Comments on "Detailed California-Modified GREET Pathway for Corn Ethanol" Version 2.1[1], February 27, 2009

Transparency and Documentation are needed for Parameter Assumptions and Underlying Data in the Life Cycle Assessment[2]

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Summary: The report entitled "Detailed California-Modified GREET Pathway for Corn Ethanol" produced by Life Cycle Associates[4] for CARB does not meet acceptable scientific standards for a regulatory framework. ***All primary assumptions and data sources are not clearly documented, the analysis utilizes obscure and inconsistent units of measure, and results cannot be traced back to underpinning calculations.*** Underlying parameter values and data sources must be clearly shown according to ISO standards, EPA standards, and federal law[5]. All calculations and data sources used should be documented in metric units in accordance with scientific standards. Life cycle assessment (LCA) methods that do not meet these standards will not be recognized by scientists, biofuel producers, or related industries. Transparent methodology is particularly important because the outcome of this LCA will likely exclude many biofuel producers from California markets[6]. As the report is currently written, the disclosure of data sources and documentation for the proposed LCA are not sufficient to allow rigorous scientific review. One key deficiency rests with the GREET model, which has been repeatedly changed and modified over the last 14 years such that data sources and documentation for the current version used by in the proposed CARB Low Carbon Fuel Standard (LCFS) are scattered amongst a number of technical reports, most of which have not undergone peer review. Moreover, some of the parameter values used in the version of GREET have not been updated such that they are no longer representative of the systems evaluated. References and justification for the associated modifications of GREET parameters by Life Cycle Associates are also not documented. Specific points to support these conclusions follow, and we append a list of industry representatives who support the message conveyed to CARB in this document.

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[1] http://www.arb.ca.gov/fuels/lcfs/022709lcfs_cornetoh.pdf
[2] This memo is a follow up to comments in two previous memos sent to CARB on March 26, 2008 and June 29, 2008, where we previously specified the need for data transparency—these suggestions were ignored. http://www.arb.ca.gov/lispub/comm2/bccommlog.php?listname=lcfs-lifecycle-ws
[3] e-mail addresses: kcassman1@unl.edu, aliska2@unl.edu.
[4] http://www.lifecycleassociates.com/
[5] See point 4 below.
[6] http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol1.pdf

1. **Primary Data Inputs for Corn-Ethanol LCA**: As the draft report is written, the majority of primary data and the citations to support them are not clearly documented[7]. Thus, the report fails to deliver the necessary information that allows rigorous scientific review. ***Incomplete documentation of assumptions and data sources is not an acceptable standard to facilitate disclosure and clarity for regulatory purposes, and it does not meet publishable scientific standards.*** The EBAMM[8] and BESS[9] LCA models and associated documentation of primary data are examples of appropriate transparency and disclosure. Such clarity is essential for setting the Low Carbon Fuel Standard (LCFS) in California. Without corresponding citations, it is not clear that the values employed in the LCA are representative of the systems evaluated. An acceptable level of documentation requires the exact parameter values used (based on primary data) directly linked to their supporting citation(s). This requirement is especially important for those parameters that have a large influence on GHG emissions, such as crop yields, nitrogen fertilizer application rates, grain to ethanol conversion yields, and energy use at the biorefinery per unit of ethanol produced. Documentation for less sensitive parameters is also needed because although they may have relatively small impact on an individual basis, their combined effect on the LCA can be substantial.

   Conclusion: All values and corresponding units for primary data inputs used in the proposed LCA framework must be provided and clearly linked to the supporting documentation. Preference should be given to documentation taken from peer-reviewed publications or other widely accessible databases.

2. **GREET Scientific Units and Calculation Structure—Embedded Assumptions:** Many scientific units used in the GREET model, and described in the CARB report, are based on unconventional units that combine both English and metric measures. Examples of such units used in the CARB-GREET model include: nutrient inputs for crop production in grams per bushel (g/bu) and grams carbon dioxide equivalent per million British thermal units (gCO2e/mmBtu)[10]. Reliance on such unconventional units reduces transparency of parameter values and does not contribute to full disclosure of data and methods employed. Metric units should be employed exclusively to correspond with scientific standards to be congruent with related international greenhouse gas (GHG) emission LCA standards under development. For example, although units of grain yield and fertilizer inputs to crops are reported by the US Department of Agriculture in English units (e.g. gal/ac or lb/ac), they should be transformed into metric units.

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[7] Appendix I.
[8] http://rael.berkeley.edu/ebamm/; Farrell et al. (2006). "Ethanol Can Contribute to Energy and Environmental Goals." *Science* 311: 506-508.
[9] http://www.bess.unl.edu; Liska et al. (2009). "Improvements in Life Cycle Energy Efficiency and Greenhouse Gas Emissions of Corn-Ethanol." *Journal of Industrial Ecology* 13(1): 58-74.
[10] See tables 2.01 and 1.09, respectively, in the report.

Calculations in the GREET model scale all crop inputs linearly to grain yield, with resulting intermediate parameters in British thermal units per bushel of grain (Btu/bu) and grams per bushel (g/bu); these units are presented as primary data in the CARB report, but they are actually integrative parameters that lack transparency as to the source of data. For example, the use of Btu/bu and grams/bu conflates reported energy and nutrient inputs per unit area for corn production (e.g. kg/ha, L/ha, kg/ha) with crop yield per unit area (Mg/ha), which results in spatial and temporal biases. Historically, nutrient use has also become more efficient and is not directly related to grain yield. Crop inputs per unit of grain yield vary substantially from state to state, with southern states requiring greater nutrient inputs per unit of grain produced, and western states requiring additional fossil fuel use for irrigation[11]. As a result there is substantial spatial and temporal variability in net energy yields and GHG emissions for a given biofuel system that cannot be captured unless region- or state-specific values are used for inputs and outputs from the feedstock production system[12]. ***Such regional analyses should use the most recent crop yields, nutrient input rates, and fossil fuel costs of energy and inputs used in all phases of the life cycle.***

Calculation of greenhouse gas emissions alone for LCFS implementation does not require estimation of criteria pollutant emissions (volatile organic carbon [VOC], and carbon monoxide [CO]). Inclusion of these calculations in the core of the calculation structure of GREET may introduce inaccuracy and is non-essential for the calculations required for a LCFS.

3. **Denaturant Blending with Biofuels:** Corn ethanol biorefineries produce ethanol as a primary product and are required to blend in a minimum amount of denaturant before shipping to the blender in accordance with liquor laws. Gasoline is used as the denaturant, and the level of denaturant added is highly variable. On average, Nebraska corn-ethanol plants in 2007 blended denaturant at 2.7% by volume based on data from the Nebraska Department of Environmental Quality (NDEQ); in 2005 and 2006 in NE, denaturant was blended at 4.1% and 4.3%, respectively. Ethanol can also be transported and used in anhydrous form, as is done in Brazil. After transport, ethanol is blended with more gasoline to reach the desired ethanol blend concentration, roughly 10% (E10) or 85% (E85).

   We would argue that a comparison of blended products (gasoline containing ethanol, and ethanol containing gasoline) is biased against ethanol. The inclusion of denaturant in the emissions intensity of ethanol results in an inflated GHG intensity of the biofuel, while inclusion of ethanol in a gasoline blend reduces its emissions intensity. Because the denaturant does not reflect the inherent biofuel GHG contribution to global warming, it should be excluded from the life cycle calculation. Regulations should compare the GHG emissions intensity of pure products based on their sources: 100% petroleum-based gasoline in the form of reformulated blendstock

[11] Liska et al. (2009); Liska AJ, Cassman KG (2008). Towards Standardization of Life-Cycle Metrics for Biofuels: Greenhouse Gas Emissions Mitigation and Net Energy Yield. *Journal of Biobased Materials and Bioenergy*, 2, 187-203

[12] Liska et al. (2009)

and 100% ethanol in anhydrous form. This is consistent with the recommendations of the Roundtable on Sustainable Biofuels, Version Zero[13].

We further argue that life cycle regulations, such as the CARB-LCFS should be based on straightforward methods, where gasoline and ethanol can be thought of as two buckets that pour into the state's fuel system. The level of denaturant blended with ethanol for transportation in California and other states should be considered part of petroleum imports, as the biofuel will be eventually further blended with petroleum before final use. ***The fraction that is denaturant should be subtracted from the ethanol volume, and considered a component of the state's gasoline imports.***

4. **Reporting of LCA Results**: Final life cycle emissions from biofuels should be reported in an emissions inventory format[14]. This format would show all emissions and enable clear inspection of the life cycle boundaries employed, the factors that contribute to each component of the life cycle, and the resulting final emissions estimates. Specifically, the individual emissions in the crop production system and the biorefinery system should be shown in a list (disaggregated) to provide a clear understanding of the results. The current CARB-GREET format documentation for corn-ethanol does not provide a complete emissions inventory, which makes it a "black box" for anyone that wishes to verify the components.

5. **ISO Standards, EPA Data Transparency Standards, and Federal Law**

ISO standards specify the need for qualifying information to supplement data used in LCA. The standard states:

"The data quality requirements should address:
- time-related coverage;
- geographical coverage;
- technology coverage;
- precision, completeness and representativeness of the data;
- consistency and reproducibility of the methods used throughout the LCA;
- sources of the data and their representativeness;
- uncertainty of the information." [15]

EPA's guidelines for environmental model development and evaluation also emphasize the need for transparency:

> "In the course of modeling, many choices must be made and options selected which may lead to biases in the model results. Documentation of this process and its limitations and uncertainties is essential to increasing

[13] http://cgse.epfl.ch/page70341.html; "The fossil fuel reference shall be global, based on IEA projections of fossil fuel mixes."
[14] Liska et al. (2009); see Table 2.
[15] ISO 14040 (1997). *Environmental management—Life cycle assessment—Principles and framework.*

> the utility and acceptability of model outcomes. **Modelers and project teams should document all relevant information about the model to the extent practicable, particularly when a controversial decision is involved**."[16] (p.35)

EPA's Information Quality Guidelines further emphasize transparency with regard to data sources used to ensure high quality analysis:

> "EPA recognizes that influential scientific, financial, or statistical information should be subject to a higher degree of quality (for example, transparency about data and methods) than information that may not have a clear and substantial impact on important public policies or private sector decisions. A higher degree of transparency about data and methods will facilitate the reproducibility of such information by qualified third parties, to an acceptable degree of imprecision…**It is important that analytic results for influential information have a higher degree of transparency regarding (1) the source of the data used, (2) the various assumptions employed**, (3) the analytic methods applied, and (4) the statistical procedures employed. It is also important that the degree of rigor with which each of these factors is presented and discussed be scaled as appropriate, and that all factors be presented and discussed." (p.20)[17]

As a complement to the EPA Information Quality Guidelines, the ***EPA Science Policy Council*** emphasizes general transparency as the third of a number of assessment factors:

> "Clarity and Completeness - The degree of clarity and completeness with which the data, assumptions, methods, quality assurance, sponsoring organizations and analyses employed to generate the information are documented."[18]

With the passage of ***section 515 of the Treasury and General Government Appropriations Act of 2001*** (Public Law 106–554; H.R. 5658), government-wide guidelines for information quality were established. Associated guidelines from the Office of Management and Budget state:

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[16] U.S. Environmental Protection Agency (2008). Draft. *Guidance on the Development, Evaluation and Application of Environmental Models.* Council for Regulatory Environmental Modeling. http://epa.gov/crem/library/CREM-Guidance-Public-Review-Draft.pdf

[17] U.S. Environmental Protection Agency (2002). *Information Quality Guidelines*: *Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity, of Information Disseminated by the Environmental Protection Agency*. Office of Environmental Information. http://www.epa.gov/QUALITY/informationguidelines/documents/EPA_InfoQualityGuidelines.pdf

[18] U.S. Environmental Protection Agency (2003). *A Summary of General Assessment Factors for Evaluating the Quality of Scientific and Technical Information.* Science Policy Council. http://www.epa.gov/OSA/spc/pdfs/assess2.pdf

> "Agency guidelines need to achieve a high degree of transparency about data even when reproducibility is not required…The purpose of the reproducibility standard is to cultivate a consistent agency commitment to transparency about how analytic results are generated: the specific data used, the various assumptions employed, the specific analytic methods applied, and the statistical procedures employed…With regard to analytic results related [to influential scientific, financial, or statistical information], **agency guidelines shall generally require sufficient transparency about data and methods that an independent reanalysis could be undertaken by a qualified member of the public**…The primary benefit of public transparency is not necessarily that errors in analytic results will be detected, although error correction is clearly valuable. **The more important benefit of transparency is that the public will be able to assess how much an agency's analytic result hinges on the specific analytic choices made by the agency. Concreteness about analytic choices allows, for example, the implications of alternative technical choices to be readily assessed. This type of sensitivity analysis is widely regarded as an essential feature of high-quality analysis, yet sensitivity analysis cannot be undertaken by outside parties unless a high degree of transparency is achieved.** The OMB guidelines do not compel such sensitivity analysis as a necessary dimension of quality, but the transparency achieved by reproducibility will allow the public to undertake sensitivity studies of interest." (p. 8456)[19]

The current draft of CARB's "Detailed California-Modified GREET Pathway for Corn Ethanol" does not include sufficient qualifying information required under ISO guidelines listed above for LCAs. The draft also provides insufficient references to validate the source and quality of the data employed, as required by EPA guidelines and federal law discussed above. Although the GREET model website was given as one of the few references in the report, documentation of the CARB-GREET model relies on a large number of informal, unrefereed reports that modify earlier versions of the GREET model and therefore do not serve to as adequate citation and justification for this report. ***Documentation for GREET also does not provide sufficient information about the changes made by Life Cycle Associates in producing the final LCA results shown in the CARB report. Therefore, the current draft version does not adequately support the findings of CARB that represent the foundation of its draft regulations for the LCFS[20].***

[19] Office of Management and Budget (2002). *Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated by Federal Agencies; Republication.* Executive Office of the President. http://www.whitehouse.gov/omb/assets/omb/fedreg/reproducible2.pdf

[20] http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol1.pdf

CONCLUSIONS

The transparency of underpinning assumptions and data sources used in the corn-ethanol LCA analysis performed by Life Cycle Associates for CARB's LCFS does not meet minimal standards to enable scientific review of the proposed LCA methods and GHG intensity values. The proposed CARB LCFS for corn-ethanol likewise does not meet ISO, EPA, or U.S. legal standards for clarity, documentation, and completeness of data and assumptions of models used in a regulatory framework. The enormous complexity of biofuel LCA analysis requires: (1) detailed description of the parameters used in the LCA method and their supporting references, (2) use of parameters that are consistent with the source documentation, and (3) metric units in accordance with other scientific and regulatory frameworks. The current document provided by CARB fails to meet these requirements and, therefore, does not provide the foundation for effective regulation.

APPENDIX I.

Undocumented Data Sources from the CARB Report "Detailed California-Modified GREET Pathway for Corn Ethanol" (Version 2.1, February 27, 2009):

- Tables 1.01 and 1.03: The sources of fossil fuel rates are not reported (Table 1.04 is referenced, yet does not include any additional references). If data from Shapouri 2001 was used, the source of the original statistics should be reported.
- Table 1.02: The source of conversion yields (liters per kg grain) is not reported.
- Table 1.04: The source of data concerning the energy consumption used in the production and delivery of fuels is not reported.
- Table 1.06: The source of emissions factors is not reported
- Table 1.07: The emission factor for Midwest average electricity is noted, but the value and source are not reported.
- Table 1.07: The crop yield is not reported to complete the calculations in this table. Appendix B in the report does indicate 158 bu/ac as the crop yield employed, but the states that make up this likely average yield are not listed, the year or years of this average are absent, and the source of these rates is not reported.
- Table 2.02: The source of emissions factors for fertilizer production is not reported.
- Table 2.03: The sources for fertilizer application rates, crop yields, and the corresponding years and states are not reported.
- Table 2.04: The sources for emissions factor and loss factors are not reported.
- Table 2.06: The source of 1.3% loss from applied nitrogen as N_2O is not reported.
- Table 3.01: The source of energy use rates per unit of corn hauled in not reported.
- Table 3.03: The source for emissions from transportation is reported as "CA-GREET Default". Documentation supporting California modified CA-GREET is not available[21]. Furthermore, as these parameters are specific for the corn-ethanol pathway and are not specific for other fuel products, such defaults should be clearly documented in the report on corn-ethanol in question.

[21] http://www.arb.ca.gov/fuels/lcfs/lcfs.htm#new

- Tables 3.05-3.07: The sources for emissions factors are not reported.
- Tables 4.02 and 4.03: The thermal energy efficiency of the biorefinery is the single most important parameter for calculations of life cycle GHG emission intensity. The origins of the values used here are not reported. There is no justification given for the use of these parameter values. Associated data describing the USA ethanol industry has no references.
- Tables 4.04, 4.06, 4.08, 4.11: The sources for emissions factor are not reported.
- Table 4.10: The source of statistics on electricity generation is not reported.
- Table 5.02: The sources for energy use rates for transportation are not reported.
- Table 5.03: The sources for emissions factors are not reported.
- Table 6.02: The data sources for feed replacement rates have changed since the time of the initial analysis (1998) used as a reference in this report.[22]
- Table 6.03: The sources for emissions factors are not reported. This table needs references for every value employed for determining feeding rates and dietary substitutions.
- Table 6.05: The sources for emissions factors are not reported.
- APPENDIX B contains no references for individual values and needs appropriate references.
- The report does not describe the assumptions for the calculation of indirect emissions from land use change (a value of 30 gCO_2/MJ is used) which is added to the well-to-tank GHG intensity of ethanol. As this is specifically added to corn-ethanol, a full description of the primary assumptions is needed, and should be included in the report in question. Appendix C[23] does not provide an adequate description of the parameter and assumptions used to determine indirect emissions from land use change (additional material in Appendix C on distillers grains feeding needs to be incorporated in the primary document "Detailed California-Modified GREET Pathway for Corn Ethanol")

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[22] Klopfenstein, T., G. Erickson, V. Bremer. Use of Distillers Byproducts in the Beef Cattle Feeding Industry. *Journal of Animal Science*, 86, 1223-1231 (2008); Liska et al. (2009).
[23] http://www.arb.ca.gov/fuels/lcfs/030409lcfs_isor_vol2.pdf

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