Staff Summary
Method 1 Fuel Pathway

California-Modified GREET Fuel Pathway: Biodiesel Produced in the Midwestern and the Western U.S. from Corn Oil Extracted at Dry Mill Ethanol Plants that Produce Wet Distiller's Grains with Solubles
(Pathway Code: BIOD021)

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Pathway Summary

California Air Resources Board (ARB) staff has developed a corn oil biodiesel pathway in which the feedstock is produced in corn ethanol plants located in the corn-oil-producing states (COPS)[1]. The resulting corn oil is either shipped to California for fuel production, or converted to biodiesel in the COPS for the California market. This pathway describes the production of biodiesel from corn oil extracted from the thin stillage at dry mill ethanol plants that produce wet distiller's grains with solubles (WDGS). The corn oil produced at such plants is a secondary product: the primary product is corn ethanol. The resulting pathway carbon intensity (CI) of the corn oil biodiesel is 29.27 grams of CO_2-equivalent greenhouse gas emissions per megajoule of biodiesel produced (gCO_2e/MJ). The biodiesel production, finished fuel transport, and finished fuel use calculation methodologies used in the development of this pathway are similar to the corresponding pathway components in the Low Carbon Fuel Standard (LCFS) Soybean-to-Biodiesel Pathway.[2] The soy and corn oil pathway methodologies differ in two ways: first, the corn oil pathway accounts for the energy and emissions associated with free-fatty acid (FFA) removal; second, emissions from electrical energy use were estimated using energy mixes from the U.S. Environmental Protection Agency's Emissions and Generation Resource Integrated Database (eGRID).[3]

Carbon Intensity of Corn Oil Biodiesel Produced

Corn oil is typically extracted at dry mill corn ethanol plants using retrofitted centrifuge-based extraction systems. Such systems extract corn oil from the distillers' grains that emerge from the fermentation and distillation processes. As such, it has no direct impacts on the production of corn ethanol. It does, however, reduce the volume and lipid content of the distillers' grains with solubles (DGS) that the plant produces.

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[1] South Dakota, Nebraska, Iowa, Minnesota, Wisconsin, Illinois, Indiana, Ohio, and Michigan.
[2] California Air Resources Board, 2009. Detailed California-Modified GREET Pathway for Conversion of Midwest Soybeans to Biodiesel (Fatty Acid Methyl Esters-FAME); December 14, 2009, Version 3.0: http://www.arb.ca.gov/fuels/lcfs/121409lcfs_soybd.pdf
[3] U.S. Environmental Protection Agency, 2014. Emissions and Generation Resource Integrated Database (eGRID); Eighth Edition 2009, Version 1.0: http://www.epa.gov/cleanenergy/energy-resources/egrid/

The corn oil that is extracted from the DGS stream is an unrefined product that has two primary uses: a livestock feed additive and a biodiesel feedstock. This pathway does not apply to corn oil that is extracted for uses other than the production of biodiesel for use as a transportation fuel. The analysis on which this pathway is based is specific to ethanol production environments in which the associated DGS co-product undergoes no drying. Prior analysis has demonstrated, however, the corn oil extraction in ethanol plants that dry their DGS will enter the biodiesel production process with a CI that is no higher than the CI of corn oil extracted at plants that do not dry their DGS. For this reason, this pathway is available to biodiesel produced from wet- or dry-DGS-associated corn oil.

ARB staff estimated the CI of corn oil biodiesel using information made available by Greenshift Corporation, a company that has commercialized a corn oil extraction process. Although Greenshift's is not the only available extraction process, more information is publicly available on its process than is available on alternative systems. The pathway described in this staff summary assumes that that the corn oil extraction equipment used, whether Greenshift's or not, is retrofitted into existing ethanol plants.

The pathway modeled by staff begins with the extraction of corn oil from the DGS process stream through a combination of washing and centrifuging. The extracted corn oil is shipped to a biodiesel production plant where it is converted to fatty acid methyl ester (FAME) biodiesel using a transesterification process—the same process that is used to produce biodiesel from other oil- and fat-based feedstocks.

Staff estimated separate CIs for corn oil biodiesel produced in California (29.06 gCO_2e/MJ) and in the corn-oil-producing states (29.27 gCO_2e/MJ). Details, including a comparative analysis of the two pathways, are provided in the pathway document. The difference between these two CIs was less than one gCO_2e/MJ. Because this difference is not significant, the higher of the two (29.27 gCO_2e/MJ) will serve as the single Method 1 pathway CI for WDGS associated corn oil biodiesel produced either in the COPS, or in the Western United States.[4] The following table reports the CI for this single, wet-DGS-associated pathway.

Because the corn oil feedstock covered by this pathway is extracted using retrofitted equipment at plants that primarily produce ethanol, corn oil from those plants is classified as a secondary or incremental product in this analysis. The accounting stance used in this pathway recognizes the secondary status of this feedstock by apportioning none of the GHG emissions associated with the production of ethanol to corn oil used to produce biodiesel. The CI of the corn oil includes only the additional energy required to operate the corn oil extraction equipment.

[4] Montana, Wyoming, Colorado, New Mexico, Arizona, Utah, Idaho, Washington, Oregon, Nevada, and California.

Corn Oil Biodiesel Pathway Lookup Table for Wet DGS

Fuel	Pathway Identifier	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)		
			Direct Emissions	Land Use or Other Indirect Effects	Total
Biodiesel from Corn Oil	BIOD021	Biodiesel produced from corn oil extracted at Dry Mill ethanol plants in corn-oil-producing states; Wet or Dry DGS; Biodiesel produced in either the corn-oil-producing states or in the Western U.S.; NG	29.27	0	29.27

Operating Conditions

Operations at biodiesel plants using this pathway will be subject to the following operating conditions designed to ensure that the CI of the corn oil biodiesel produced will remain at or below the value appearing in table above.

1. Biodiesel produced at plants in corn-oil-producing states must be transported to and sold in California.
2. Corn oil extracted at plants in corn-oil-producing states must be transported to plants in California to be used for biodiesel production. Because staff has confirmed that biodiesel produced in California using corn oil extracted in California will have a CI at or below that appearing in the table above, this pathway is available to biodiesel produced in California from corn oil extracted in California.
3. This pathway can be used by any biodiesel producer that meets the operating conditions set forth herein, regardless of whether the DGS associated with the extracted corn oil is dried.
4. The total thermal and electrical energy used for corn oil extraction and transport, biodiesel production, and biodiesel transport must be at or below the values specified in the pathway document.

Staff Analysis and Recommendations

Staff estimated the CI of biodiesel produced from WDGS-associated corn oil in the corn-oil-producing state and the Western United States. This CI was calculated using CA-GREET1.8b, using inputs reflecting typical ethanol and biodiesel production in this region. The resulting CI of 29.27 gCO_2e/MJ may, therefore, be used by corn oil biodiesel producers within this region, so long as they meet the operating conditions set

forth in this staff summary. For these reasons, staff recommends that this single Method 1 pathway CI be certified for use under the LCFS.