UIC UNIVERSITY OF ILLINOIS AT CHICAGO

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Energy Resources Center (MC 156)
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Life Cycle Greenhouse Gas Emissions Impact of Proposed RVO Adjustment Scenario

This University of Illinois at Chicago Energy Resources Center conducted an analysis that looked at the greenhouse gas emissions impact of EPA's RVO adjustment from the original RVO to the waivered RVO which will presumably leave conventional biofuels (starch ethanol) short by 1.6 billion gallons in 2015 (Original RVO of 15 billion gallons for 2015 to the waivered RVO of 13.4 billion gallons in 2015). This brief provides a technical explanation of the findings.

Background on Life Cycle Analysis (LCA)

The life cycle carbon intensity (CI) of a fuel is generally stated as the mass of carbon dioxide equivalent (including carbon dioxide, nitrous oxide, and methane) emitted per energy unit of fuel. The common unit is gCO_2e/MJ. The CI of a fuel is determined by adding the emissions incurred along its production pathway for the product life cycle including fuel feedstock origination (e.g. drilling, mining, corn growing), feedstock conversion at refineries, and combustion in the vehicle. For biofuels, in particular, the land requirements for feedstock production can also produce emissions and/or sequestration effects from carbon stock adjustments. Computable economic equilibrium models are often used to determine land use change (LUC) prompted by biofuels production and the assessed LUC is subsequently multiplied by carbon stock emissions factors specific to ecosystem changes to derive LUC carbon emissions associated with a particular biofuels pathway.

Advancements in LCA of Biofuels

New processing technologies as well as updated life cycle models and databases accessed by computable general equilibrium models have significantly advanced the CI assessments of biofuels over the last 10 years. For corn ethanol, for example, the following research updates have occurred:

1) <u>LUC Carbon Emissions</u>

   Published studies on LUC emissions have shown a significant reduction in the predicted carbon emission magnitude over time. This downward trend in predicted emissions is due to several factors in improved CGE models including 1) an evolving understanding of the elasticity of land transitions and yield-price relationships, 2) better addressing of ethanol co-product substitutions in animal feed markets, 3) better understanding and data availability of global land types, and 4) carbon adjustments during land transitions.

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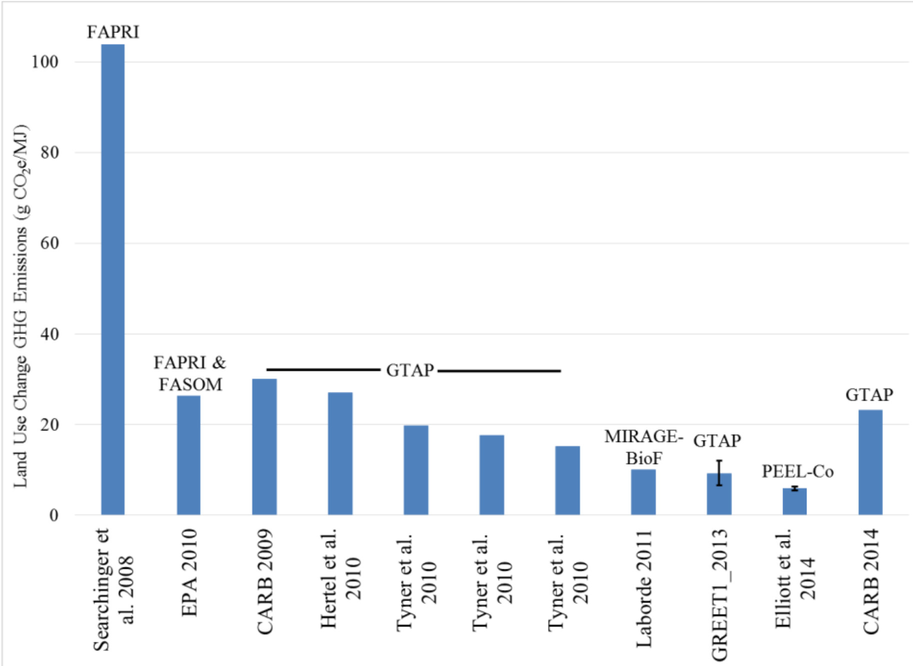

Figure 1: Predicted Land Use Change Emissions by Different Studies Over Time

2) Technology Innovation at the Biorefinery
The use of fossil energy at the biorefinery is a significant contributor to the CI of ethanol. Published surveys of the ethanol industry showed that 2008 ethanol plants use 30% less energy to convert corn to ethanol than 2001-era plants.[1] A recent follow up survey showed further energy reductions.[2]

3) Technology Innovation in Feedstock Agriculture
Emerging agricultural practices and technologies have been shown to further reduce land demands and emissions from biofuels production. Most noteworthy are applications of nitrification inhibitors which stabilize nitrogen fertilizer inputs (a market that has seen 20% year over year growth for the last 5 years), advanced hybrid seeds, and precision agriculture.

4) Updated Modeling
The Argonne CCLUB greenhouse gas emissions model from biofuels production incorporates detailed carbon stock factors for different ecosystems that enable an exhaustive analysis of carbon emissions and sequestration from LUC. For selected modeling runs (that take realistic, projected crop yield increases into account) the LUC emissions in CCLUB for corn ethanol total 7-9.0 gCO_2e/MJ (as opposed to 28 gCO_2e/MJ used by EPA for corn ethanol). [3,4]

[1] Mueller, S. (2010). 2008 National dry mill corn ethanol survey. *Biotechnology Letters, 32*, 1261-1264.

[2] Mueller, S. and John Kwik. Corn Ethanol: Emerging Plant Energy and Environmental Technologies, 2012, available at www.erc.uic.edu

[3] Ho-Young Kwon, Steffen Mueller, Jennifer B. Dunn, Michelle M. Wander; Modeling state-level soil carbon emission factors under various scenarios for direct land use change associated with United States biofuel feedstock production; Biomass and Bioenergy (2013), http://dx.doi.org/10.1016/j.biombioe.2013.02.021

[4] Jennifer B Dunn, Steffen Mueller, Ho-young Kwon and Michael Q Wang; Land-use change and greenhouse gas emissions from corn and cellulosic ethanol; Biotechnology for Biofuels 2013, 6:51 doi:10.1186/1754-6834-6-51; Published: 10 April 2013

Greenhouse Gas Increase from RVO Reduction Scenario

Peer-reviewed Argonne GREET life cycle emissions analyses estimate that corn ethanol greenhouse gas emissions are 19-48% (mean=34%) lower than conventional gasoline.[5] EPA's RVO adjustment from the original RVO to the waivered RVO will likely leave conventional biofuels short by 1.6 billion gallons in 2015 (Original RVO of 15 billion gallons for 2015 to the waivered RVO of 13.4 billion gallons in 2015). We modeled the emissions impact from this assumed RVO reduction using the Argonne GREET spreadsheet model and a separate post-processing spreadsheet. The results show that the 1.6 billion gallons difference will increase GHG emissions by 4,520,000 tonnes CO2e for that year (2015). According to the EPA Equivalency calculator this is equivalent to the annual greenhouse gas emissions of 951,600 passenger vehicles.

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[5] Wang, M., et al (2012) Well-to-wheels energy use and greenhouse gas emissions of ethanol from corn, sugarcane and cellulosic biomass for US use. Environ. Res. Lett. 7 045905