Summary of the California-GREET Pathway For Dry Mill Sorghum Ethanol

This document estimates the energy use and GHG emissions arising from the production and use of ethanol using sorghum as a feedstock. In this pathway, all steps except for the transportation and use of ethanol in a motor vehicle are assumed to occur in the Midwest. Ethanol production for this pathway is assumed to be from a dry mill ethanol plant located in the Midwest and producing either 100 percent dry distillers' grains with solubles (DDGS) or 100 percent wet distillers' grains with solubles (WDGS) as co-products.

This analysis was performed in two stages. Staff estimated the energy use and emissions associated with the agricultural production of sorghum and the transportation of the harvested feedstock to processing mills. Second, staff estimatedthe energy and emissions associated with the processing of sorghum into ethanol. The energy used in the production of sorghum ethanol, and the GHG emissions associated with that energy use, are assumed to be identical to the corresponding values reported in the Air Resources Board's "Detailed California-Modified GREET Pathway for Corn Ethanol."[1] The carbon intensity differences between the corn and sorghum ethanol pathways arise solely from differences in the agricultural production and agricultural chemical manufacturing processes. Table 1 summarizes the findings of the Air Resources Board's sorghum-to-ethanol life cycle analysis.

Table 1: Summary of Direct GHG Emissions from Midwest Dry Mill Sorghum Ethanol Production (DDGS and WDGS Co-products)

Sorghum Ethanol Fuel Cycle Components	**DDGS Production (gCO2e/MJ)**	**WDGS Production (gCO2e/MJ)**
Sorghum Farming	3.49	3.49
Ag Chemicals Production and Use	27.06	27.06
Sorghum Transportation	2.22	2.22
Ethanol Production	38.33	30.47
Ethanol Transport & Distribution	2.63	2.63
Total GHG Emissions	73.73	65.87
Co-Products	-11.51	-11.51
Total well-to-tank	**62.22**	**54.36**

[1] Detailed California-Modified GREET Pathway for Corn Ethanol, Anil Prabhu, et.al., February 27, 2009, http://www.arb.ca.gov/fuels/lcfs/022709lcfs_cornetoh.pdf

The agricultural and chemical production data used to calculate the estimates appearing in Table 1 are from the Economic Research Service of the USDA (February 1997).[2]

As with corn, the diversion of sorghum to biofuel production creates the likelihood that new land will be brought into agricultural production resulting in land use change effects. The land use change impacts associated with the production of sorghum ethanol have yet to be estimated. In the interim, ARB will use the land use change value associated with corn ethanol: 30 gCO2e/MJ. Adding this to the values appearing in Table 1 yield total carbon intensity values of 92.22 gCO_2e/MJ for the DDGS pathway and 84.36 gCO_2e/MJ for the WDGS pathway.

Staff recommends that the executive officer approve this fuel pathway.

[2] Economic Research Service, U.S. Department of Agriculture, February 1997, FBEI UPDATES: Costs of Production. Updates on Farm Business Economic Indicators FBEI 97-1. http://www.ers.usda.gov/publications/fbei/fbei-sor.pdf