# *Methodological Comparison of GREET, GHGenius and BioGrace*

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**CRC WORKSHOP ON LIFE CYCLE ANALYSISOF TRANSPORTATION FUELS**

# *Agenda*

- Model Intent
- Model Structure
- System Boundaries
- Allocation
- Data Quality

# *Model Differences*

- There are a variety of reasons for differences in the models
  - Allocation approaches, system boundaries, geographic differences, age of data, quality of secondary data, process assumptions.
  - These are relatively easy to identify, the issue is what is the best approach to reducing the differences recognizing that there will always be some variability.

# Original Intent

- The three models were originally designed to do different things.
- GREET and GHGenius have evolved so that they meet not only their initial intent but are also able to function as compliance tools.
- BioGrace duplicates the biofuel pathway emissions specified in the RED default values. It only includes biofuel pathways.

| Model | Original Intent |
|---|---|
| GREET | Inform Policy |
| GHGenius | Inform Policy |
| BioGrace | Compliance Tool |

# Model Structure

- Consistent with their different original intents, the models have different structures.
- In a circular model the changes in one pathway can impact the results of another pathway. In a linear model, the results for each pathway are independent of other pathways.

| Model | Structure |
|---|---|
| GREET | Circular |
| GHGenius | Circular |
| BioGrace | Linear |

# *Analysis Tools*

- Also consistent with the original intents, GREET and GHGenius have tools to address the analysis uncertainties.

| Model | Analysis Tools |
|---|---|
| GREET | Yes |
| GHGenius | Yes |
| BioGrace | No |

# System Boundaries

- There are some differences in the system boundaries between the models.
- BioGrace does not include any infrastructure emissions.
  - GREET has the most optionality to include these emissions.
- GREET does not include refueling station energy use.
  - The other two models do. Generally a small impact.
- Each model takes a different approach to land management changes.
  - All models have some capacity to include these emissions but only GHGenius has non zero values as default values. This has a large impact on the palm oil pathways.

# System Boundaries

- BioGrace does not include avoided emissions in their single MSW pathway.
- BioGrace has a limited number of pathways. Important commercial pathways not included.
  - Corn oil to biodiesel and renewable diesel.
  - UCO and tallows to renewable diesel.
- BioGrace does not have a full set of transportation options for all of the transportation requirements.
  - No diesel rail and limited electric rail.

# Allocation

- BioGrace follows the energy allocation methodology specified in the RED
- GHGenius provides options of using displacement, energy, and mass and hybrids where different approaches can be used for different aspects of a pathway. With one exception, displacement is used as the default.
- GREET has the most options for allocation. It also includes economic and process energy use. It also allows for hybrid approaches.

| Model | Options |
|---|---|
| GREET | Displacement, Energy, Mass, Economic |
| GHGenius | Displacement, Energy, Mass |
| BioGrace | Energy |

# *Allocation*

- The energy allocation used by BioGrace compared to the displacement approach used in GREET and GHGenius drives the lower ethanol GHG emissions in BioGrace.
- Similarly the energy allocation for oilseed crushing compared to the mass allocation in GREET and GHGenius drives higher GHG emissions for oilseed biodiesel in BioGrace.
- Two plants doing the same thing, in the same region can get very different CIs by changing the location of the fence!
  - Under an energy allocation system co-products have the same CI as the main product.
  - If a plant can utilize the co-product to displace a fossil product within the plant boundary, it will effectively get a displacement credit.

# *Regulatory Compliance*

- The Low Carbon Fuel Standard in California, British Columbia, and the FQD in Germany have moved to a plant specific CI for most fuels (except gasoline and diesel).
- California started with some default pathways but have moved away from that with the second generation of CIs in 2016. California are now working on their third generation modelling for CI calculations.
  - They moved away from default values because the data that was used in the default pathways wasn't representative of actual plant performance.

# *LCA for Policy vs Compliance*

- There is actually a shift in emphasis on what is important in a LCA model between one used for policy development (historical use) and one used compliance (current use).
- Historically there was more emphasis on the fuel production process and less on the background processes. That has now shifted.

# *LCA for Policy vs Compliance*

- ISO definitions
  - Primary Data
    - quantified value of a *unit process* or an activity obtained from a direct measurement or a calculation based on direct measurements at its original source.
  - Secondary Data
    - data obtained from sources other than a direct measurement or a calculation based on direct measurements at the original source
    - Note: such sources can include databases and published literature validated by competent authorities.

# *LCA for Policy vs Compliance*

- Under a compliance scenario the primary data is entered into the models. It is real and verifiable, although not necessarily public.
- It is the secondary data that becomes the focus of uncertainty and variability.
  - Fertilizer manufacturing
  - $N_2O$ emissions
  - Direct energy use for feedstock production
  - Changes in carbon stocks from land management changes.

# *Identifying Primary Data*

- The regulator needs to decide what is primary data and what is secondary data for a pathway.
- It needs to be consistent.
  - You can't have one parameter specified as primary and a related parameter identified as secondary data and thus not modifiable.
  - Unfortunately this happens in BioGrace and CA GREET.
    - Biodiesel co-product volumes are a function of yield, the CA GREET Tier 1 model requires the yield to be plant specific but does not allow any non-glycerine co-product to be accounted for.
    - Same thing happens with renewable diesel.

# *Data Quality*

- How do we assess data quality?
- Generally consider five aspects, usually qualitatively.
  - Reliability
    - Government Sources, verified?
  - Completeness
    - Does it consider all emissions?
  - Temporal Representativeness
    - How recent is the data? Is the full set from the same time period?
  - Geographic Representativeness
    - Is the data from the same region where the study is being undertaken?
  - Technological Representativeness
    - The level of activity coverage? Does it cover all of the major technologies employed.

# *Quality of Secondary Data*

- Secondary can be hard to come by, even in this age of Big Data.
- In general the quality of secondary data is improving.
- There is always room for improvement in the models and none of them are perfect.

| Parameter | GREET | GHGenius | BioGrace |
|---|---|---|---|
| Reliability | Good | Good | Poor |
| Completeness | Generally Good | Good | Poor |
| Temporal Representativeness | Good | Very Good | Poor |
| Geographic Representativeness | United States | Canada, United States, Mexico, India | Europe |
| Technological Representativeness | Good | Good | Low |

# *Is a Unified Model Possible?*

- In theory yes, but not likely in the near term.
- Secondary data limitations make it difficult to update all of the data for a specific parameter at the same time.
- Regional political sensitivities.
  - Makes agreement on the “Art” part of an LCA a challenge.

# *Challenges for Regulators*

- Ensure that the models used for compliance properly reflect the processes being modelled.
  - The models are fair to all producers of the same fuel.
  - The models don’t have built in biases between fuels.
- That the models contain good quality secondary data.
  - The data needs to be timely and have good geographic scope.

# *Challenges for Biofuel Producers*

- Low carbon fuel programs reward low CI fuels. The reward can be significant (25 to 50 cpl) and producers are interested in investing in lowering their GHG emissions.
- The compliance tools don't always have the flexibility to properly model their process, supply chain, or proposed innovations.
- Models need to ensure that they reward real change that results in real GHG emission reductions.

# *Challenges for Biofuel Producers*

- Markets can be fluid, for multi-feedstock plants the relative scores between regulatory systems for different feedstocks can be a challenge to align the feedstock with the customer demand.

# Questions?