

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

October 27, 2015



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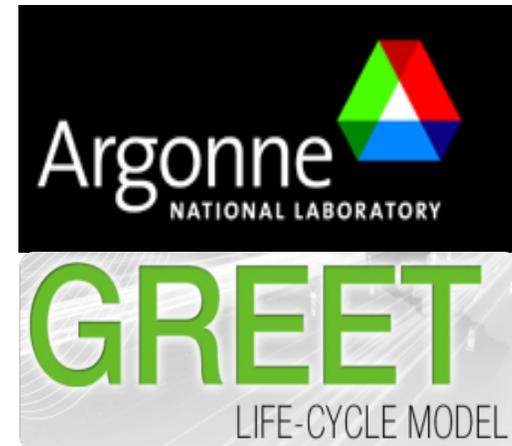
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Goals

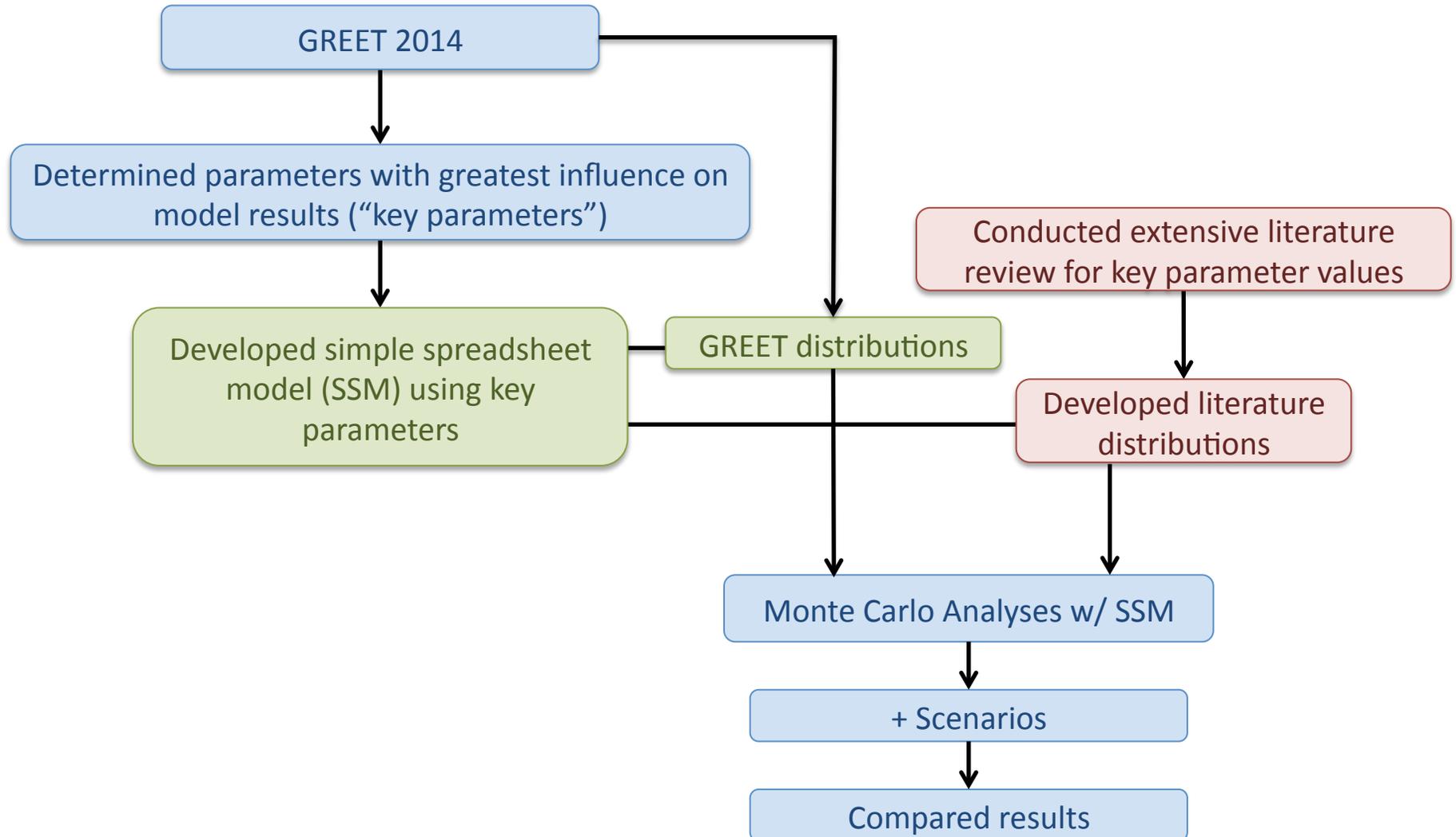
- Use a standard, accepted model structure to compare results for a biofuels pathway versus plausible values for important parameters from the peer reviewed literature.
- Determine the overall uncertainty related to “key parameters” using this structure and plausible parameter values.

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



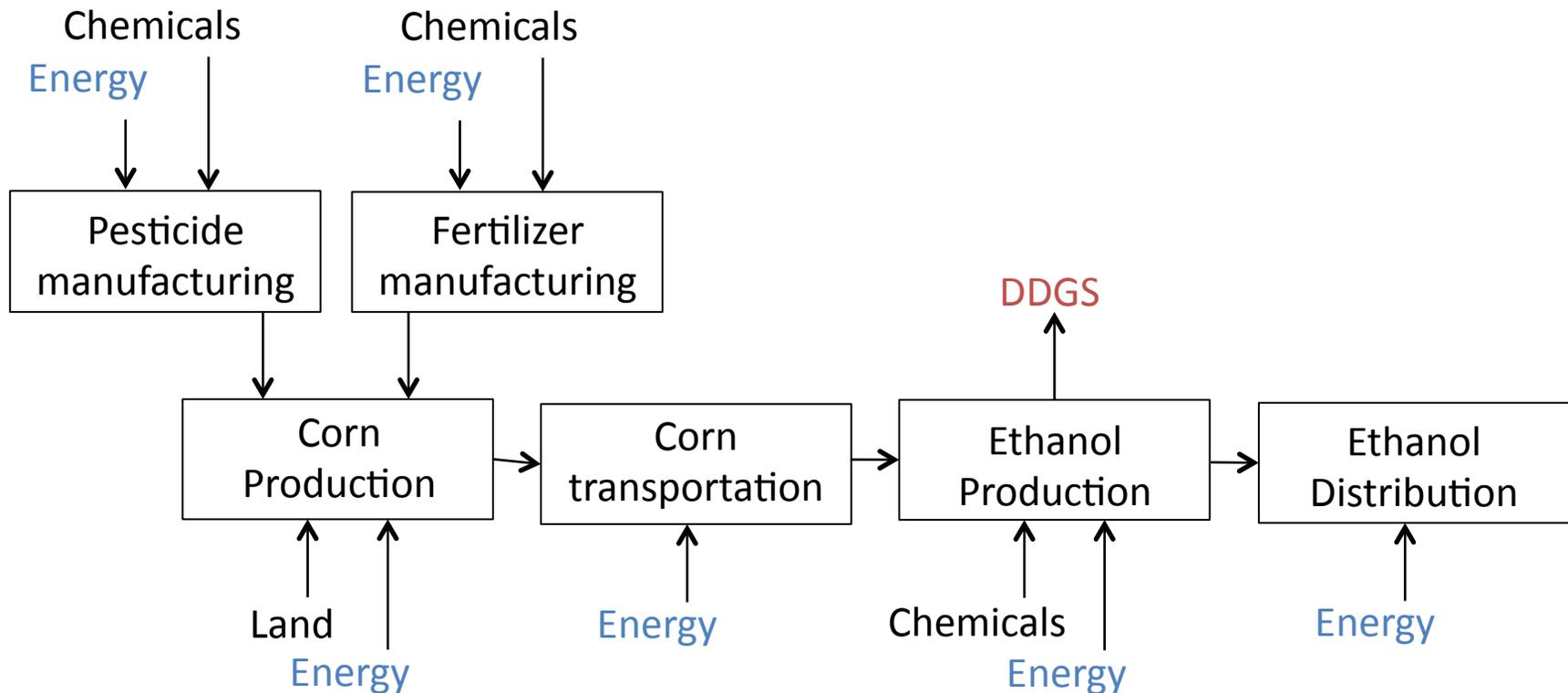
Approach



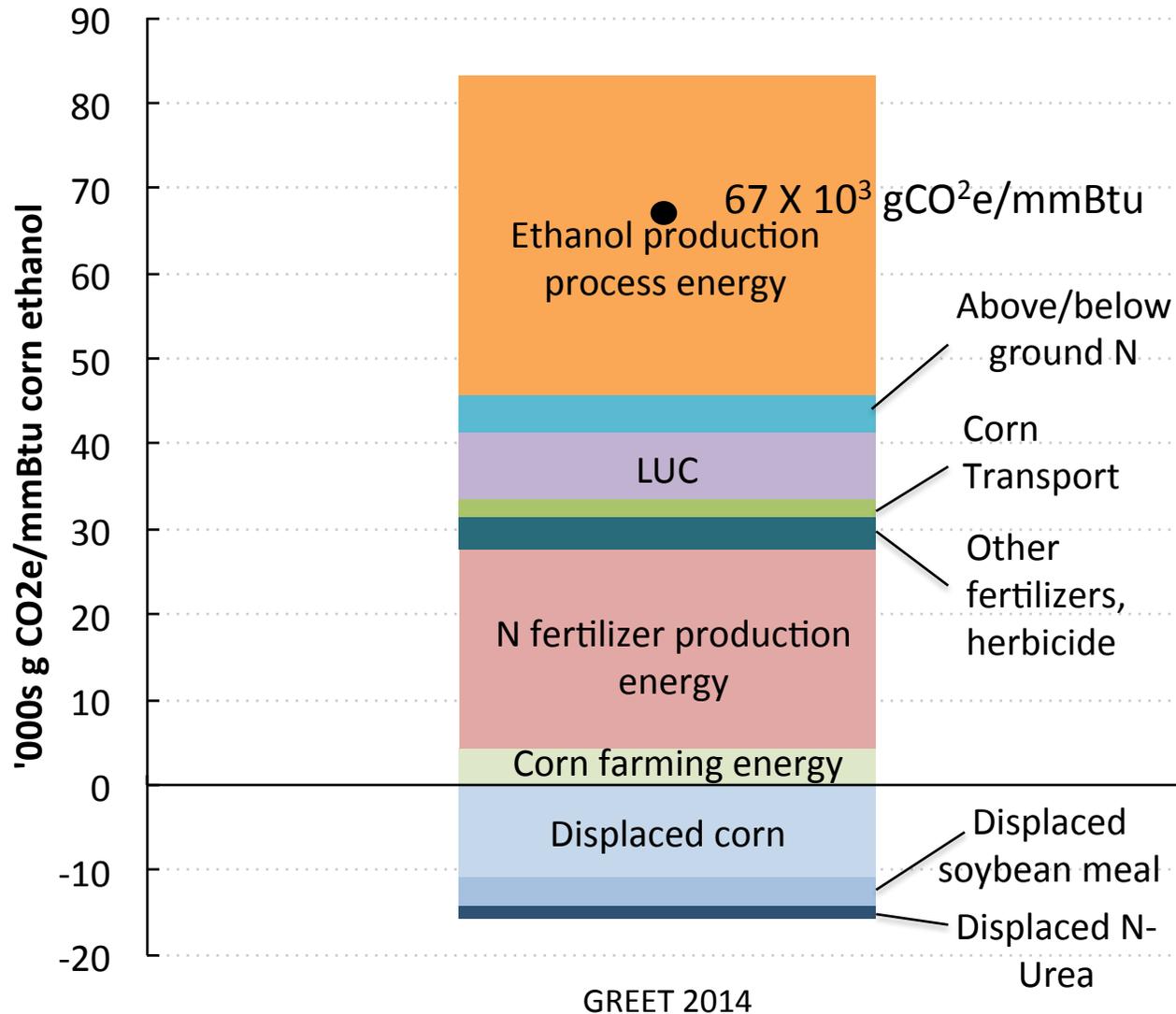
Corn Ethanol Process

- 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)



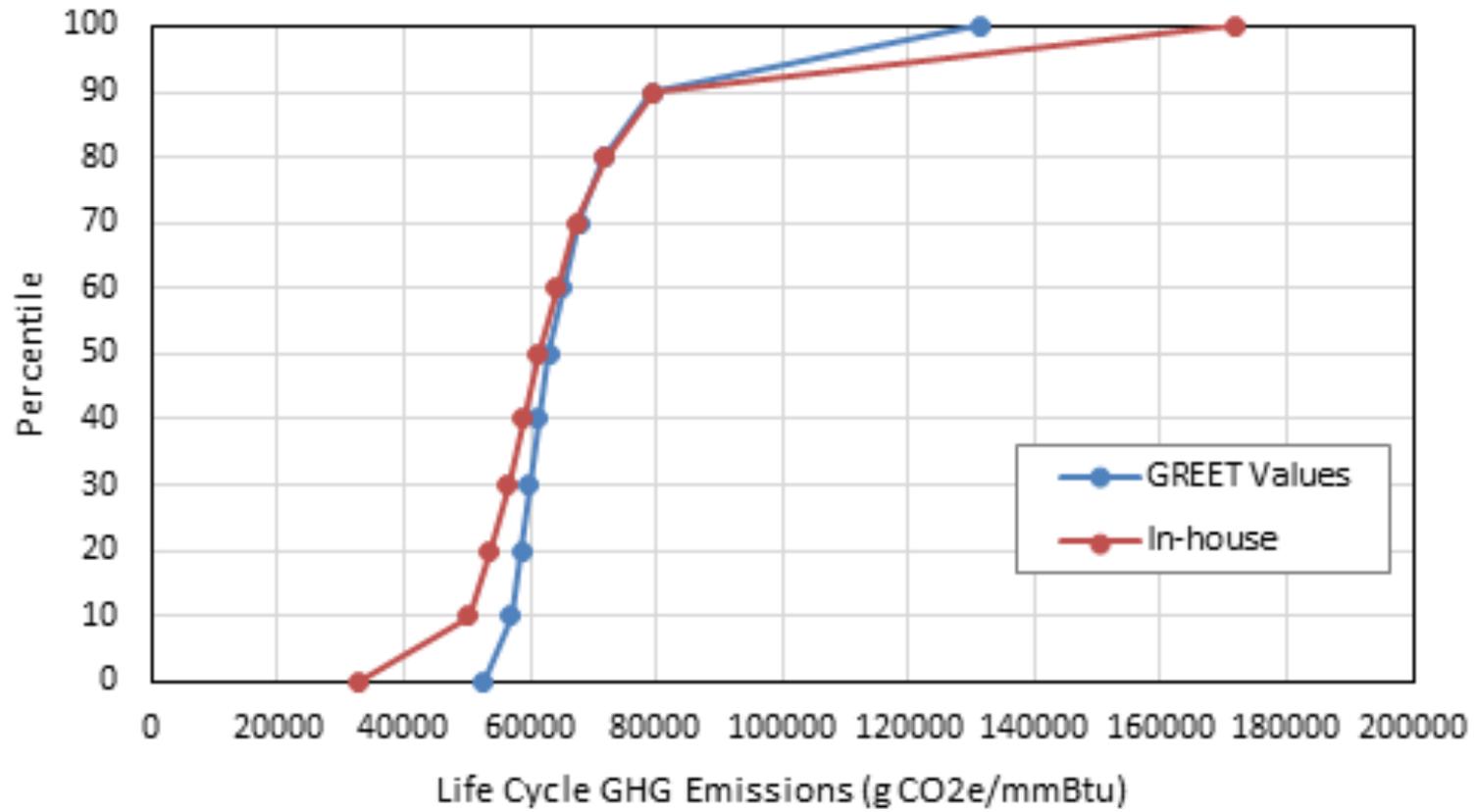
Contribution of Parameters and Key Parameters – Corn Ethanol



Key Parameters:

1. Corn farming energy
2. Application rate of N fertilizer
3. N₂O emission rate
4. Ethanol production process energy
5. Process yield
6. LUC*

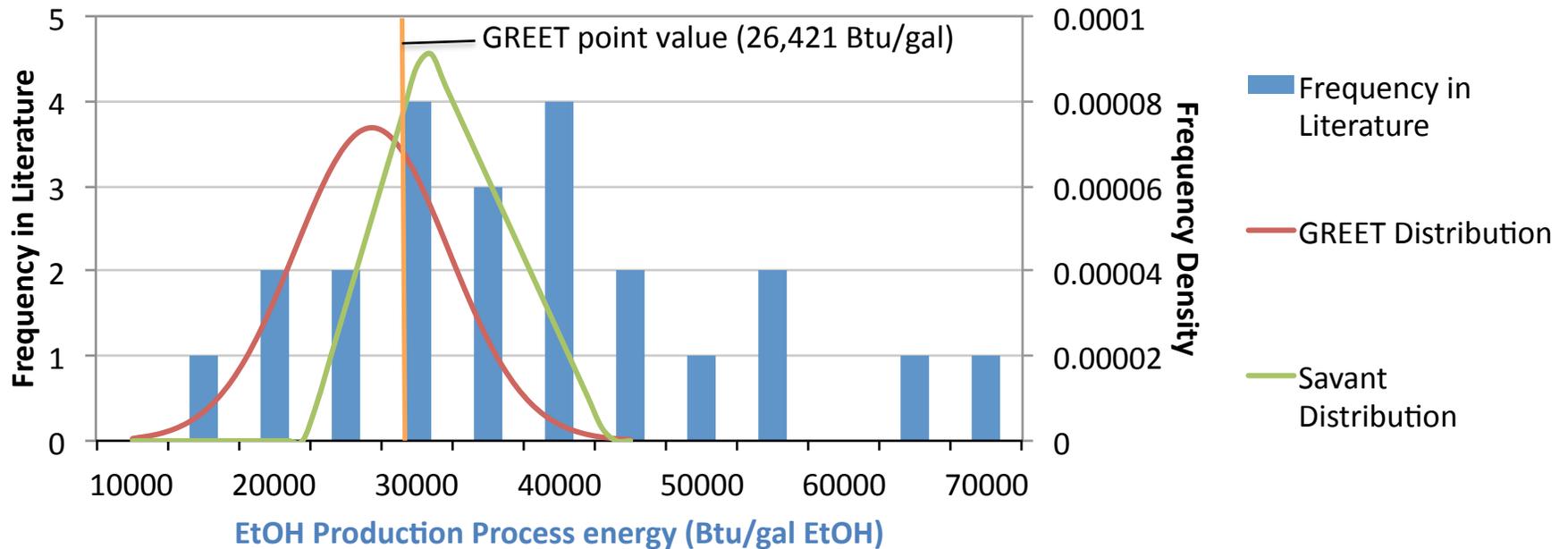
GREET 2014 Distribution, WTP EtOH, Cumulative



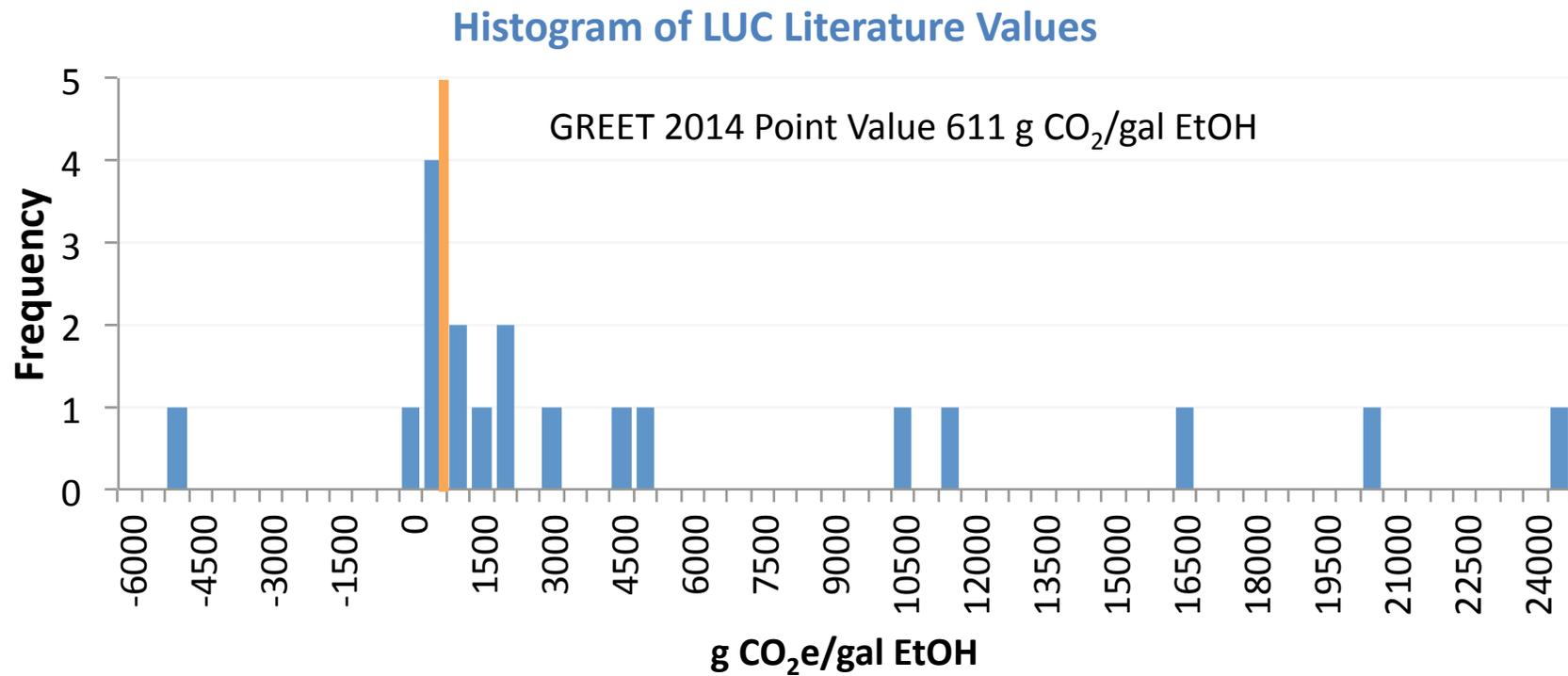
Summary of Literature

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

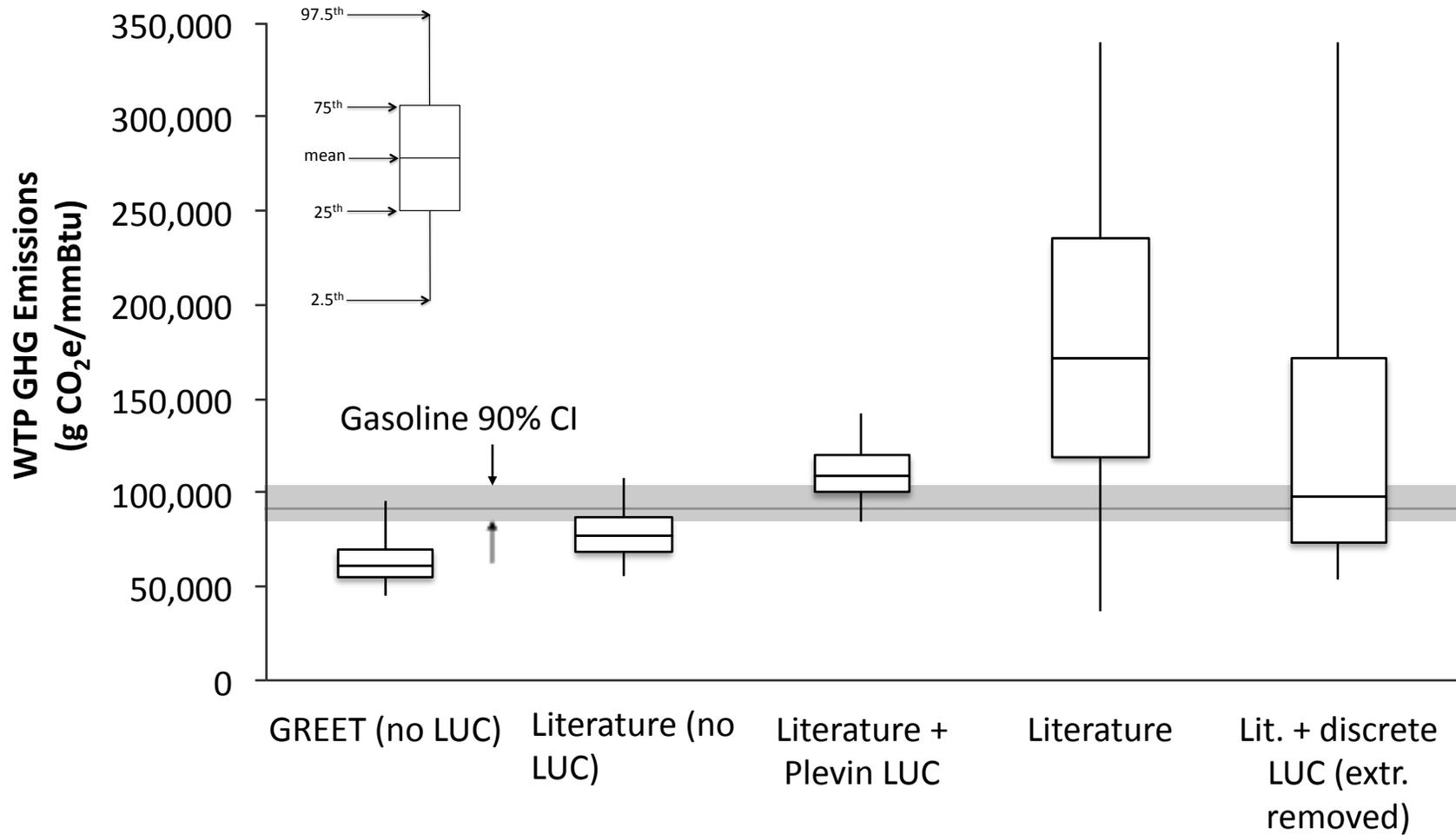
Sample Parameter Distributions – Corn Ethanol



LUC – Corn Ethanol



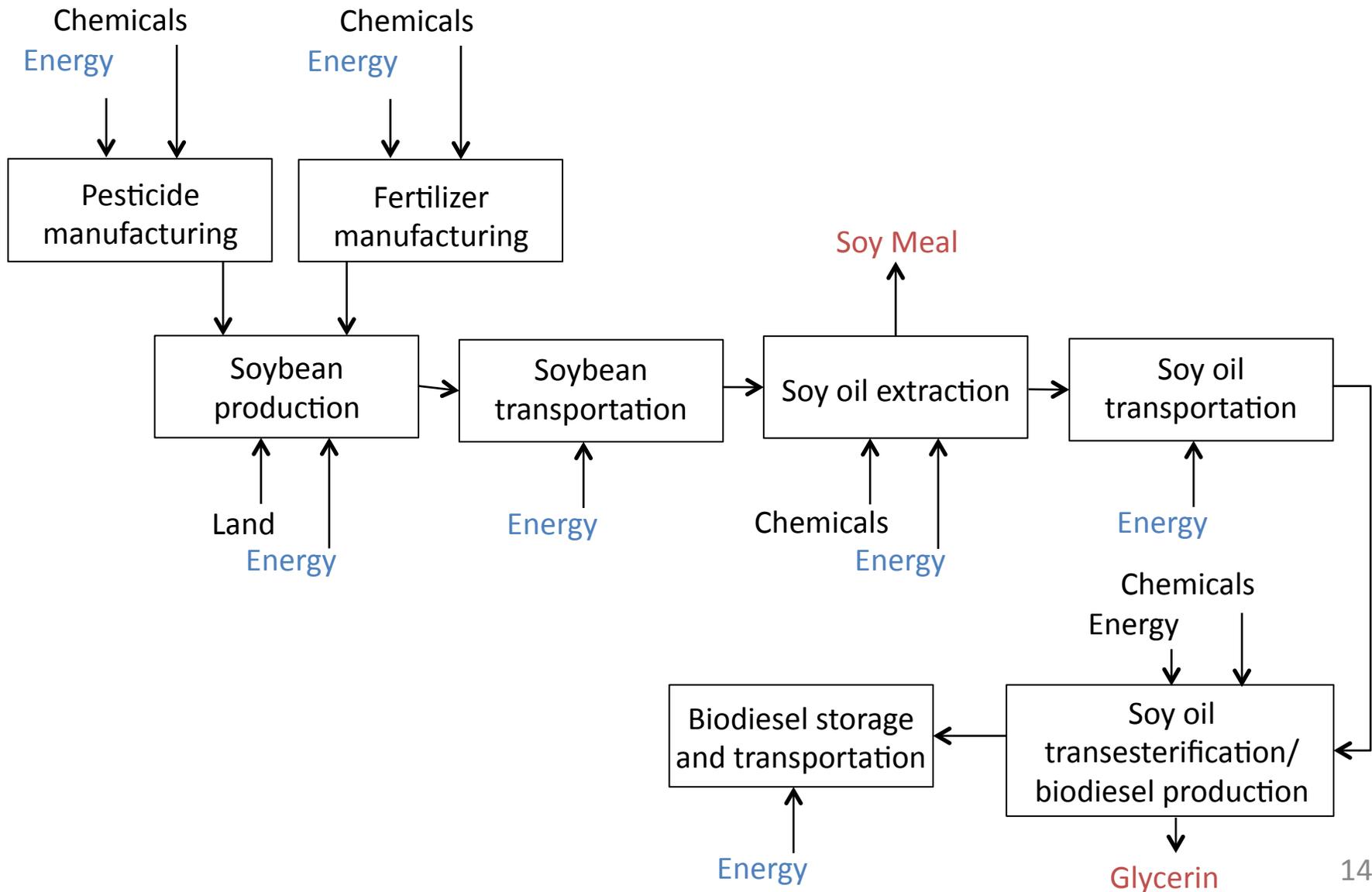
Monte Carlo Analysis – Corn Ethanol



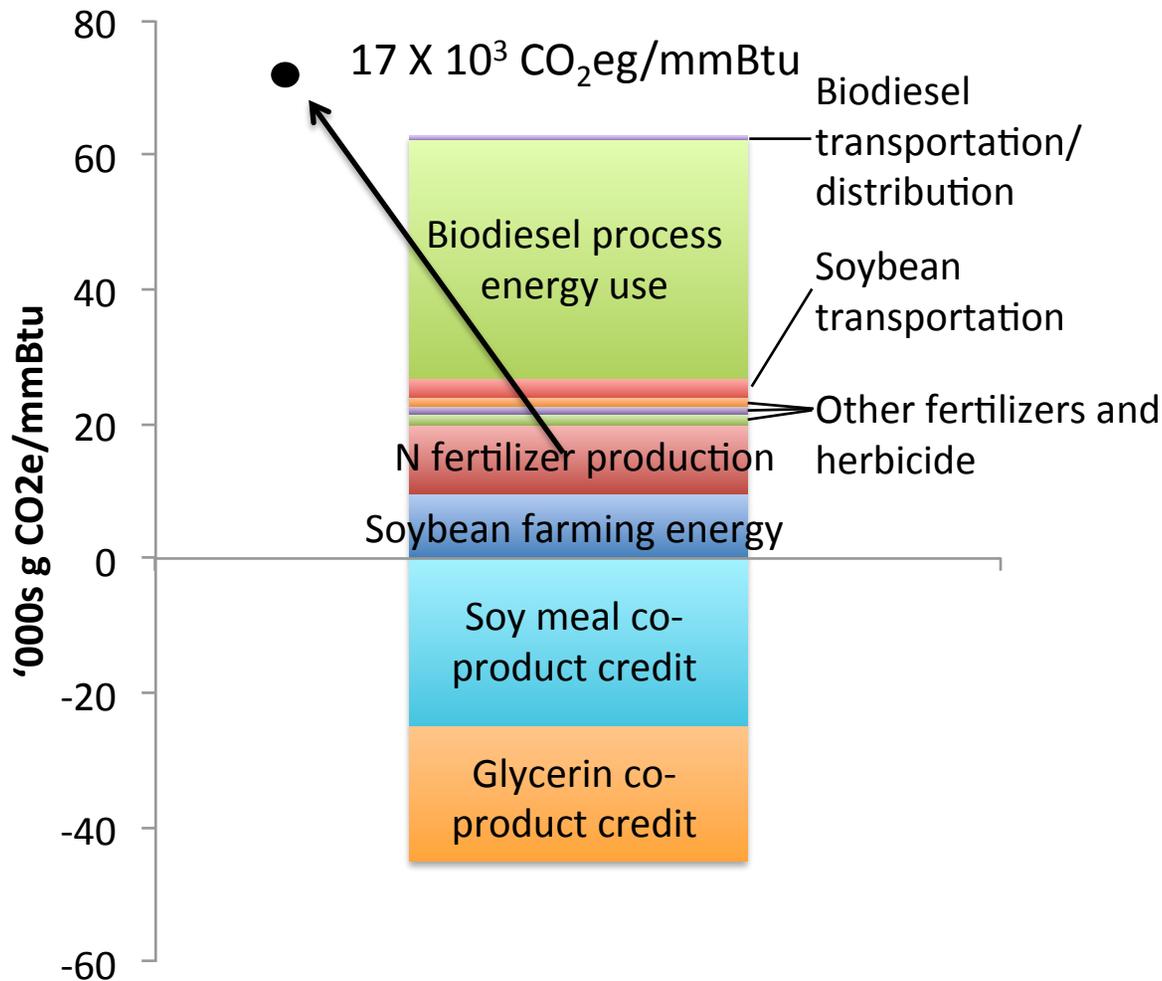
Soybean Biodiesel Process

- 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



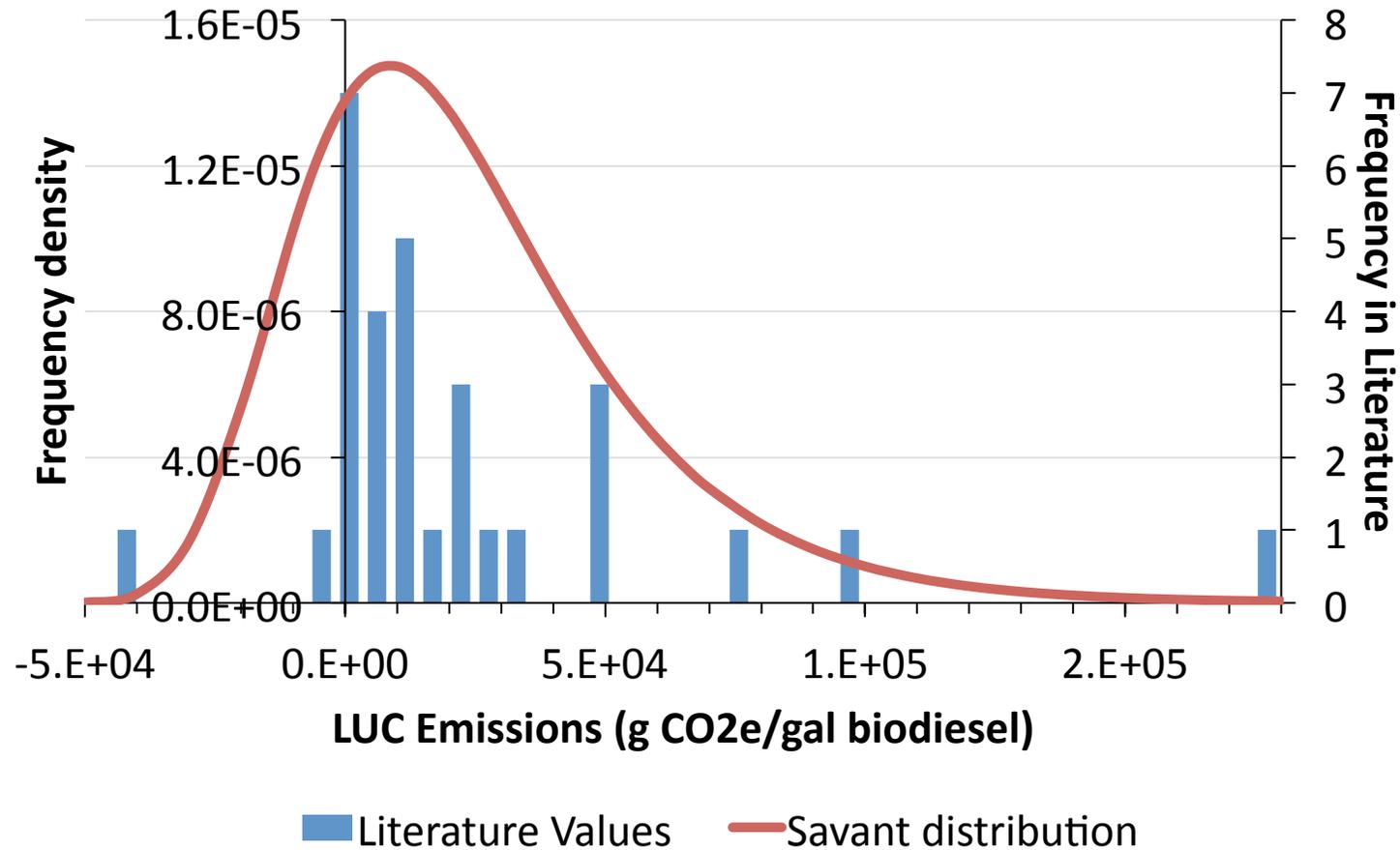
Contribution of Parameters and Key Parameters – Soybean Biodiesel



Key Parameters:

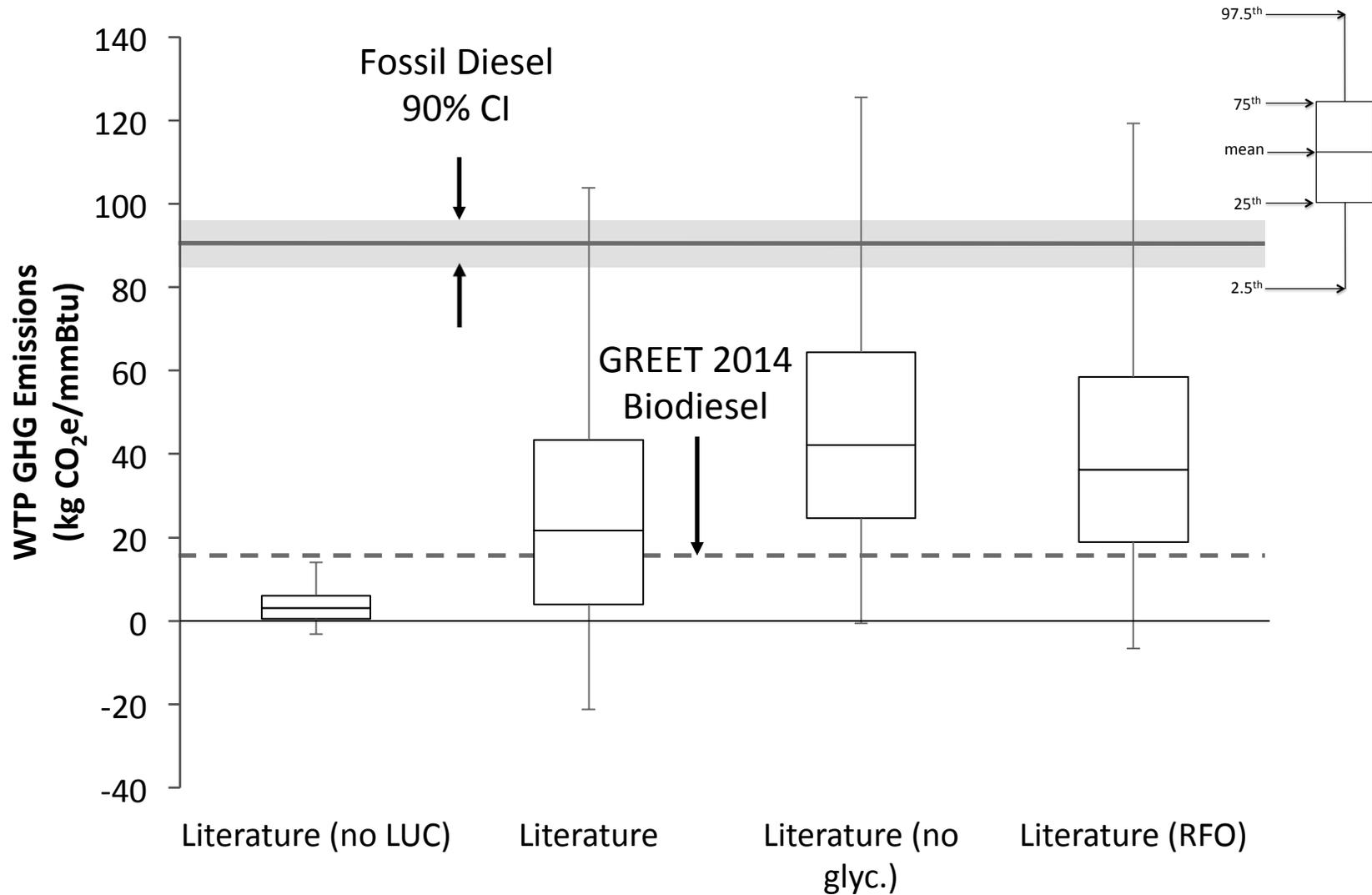
1. Soybean farming energy use
2. Application rate of N fertilizer
3. N₂O emission rate
4. Biodiesel process energy (soy oil extraction, transesterification)
5. Process yield
6. LUC*
7. Co-product yield

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 N₂O 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