Review of Transportation Fuel Life Cycle Analysis and CA GREET

CRC Workshop on Life Cycle Analysis of Biofuels

Argonne, Illinois

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Outline

- Fuel LCA Studies
- Model result comparison
- Model calculations
- Recommendations

Objectives of Fuel LCA Comparison

- Expanding use of fuel LCA in global fuels policy
- Several fuel LCA models
  - Models: GREET, JRC/LBST, GHGenius, BESS
- And Studies/Policies
  - ARB LCFS, EPA RFS2, GM/ANL, CEC AB1007, EU
- What are the differences, strengths, weaknesses?
- How can the models be improved?

Fuel Life Cycle Studies

Study	WTT Model	Vehicle Data
JRC/Concawe/EUCAR 2008	JRC/LBST database	EUCAR
GM/ANL 2001	GREET 1.6	GM model
GM/LBST 2002	LBST database	GM model
UCD/LEM 1997-2006	LEM	Inputs
CEC/TIAX 2007	GREET 1.7	EPA, various
ARB LCFS 2009	CA GREET1.8b	various
EPA RFS 2009	GREET/FAPRI	MOVES
GREET 2009	GREET 1.8c.0	PSAT
GHGenius	GHGenius 3.1.5	various
BESS Documentation	BESS	N/A

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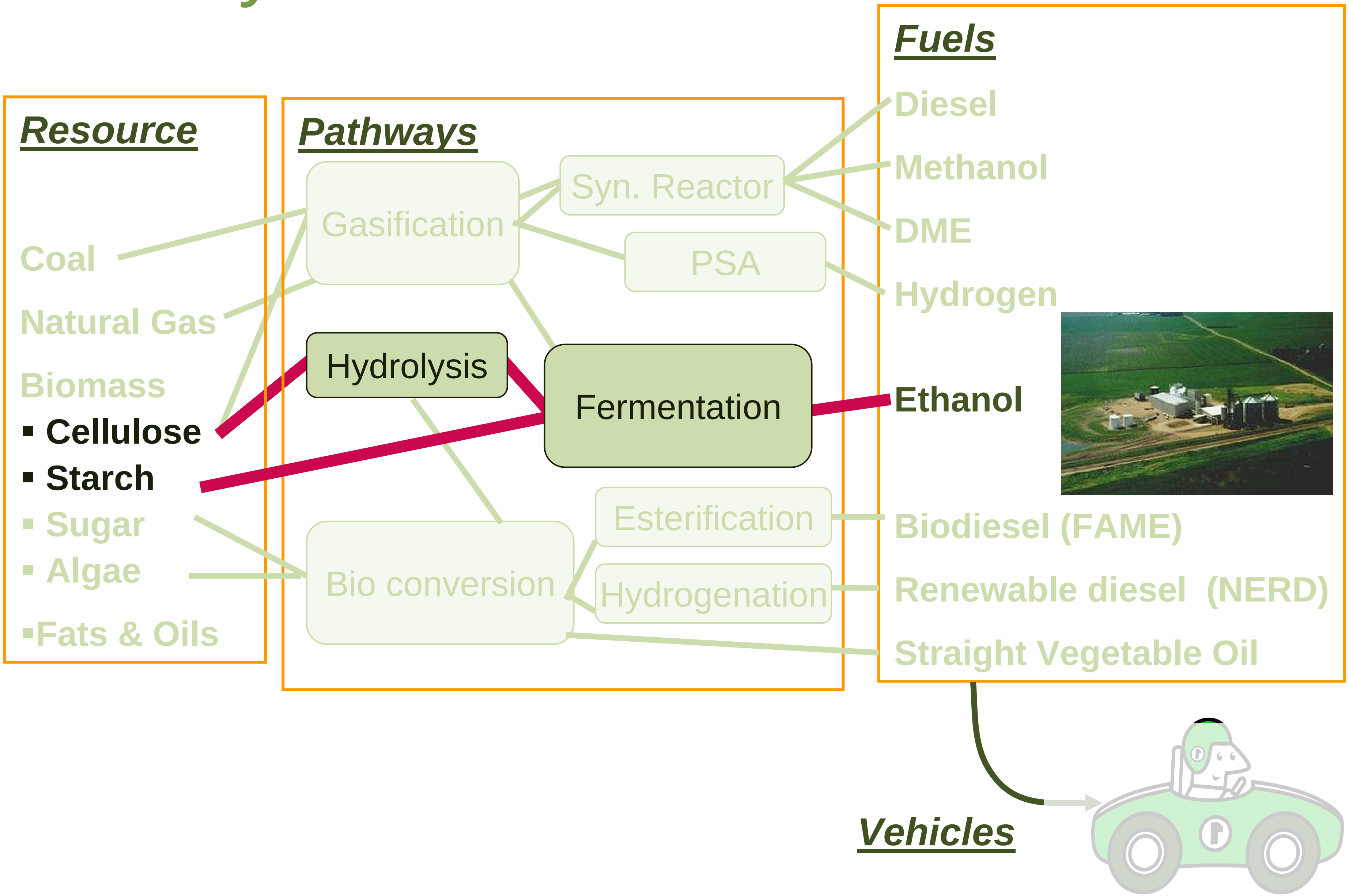
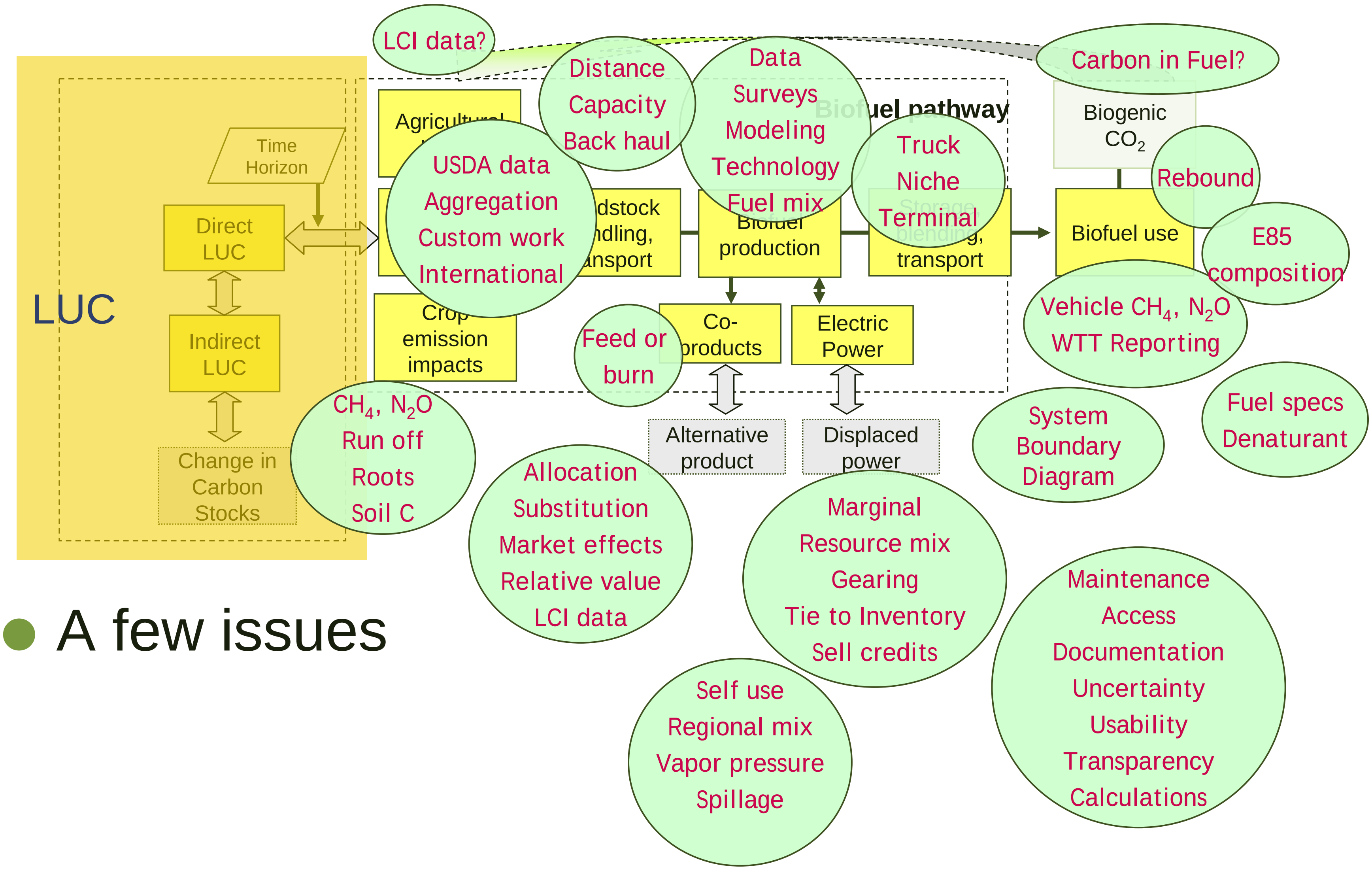
Today's Presentation



Fuel LCA Models

Model	Date
GREET 1.8c.0	March 2009
CA_GREET 1.8b	February 2009
JRC/CONCAWE v3.0	October 2008
BESS 2008.3.1	March 2008
GHGenius 3.1.5	May 2009
LEM	May 2006

Life Cycle Analysis of Biofuels

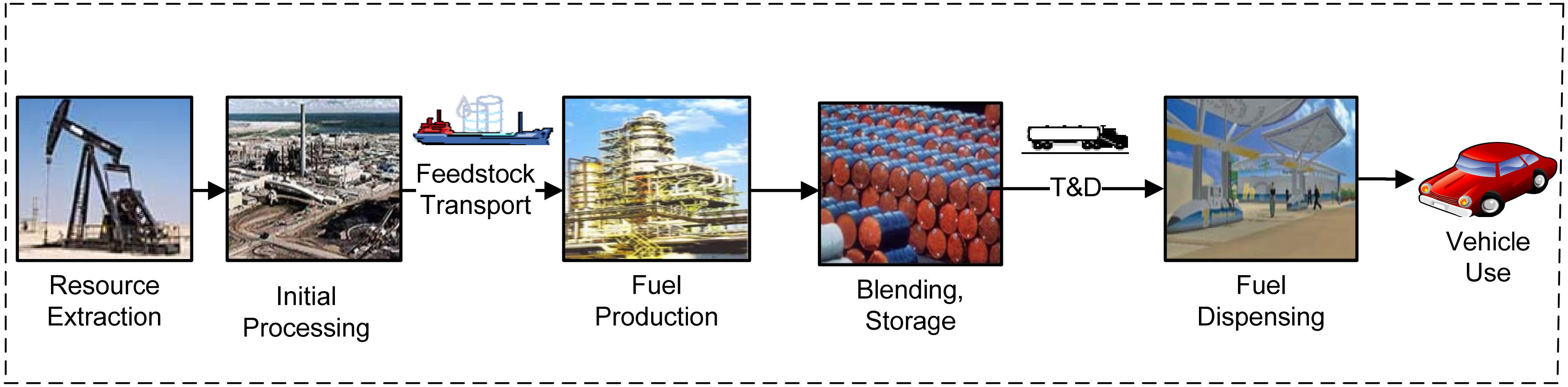


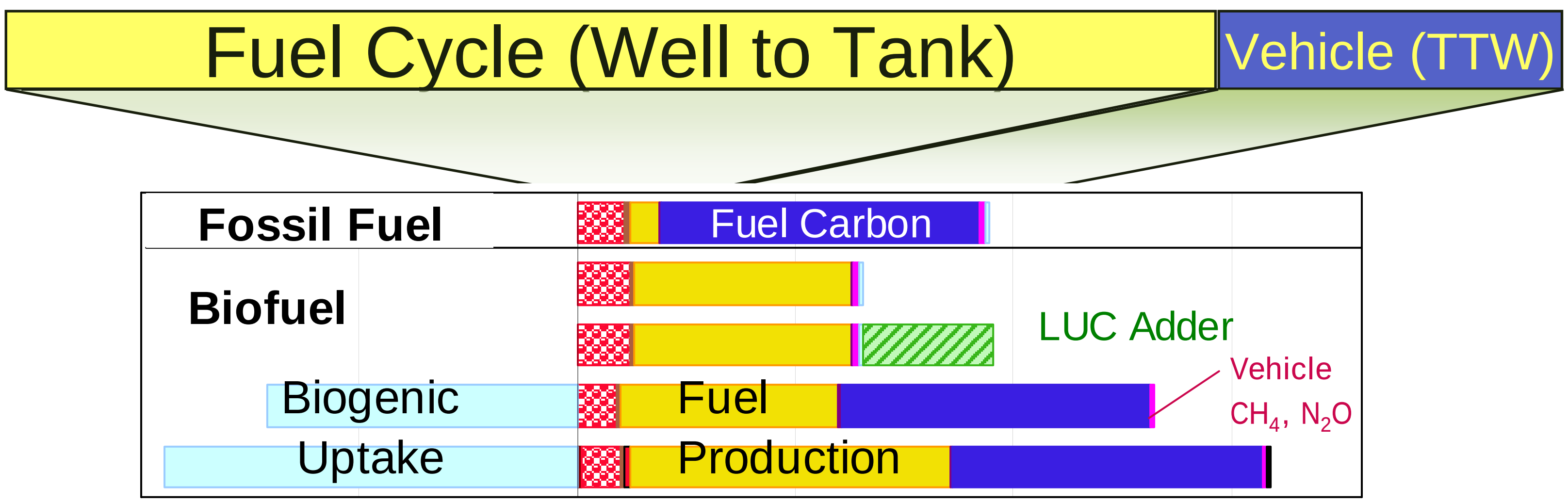
- A few issues

Comparison of LCA Models

- Significant differences among fuel LCA model results
- … but fuel LCA models do the same math
  - Scenario
  - Allocation method
  - Data inputs
  - Errors

Life Cycle Steps and CI

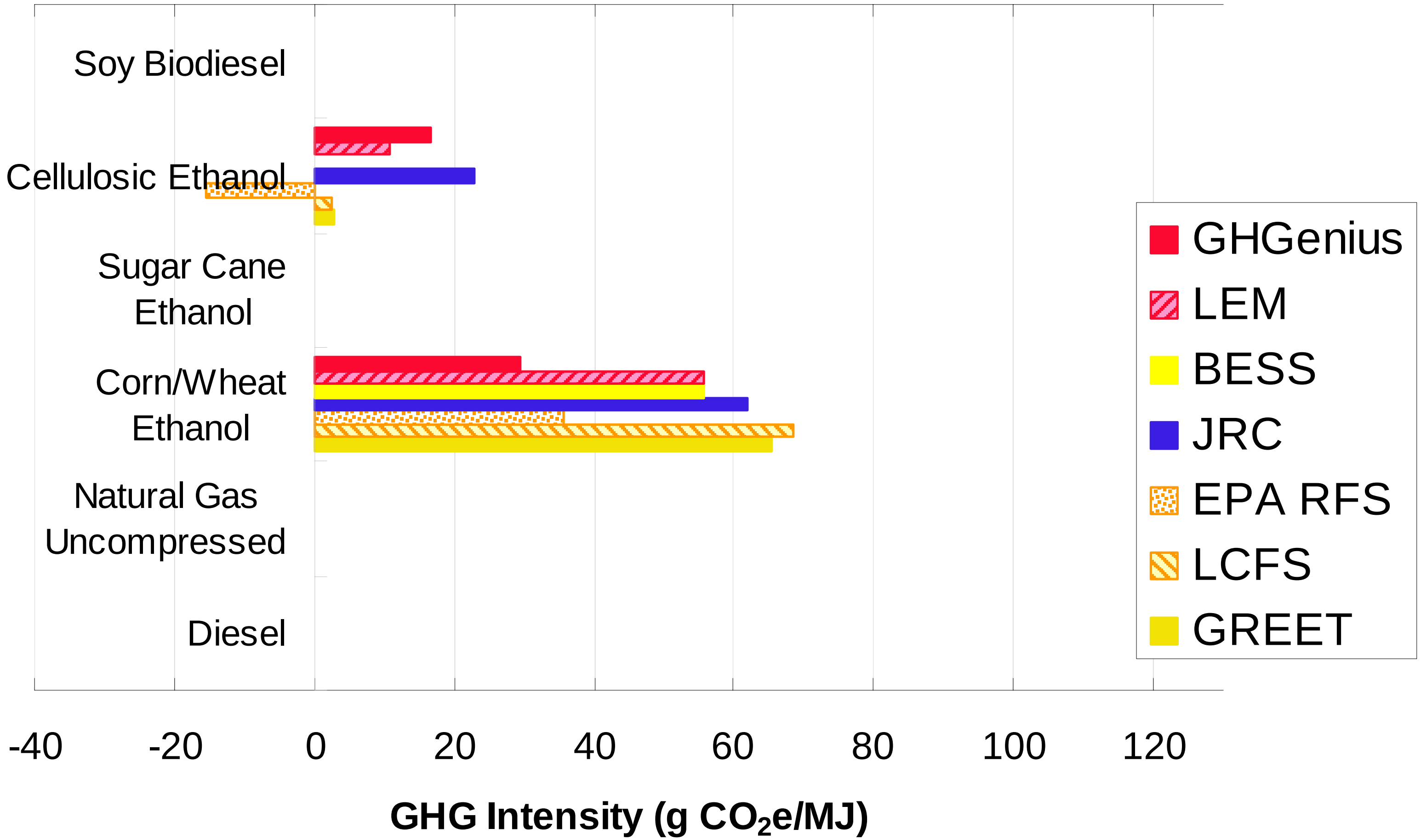




Well to Wheel: WTW = WTT + TTW (g/mi)

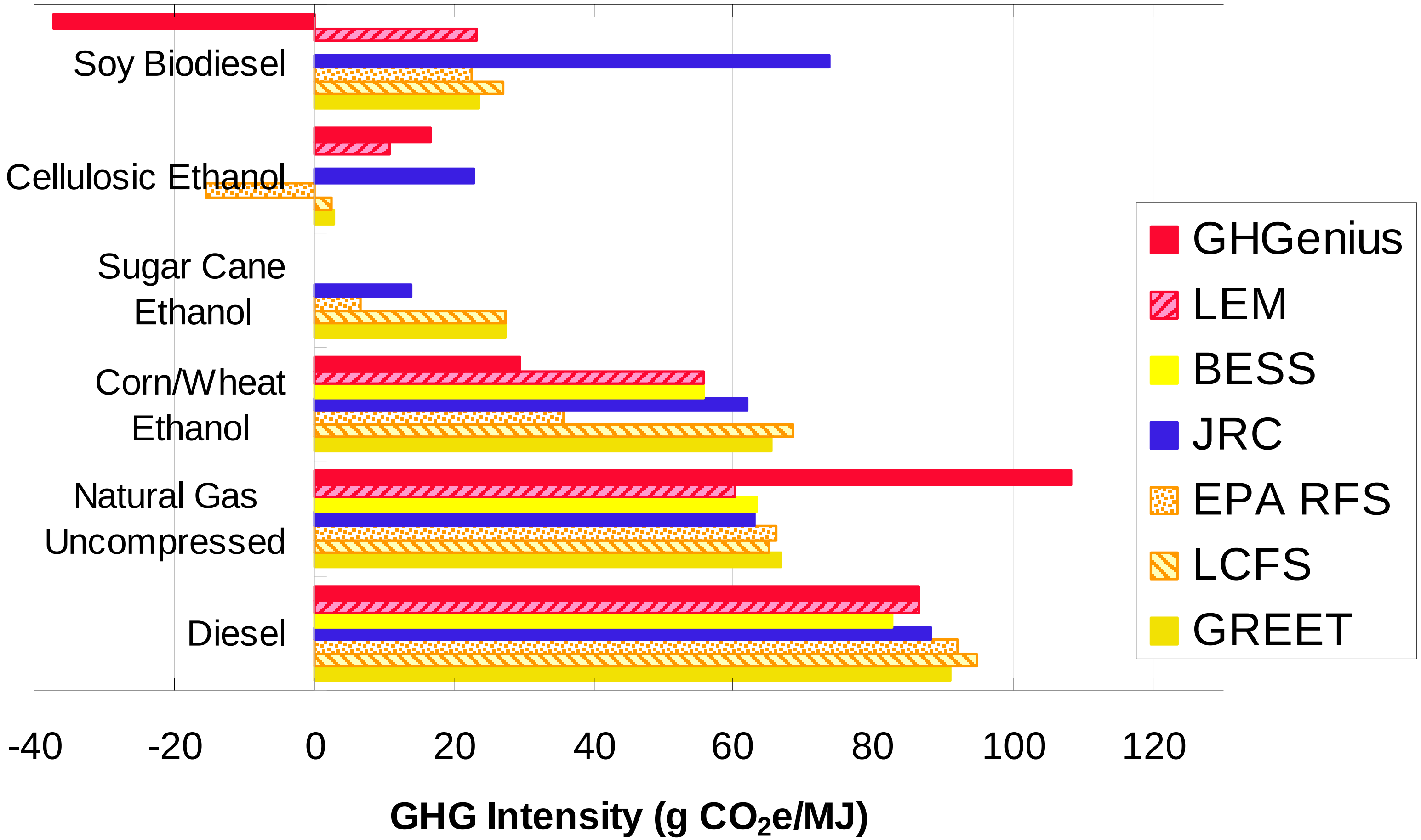
Fuel CI: = WTT + Fuel Carbon + Vehicle CH_4, N_2O (g CO_2e/MJ)

Comparison of Fuel LCA Results



Carbon intensity includes WTT + Fuel CO_2 + vehicle CH_4 & N_2O emissions. There results do not include an adjustment for vehicle fuel economy. Base case results are shown here (open the model or first document). Corn ethanol represents Midwest Dry Mill plant. In most cases, the model or documentation show a range of results and alternative pathways. EPA results are for 2022 scenario with 30 year time horizon. ARB LCFS results are for 2005 to 2010 scenario.

Comparison of Fuel LCA Results



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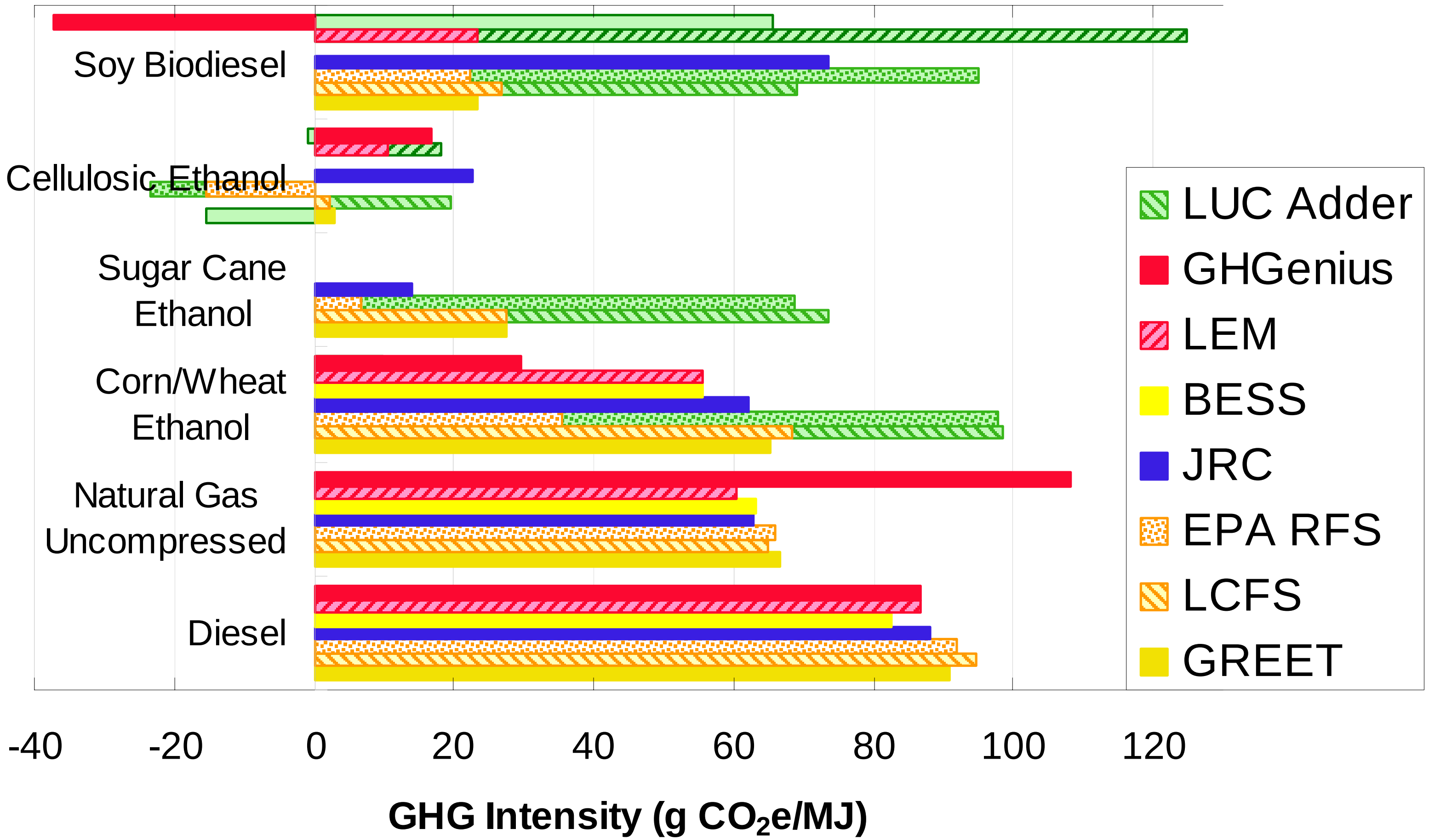

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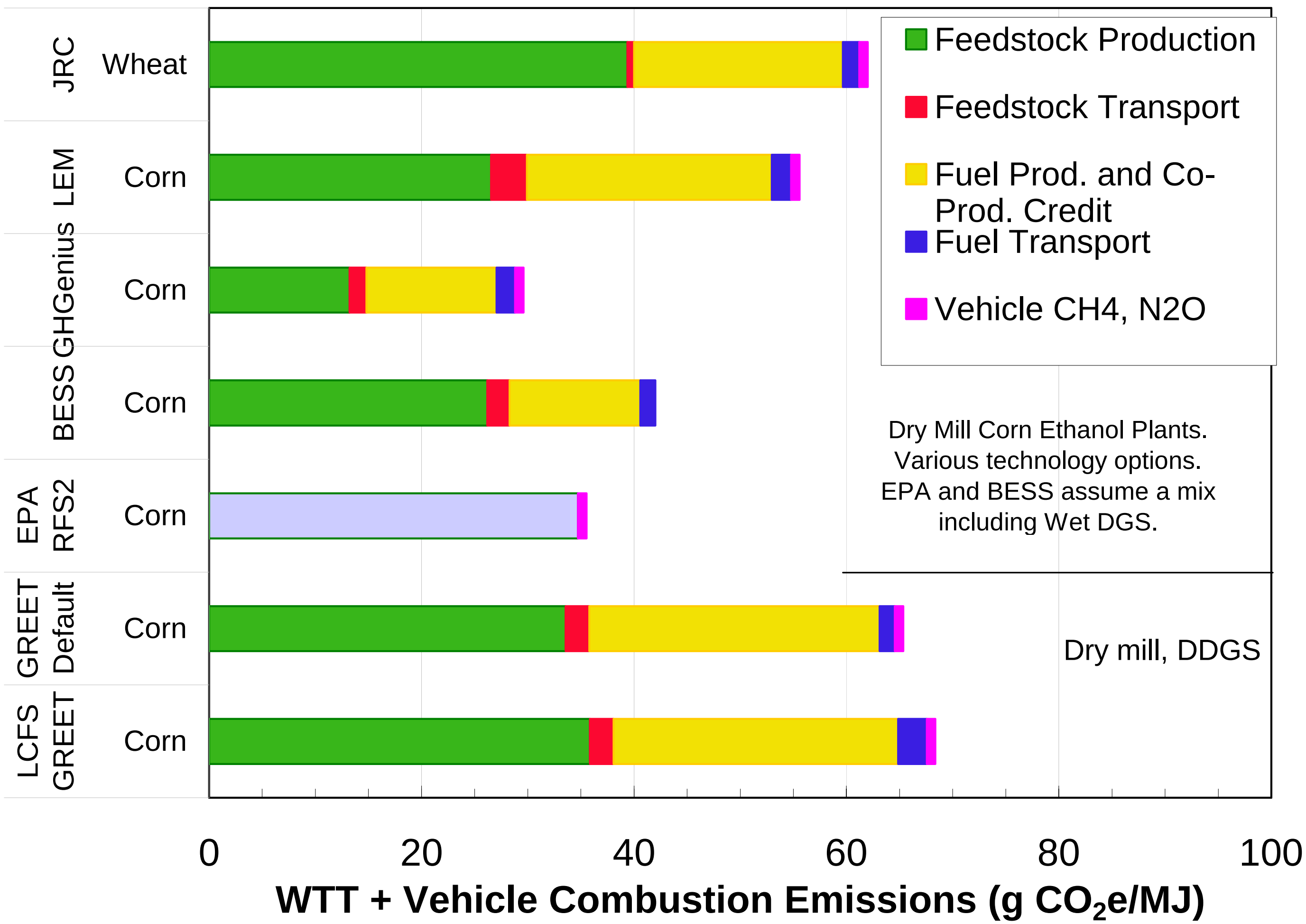
Analysis Steps

- Disaggregate results
    - Feedstock
    - Transport
    - Refining
    - Delivery
    - Fuel Carbon/vehicle
- Summarize inputs
- Examine differences

Corn/Wheat to Ethanol



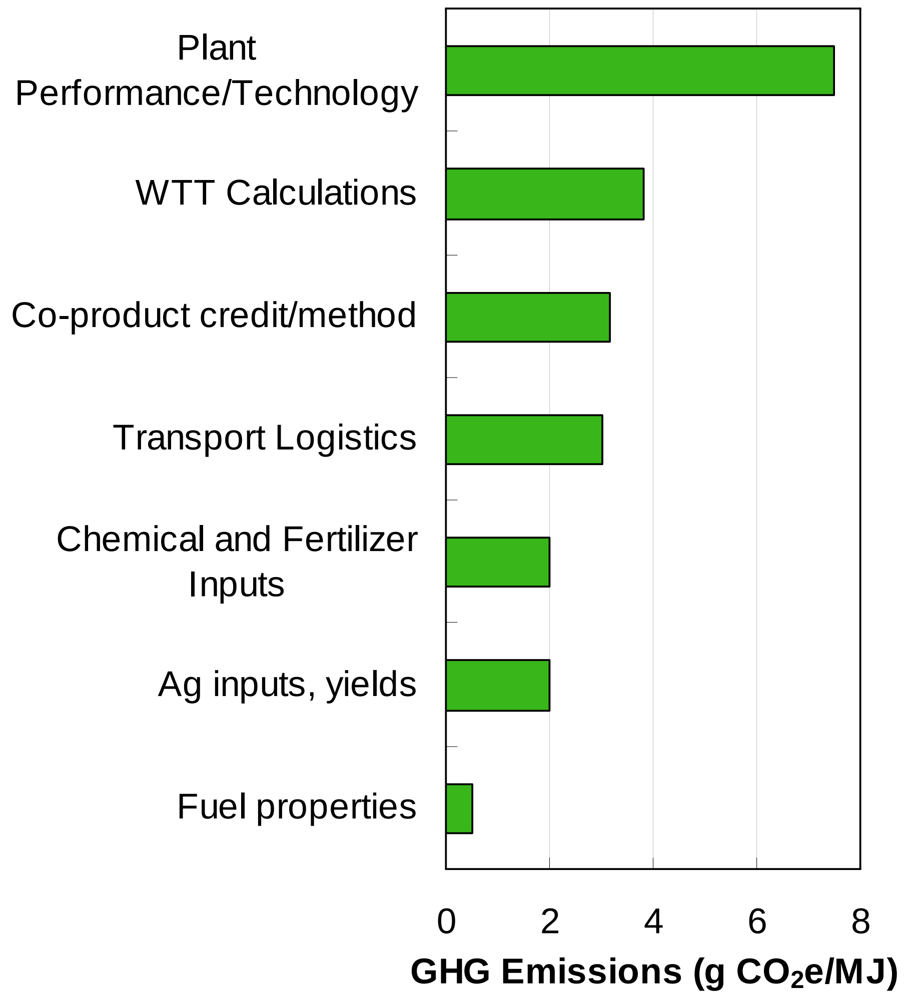
Base case scenario. Anhydrous ethanol. Dry mill corn plan. Net biogenic carbon in fuel shown as zero. Does not include LUC emissions.

CA GREET Differences

- GREET 1.8c.0
  - U.S. Average transport, electricity mix
  - DGS credit = 0.992 corn + 0.306 SBM + 0.022 urea
- CA LCFS GREET
  - CA Transport
  - Regional electricity and petroleum mix
  - 1:1 corn to DGS credit
  - Coal carbon content
  - 10 sub-pathways

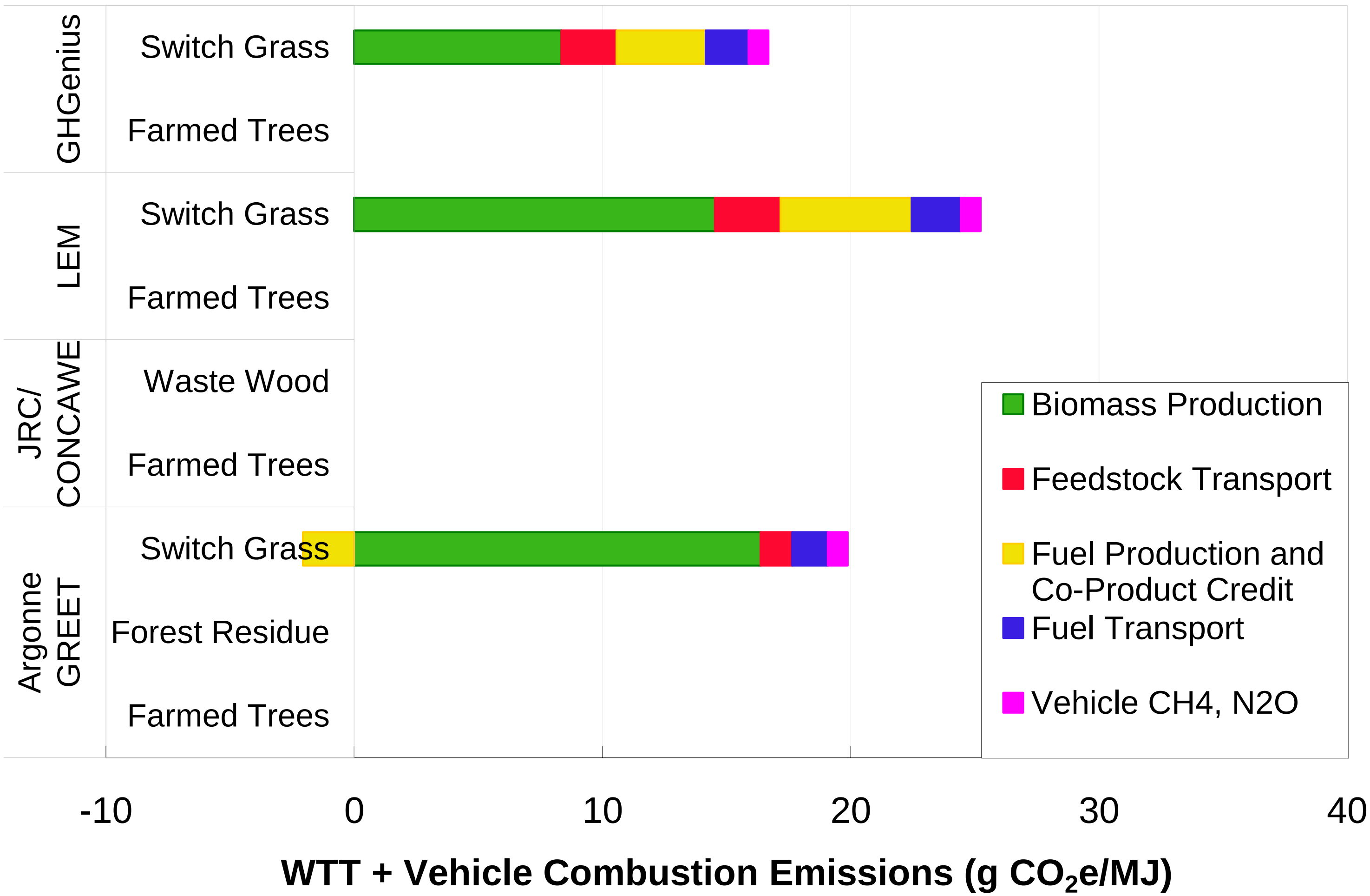
Corn/Wheat to Ethanol Variation

- Differences between fuel LCA models
  - Technology scenario
  - Modeling differences
  - Input assumptions
- Allocation
  - Substitution
  - Allocation



Example model to model variation in CI values.

Cellulose to Ethanol



Anhydrous ethanol. Net biogenic carbon in fuel shown as zero. Does not include LUC emissions. Note: LCFS case is based on U.S. average and comparable to GREET default.

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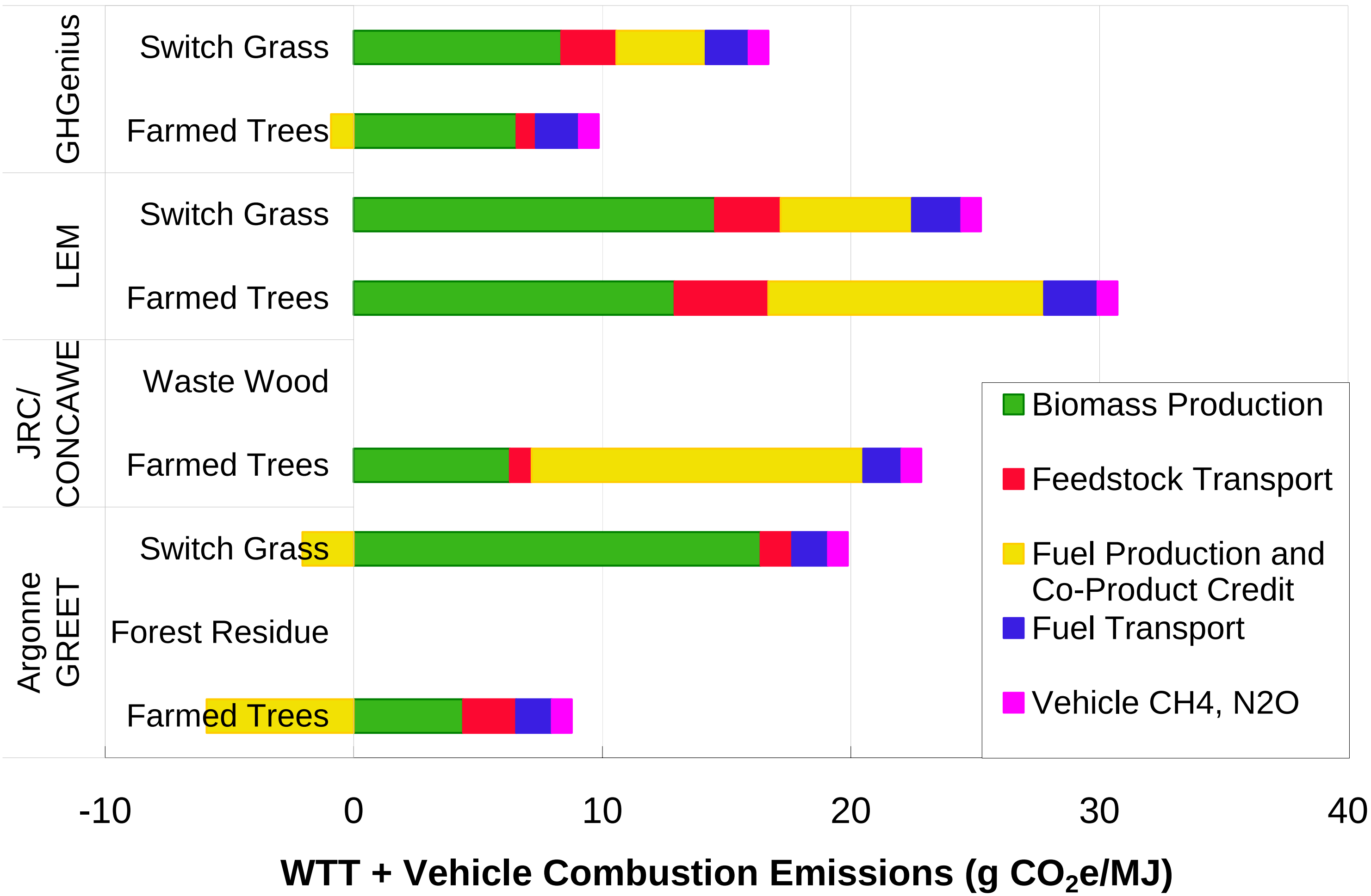

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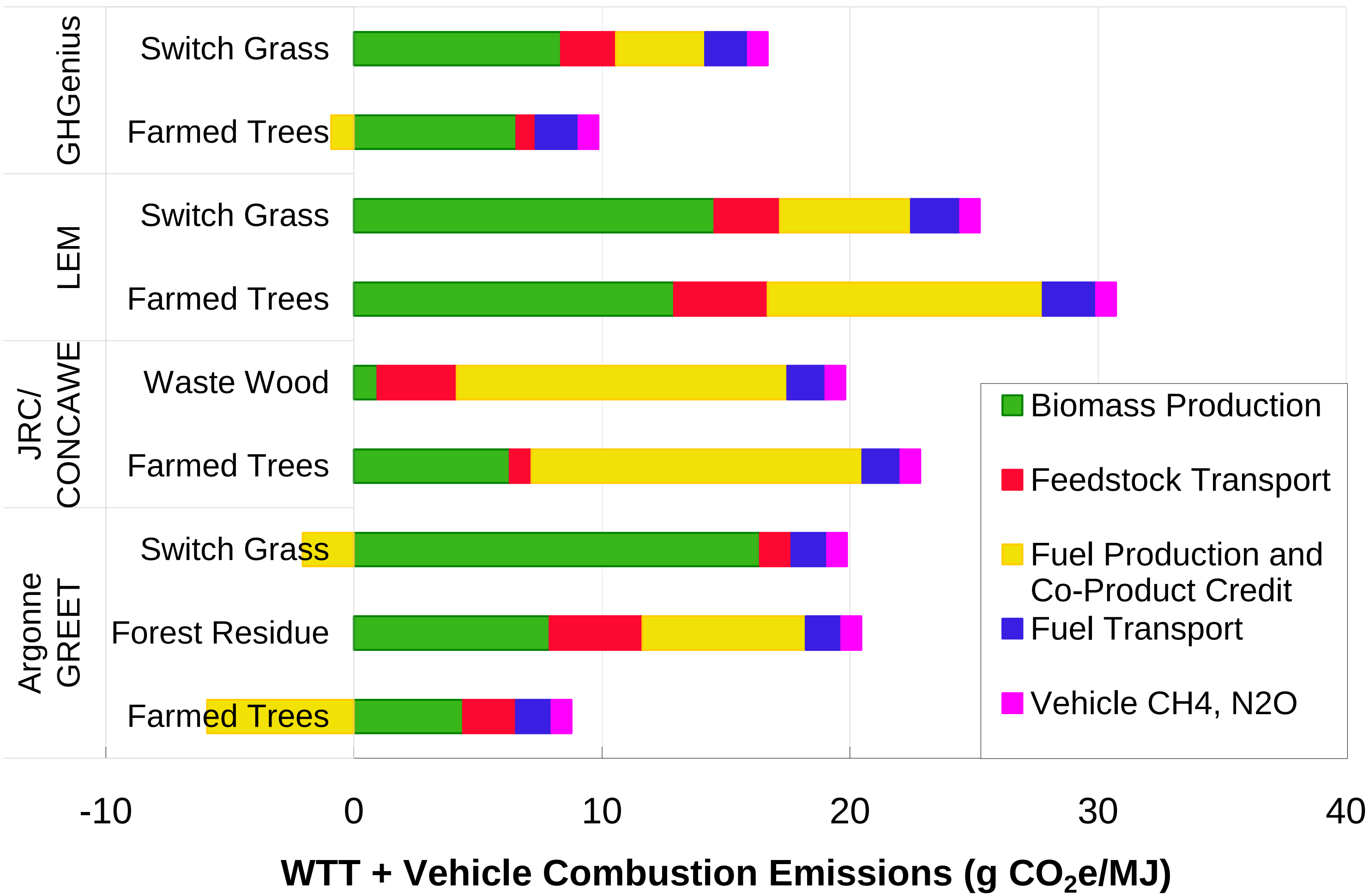

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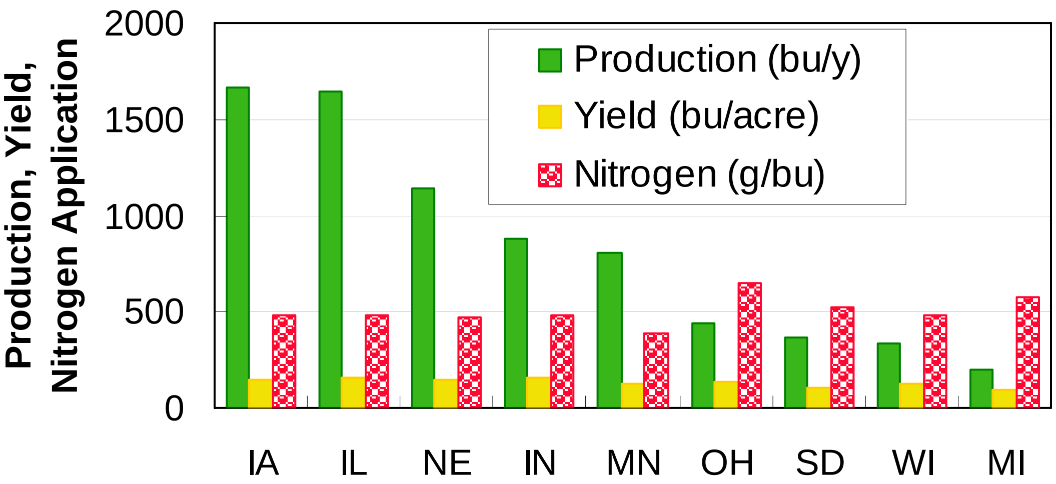
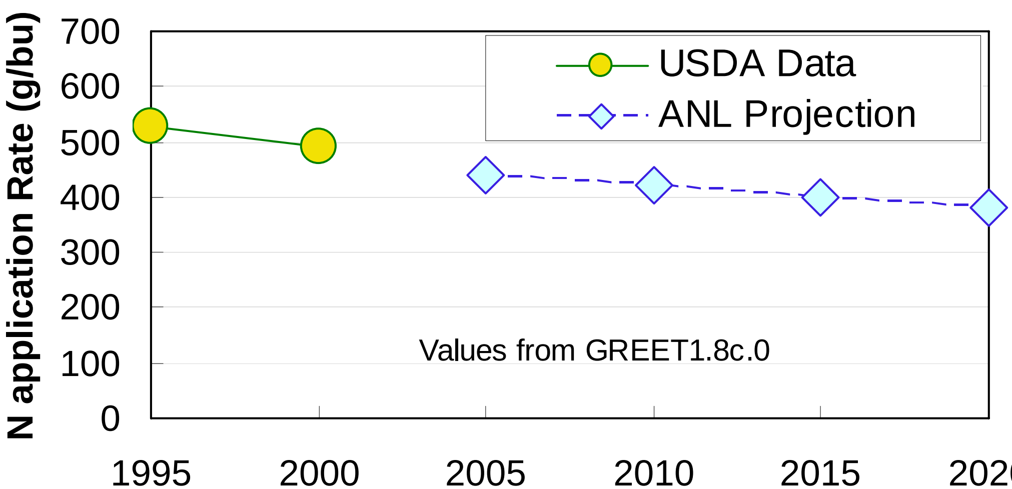
Life Cycle Data and Inputs

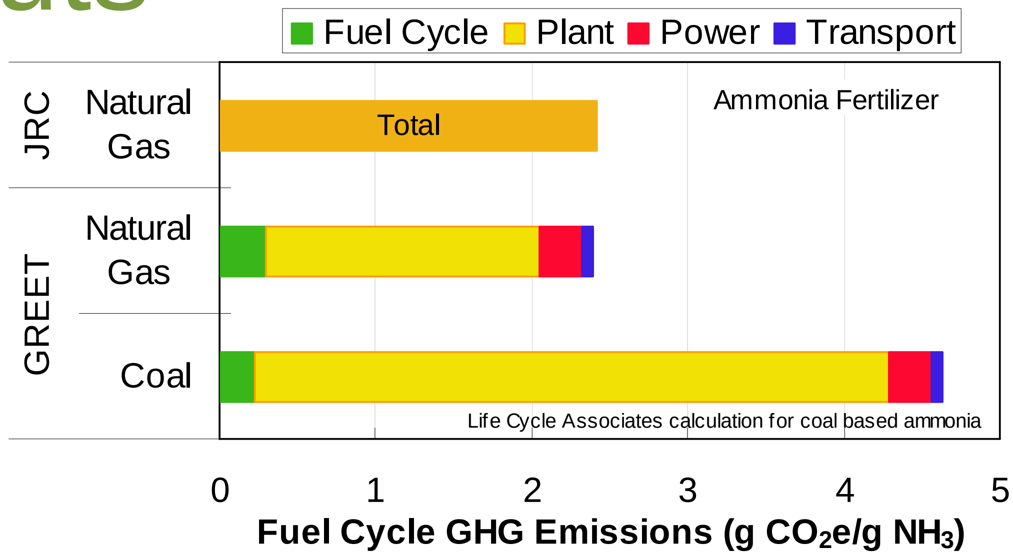
- Data Sources
  - Variation
    - Year to year
    - Regional
    - Uncertainty
- Model Inputs
  - Aggregation
  - Future projections

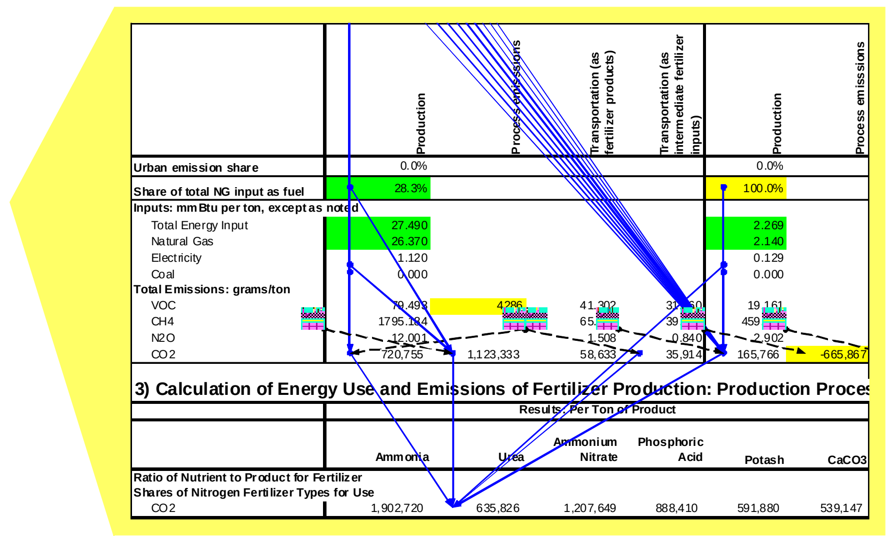




Chemical Inputs

- Resource mix
- Technology options
- Model approach
  - Internal calculation
  - Same complexity as fuels





Suggestions for Transparency

- Interim results
  - Natural gas, coal, fertilizer, diesel, fuel carbon
  - Show derivation of inputs
- Carbon intensity - universal metric
  - WTT + Fuel Carbon + Vehicle CH_4 & N_2O
- Simple calibration case (e.g. natural gas, dry mill corn ethanol)
  - Complex scenarios hide underlying data
- Consistent summary tables of all input data

Note: These suggestions have been acted on to some degree in all of the fuel life cycle models and documentation reviewed here.

Additional Research

- Input data
  - Document fuel properties and variation
  - Maintain USDA data collection
  - Perform farm input case studies
  - Validate biorefinery plant process data
- Analysis
  - Develop alignment between different fuel LCA models
  - Develop consistent reporting metrics
  - Perform LCA on biorefinery inputs
  - Use consistent metrics for LUC
- Uncertainty analysis
  - Develop/maintain tools
  - Analyze data to determine basis for uncertainty
- Develop consistent approach for co-products

Thank You!

- This work was completed under CRC project E-88
- Project Manager: Dr. Christopher Tennant
- Input from review team
- Final report to be completed soon

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