Staff Summary
Method 2B Application for
Brazilian Sugarcane By-Product Molasses-to-Ethanol Pathway

Copersucar, S.A. – Usina Cerradao Ltda.
(Pathway Code: ETHM012)

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Pathway Summary

Copersucar S.A. (Copersucar) produces ethanol derived from sugarcane juice as well as by-product molasses at their Usina Cerradao Ltda. (Cerradao) integrated sugar and ethanol production facility in the State of Minas Gerais, Brazil. However, this pathway is only for ethanol produced from the by-product molasses. Sugarcane is harvested on company-owned and partnership farms, and then transported to the sugar mill and ethanol distillery located in the city of Frutal. After the sugarcane has been crushed, the cane juice is filtered, treated, and decanted. A portion of the cane juice is sent directly to the ethanol distillery, with the remainder being sent to the sugar production process. A by-product of the sugar production process is molasses, which also becomes a feedstock for the ethanol production process.

The life cycle of the Copersucar Cerradao pathway begins with sugarcane cultivation and transport, followed by sugar and ethanol production. The agricultural and ethanol production phases of this pathway are identical to those described in the ARB's Brazilian sugarcane ethanol pathway.[1] The majority of the sugarcane harvested by Copersucar Cerradao sugarcane farms is done by mechanical harvesters.

The Copersucar Cerradao facility also generates and utilizes process heat and electricity from bagasse combustion for all its industrial operations. Surplus electricity produced is exported to the local electrical grid. The major difference between the proposed Copersucar Cerradao pathway and the Brazilian sugarcane-based ethanol pathway is that the Copersucar Cerradao pathway includes only Ethanol from feedstock of by-product molasses for the production of ethanol, whereas the Brazilian sugarcane ethanol pathway was based upon the use of pure sugarcane juice for ethanol production.

Ethanol produced from fermentation of the molasses is transported by truck to the eastern port of Santos, and loaded onto ocean-going tankers for shipment to California. Ethanol transport and distribution modes in California are assumed to be identical to those used in the Brazilian sugarcane juice-based ethanol pathway.

[1] California Air Resources Board, 2009. Detailed California-Modified GREET Pathways for Brazilian Sugarcane Ethanol: Average Brazilian Ethanol, With Mechanized Harvesting and Electricity Co-product Credit, With Electricity Co-product Credit, version 2.3, September 23, 2009. http://www.arb.ca.gov/fuels/lcfs/092309lcfs_cane_etoh.pdf

Carbon Intensity of the Copersucar Cerradao Pathway

ARB staff has assessed the inputs used by Copersucar to determine its well-to-wheels (WTW) pathway carbon intensity. As sugar and molasses are products of the same agricultural, feedstock transport, and sugar production processes, the GHG emissions from these activities must be allocated between the two products. The allocation method chosen by Copersucar is the mass-based allocation methodology in which the total upstream and sugar production emissions are allocated on the basis of the ratio of the total recoverable sugars (ART) in the molasses entering the ethanol distillery to the ART that enter the sugar production process for each ton of sugarcane that enters the factory gate.

The Copersucar Cerradao mill exports surplus cogenerated electricity to the public grid. Since the Cerradao mill is an integrated refinery producing two products directly from sugarcane juice (sugar and ethanol), and a third product (ethanol) derived from a by-product (sugarcane molasses), the bagasse used for cogeneration must be allocated between the feedstocks used to produce sugar and ethanol from sugarcane juice, and must be further sub-allocated between finished sugar and by-product molasses. The applicable electricity cogeneration export credit for each pathway must be calculated based on this allocation. The reason is that, when the sugarcane juice is sent to ethanol production, the sugarcane bagasse that is generated after the cane crush is assumed to belong to the ethanol production pathway. When the sugarcane juice is sent to the sugar production process, the sugarcane bagasse that is generated after the cane crush is assumed to belong to the sugar mill. Since only the by-product of the sugar production process is fermented into ethanol, the credit is therefore assumed to be proportional to the fraction of ART in by-product molasses to the total amount of recoverable sugars[2] in the pure sugarcane juice, measured after the cane crush. In other words, the mass allocation methodology used to allocate upstream emissions is also used to determine the quantity of surplus cogenerated electricity exports that should be credited to the by-product molasses pathway.

Table 1 below shows a disaggregated breakdown of the carbon intensity (CI) contribution of each stage of the pathway.

[2] This ratio was found to be 0.2430 for the sugarcane by-product molasses-to-ethanol pathway. For a sugarcane juice-to-ethanol pathway, the mass allocation ratio is assumed to be 1.0.

Table 1: Summary of Disaggregated WTW GHG Emissions for the Copersucar Cerradao Pathway

Disaggregated Item	Value Reference	Mass-Based Allocated GHG Emissions: Molasses to Ethanol (g CO_2e/MJ)
Well -to-Tank (WTT) Allocated GHG Emissions:		Mass Allocation Factor for Molasses: 0.2430
Sugarcane Farming	See Worksheet "Cane Farming Inputs"	**4.28**
Agricultural Chemicals Use	See Worksheet "Cane Farming Inputs"	**9.90**
Straw Burning Emissions	See Worksheet "Straw Burning"	**8.58**
- Less Credit for Mechanized Harvesting	Based Upon the MODIS Burn-Area Evaluation	**-6.44**
Sugarcane Transport	See Worksheet "T&D"	**1.05**
Lime (CaO) Application for Juice pH Adjustment	Seabra et al, 2011[1]	**0.63**
Sugar Production	See Worksheet "Allocation" (Parameter S)	**2.26**
Total Upstream GHG Emissions		**20.28**
Ethanol Production	See Worksheet "EtOH Prod"	**2.29**
Ethanol Transport & Distribution	See Worksheet "T&D"	**6.30**
Added Denaturant	Indonesian Molasses Pathway	**0.80**
Well-to-Tank (WTT) Estimate Before Electricity Export Credit:		**29.69**
Electricity Cogeneration and Export Credit	See Worksheet "Cogen Exp Cr"	**-8.25**
Total Well-to-Tank (WTT) CI Estimate:		**21.45**

*Seabra et al. "Life cycle assessment of Brazilian sugarcane products: GHG emissions and energy use," Seabra, J.E.A., Macedo, I.C., Chum, H.L., Faroni, C.E., and Sarto,C.A., Biofuels, Bioproducts, & Biorefining, 5:519-532, March 7, 2011.

When life cycle emissions due to indirect land use change (ILUC) of 46 gCO_2e/MJ[1] are added to the WTT CI estimate (above), the final WTW CI for the Copersucar sugarcane by-product molasses-to-ethanol pathway is estimated to be 67.45 gCO_2e/MJ of ethanol fuel produced. The proposed Lookup Table entry for the Copersucar Cerradao pathway is presented in Table 2 below:

Table 2: Proposed Lookup Table Entry for Fuel/Feedstock

Fuel	Pathway Identifier	Pathway Description	Carbon Intensity Values (gCO_2e/MJ)		
			Direct Emissions	Land Use and Other Indirect Effects	Total
Sugar Cane Molasses Ethanol	ETHM012	2B Application: Brazilian Sugar Cane Molasses to EtOH;	21.45	46.00	67.45

Applicable Operating Conditions

Operations at the Copersucar Cerradao mill will be subject to the following conditions designed to ensure that the CI of the sugarcane by-product molasses-to-ethanol pathway described in this Staff Summary will remain at or below the values appearing in Table 2 above. The conditions must be met for every gallon of ethanol sold by Copersucar Cerradao in California. Exceptions are allowable only in the case of brief periods of planned maintenance or unpredictable, unavoidable, and uncontrollable force majeure events.

1. No conditions are placed on the ethanol yield, processing conditions and production volume at the Copersucar Cerradao mill, so long as the CIs reported in the above table are not exceeded. For purposes of determining compliance with this operating condition, the plant's CI will be calculated based on data from the most recent 12 months of operation, excluding periods of abnormal operations, such as planned maintenance or unpredictable, unavoidable, and uncontrollable force majeure events. The plant's ethanol yield and processing conditions are classified by the applicant as confidential business information.

2. The CI for ethanol produced by the Copersucar Cerradao pathway is based on the allocation factors applied to upstream emissions from sugarcane farming, agricultural chemical use, the estimated fraction of in-field straw burning, sugarcane transport, and sugar production allocated based upon the quality of by-product molasses derived from the sugar production process. This allocation factor is identified in the worksheet "Allocation."[3] If any of the input assumptions or parameters used to determine the allocation factors are changed, the CI estimate may no longer be valid. ARB must be

[3] See spreadsheet entitled "Final_Staff Disag Analysis_Copersucar Cerradao.xlsx" posted in "Supporting Information."

notified of such changes as they occur, and their impacts on the ethanol fuel CI must be re-assessed.

3. The CI for ethanol produced by the Copersucar Cerradao pathway includes a credit for electricity cogeneration and surplus exports. If the bagasse is used for any purpose other than cogeneration of electricity, or if additional bagasse is brought into the facility for cogeneration from outside the Copersucar Cerradao mill, or if the boilers are de-rated, then the CI for the ethanol produced may no longer be valid and must be reassessed.

Staff Analysis and Recommendations

Staff has reviewed Copersucar's application for certification of Brazilian sugarcane by-product molasses-based ethanol pathway for its Cerradao mill located in the Minas Gerais State of Brazil and finds the following:

- Staff has replicated with reasonable accuracy, using a mass-based allocation methodology, the CA-GREETv1.8b GHG lifecycle emissions modeling spreadsheet, and other input process parameters furnished by Copersucar, the CI values being proposed in this pathway.

- Staff recognizes that the plant energy (process heat and electricity) consumption values reported for the process reflect cogeneration activities from bagasse combustion with surplus electricity export to the public grid. In addition, the pathway well-to-tank GHG emissions analysis reflects applicable credits for the use of mechanized harvesting practices at the sugarcane farms.

- Staff agrees that the mass-based method used to allocate GHG emissions to the upstream sugarcane farming, transport, and sugar production processes is valid and representative for the sugarcane by-product molasses pathway being proposed for adoption.

On the basis of these findings, ARB staff recommends that Copersucar's application for the above Method 2B LCFS pathway be certified.