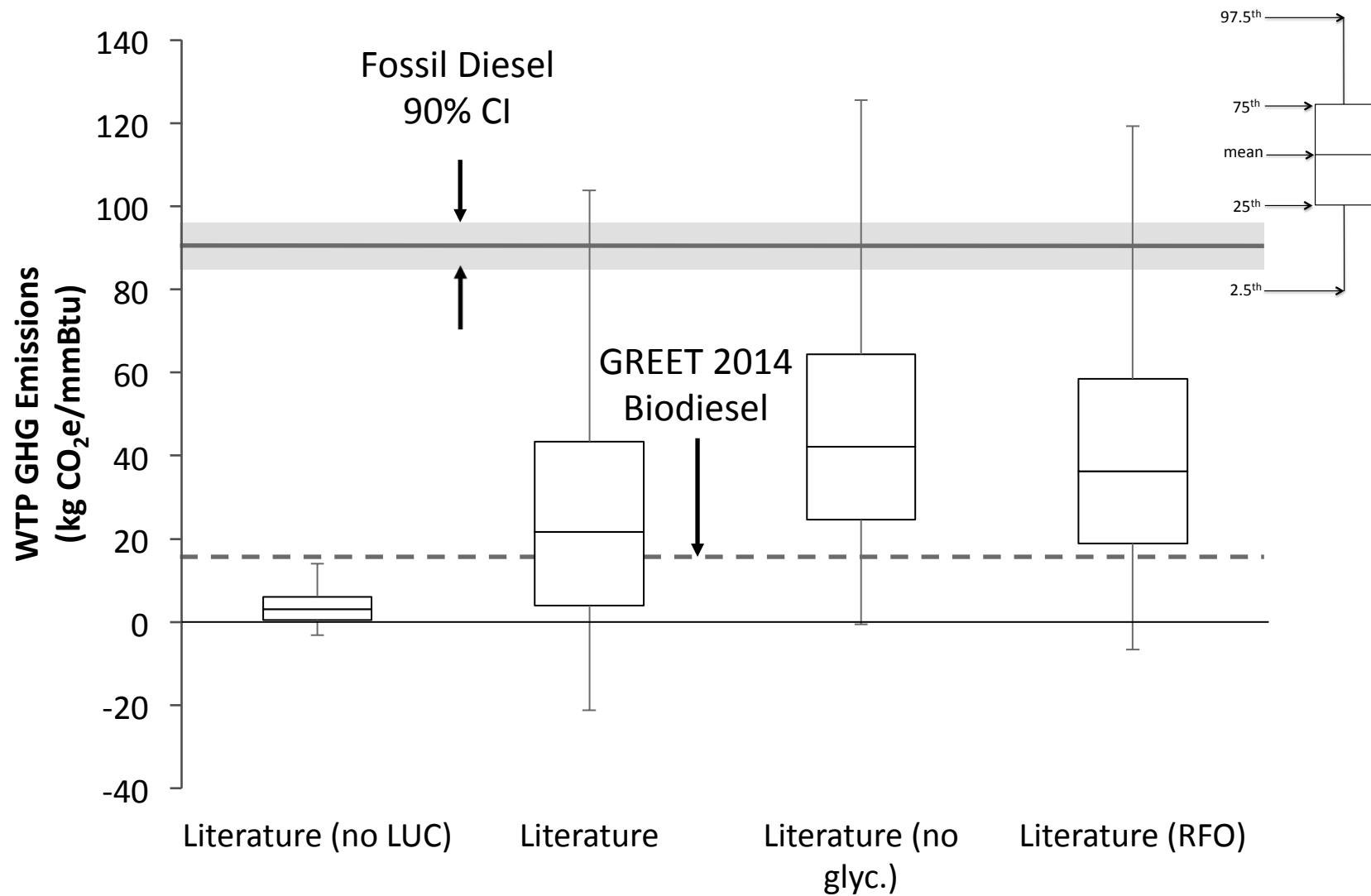
# LUC Literature Distribution - Biodiesel



NB: LUC point value is 0 in GREET 2014



# Monte Carlo Results - Biodiesel



# Messages

- There is uncertainty in underlying parameters
  - Deterministic values are simply informed choices that can lead to disparate and perhaps misleading results
  - Investigators have made a wide variety of choices for a variety of valid reasons
- LUC and N<sub>2</sub>O emissions (spec. to corn) allocation to co-products are the principal sources of this uncertainty for corn ethanol and soybean biodiesel estimates shown here
- Allocation is an important choice and should be explored rigorously to demonstrate its impact on the answer

# Aphorism of the day

All models are wrong, some are useful

George Box, 1978