

# GHG Impact of Corn Oil from Ethanol Plants

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Corn Ethanol with CO extraction

## Comment

Life Cycle Associates would like to take this opportunity to provide our comments on the starch ethanol LCFS calculator under development. Based on our review of the Starch-etoh\_v43.xls, the following considerations should be made for the next version of the calculator.

- Most of the emission factors in starch sheet are in the ballpark but do not exactly match the factors in CA\_GREET3 (GR3) to decimal places. They should be recalculated and pasted again to accurately replicate the results from GR3. We have pasted the EF we calculated from GR3 in the starch sheet for your reference. We have also marked these EF calculations in the attached GR3 in blue to demonstrate the calculation these and allow quick replication for regions/model versions.
  - In the GR3, our calculations are marked in light blue. The EF calculations are located on the respective sheets. For example, we have calculated the
    - electricity EF on electric sheet,
    - NG EF on NG sheet,
    - soy oil EF on BioOil sheet,
    - corn farming EF on EtOH sheet next to farming calculations,
    - corn and EtOH transportation calculation next to the calculation summary at bottom of EtOH sheet etc.
- Corn oil credit calculation is off for multiple reasons
  - The EF of soy oil (cells D55:58 on EF tables) are incorrect. We calculated the correct EF in attached greet in BioOil sheet for your reference (including the N2O from fert and CO2 from urea). The total soy oil CI should be the sum of the 4 blue cells next to soy farming calculations (near row 320). This can be verified by the intermediate feedstock calculation in cell G358 (both should match, except correct the GWP formula in the row 358 first). We further checked this through making a biodiesel disaggregation for GR3 which matched this number. The calculations for this is also described in a later section in this analysis.
  - The credit calculation formulas on EtOH sheet (in cells E89:90) essentially make the credit independent of the corn oil lb/gal by first multiplying AP58 in cell E90 and then dividing the same in the cell E88. In the attached version, we have fixed the calculation in cell E88 to rectify it.
  - The ILUC of soy oil also needs to be incorporated in the credit. This is described in a later section of this analysis.
- The ethanol (and even other finished fuels) transportation EF in the starch sheet are currently based on US average region. However, changing these EF to match CA specific diesel should be considered as that will be the most likely case. You can also consider adding a note on the rail vs truck distance that they are an either-or case. meaning, that a plant will typically deliver its fuel to bulk terminal by EITHER rail OR truck, not both.

- The GWP for the non-combustion (fugitive) emissions during the fuel production phase should be zero as they have biogenic origin. The change needs to be made in the CA\_GREET3 as well as the starch sheet.
- The use of loss factor needs to be corrected. Currently, it is applied in the cells C12, C14 and C16 to all the steps in the CI calculation. However, it should only be applied to the steps till the fuel production step including fuel production. It should not be applied to the ethanol T&D, denaturant and iLUC.

### Soy Oil Production

CO credit in verification calculator is based on substitution of soy oil. The EF for the soy oil should be based on the Soy oil LCI from Soy Oil for other uses on the BioOil sheet. The GWP of carbon black and organic carbon as well as the short term GWP should be made equal to 0. The equation determining this EF is as follows.

$$E_{SO, \text{ other}} = E_{SB} / \rho_{SB} / OYF \times X_{SO} + (E_{SO, \text{ Extract}} \times OYF + E_{SO, T\&D})$$

where,

$E_{SO, \text{ other}}$  = GHG of soy oil (soybean farming + SO extraction) for other uses such as for CO substitution credit. (g CO<sub>2</sub>e/lb soy oil)

$E_{SB}$  = GREET upstream fuel cycle for soybeans per bushel = ( $E_{\text{Farm}} + E_{\text{Fert/Chem}} + E_{\text{T\&D}}$ )

$\rho_{SB}$  = Density of soybean on dry basis (lb soybean/bu soybean) = 52.2

OYF = Oil yield factor (lb soyoil/lb soybean) = 0.2

$X_{SO}$  = Allocation factor for soybean to soyoil = 0.2

$E_{SO, \text{ Extract}}$  = Unallocated soy oil extraction energy and emissions

$E_{SO, T\&D}$  = Soy oil transportation and distribution energy and emissions per lb soy oil

### Soy Oil ILUC

Soy oil ILUC directly related to ILUC from Soy BD pathway. ILUC calculations take into account SO to BD yield. Soy bean density and allocation factors are also part of the calculation. ILUC calculations for SO and SBM are referred to as Method 1S in the analysis.

This method involves the soy oil and soybean meal as the only products of soybean. This method simply gives us the ILUC of soybean meal and soyoil based on the BD ILUC, and the relevant yields and allocation factors.

### Lost ILUC from DGS

Corn oil used for BD or animal feed diverts the corn oil from the DGS mass. This reduces the DGS that is produced and thus the ILUC credit for DGS should also be lowered.

ARB GTAP ILUC analysis took into account the substitution of corn, soybeans, and other agricultural products. The GREET substitution ratios provide basis for estimating ILUC portion of DGS and corn separately.

### ILUC Calculation Method 1

Method 1 combines the GREET substitution ratios with GTAP ILUC results for corn ethanol and soy biodiesel and builds on Method 1S. This allows the calculation of the ILUC for corn and DGS separately.

### ILUC Calculation Method 2

Corn and soybean yields combined with GTAP ILUC for corn ethanol provide basis for determining ILUC of DGS, corn, and soybeans. This method assumes that an acre of land can grow either corn or soybeans. The ILUC of corn, DGS and soybeans is determined based on the relative yields of the crops with ethanol ILUC as the fixed starting point.

**Table 1.** ILUC Calculation Results

Parameter	Method 1s	Method 1	Method 2
M <sub>CORN</sub> (kg corn/bu corn)		25.40	25.40
M <sub>EtOH</sub> (kg EtOH/bu corn)		8.13	8.13
M <sub>DGS</sub> (kg DGS/bu corn)		6.95	6.95
M <sub>SB</sub> (kg soybean/bu soybean)	27.22	27.22	27.22
M <sub>BD</sub> (kg biodiesel/bu soybean)	5.23	5.23	
M <sub>SBM</sub> (kg soybean meal/bu sb)	21.77	21.77	21.77
M <sub>SO</sub> (kg soyoil/bu soybean)	5.44	5.44	5.44
iluc <sub>EtOH</sub> (gCO <sub>2</sub> e/kg EtOH)		533.6	533.6
iluc <sub>BD</sub> (gCO <sub>2</sub> e/kg BD)	1,092.1	1,092.1	1,449.8
iluc <sub>SBM</sub> (gCO <sub>2</sub> e/kg SBM)	1,050.0	1,050.0	1,393.9
iluc <sub>CORN</sub> (g CO <sub>2</sub> e/kg corn)		329.4	443.2
<b>Back Calculate:</b>			
iluc <sub>DGS</sub> (gCO <sub>2</sub> e/kg DGS)		579.8	995.5
iluc <sub>SB</sub> (gCO <sub>2</sub> e/kg SB)	1,050.0	1,050.0	1393.9
iluc <sub>SoyOil</sub> (gCO <sub>2</sub> e/kg SO)	1,050.0	1,050.0	1393.9
iluc <sub>SoyOil</sub> - iluc <sub>DGS</sub>		470.2	398.4

For more details of the calculations, please refer the linear ILUC model attached with the analysis.

**Conclusion**

The difference in Soy oil ILUC and DGS ILUC is consistent with Methods 1 and 2 even though Method 2 shows higher ILUC values for both DGS and soy oil. The results from method 2 are consistent with method 1 but do not rely on the ILUC of Method 1S.

The average difference in ILUC of soyoil and DGS is 434 g CO<sub>2</sub>e/kg soy oil or 197 g CO<sub>2</sub>e/lb soy oil. This should be added to the EF of the soy oil calculated from the soy oil for other uses. The sum should then be used to provide the substitution credit to the CO extracted.

Thank you for your consideration.

Best Regards,



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Love Goyal  
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