

**ARB Staff Summary
Method 2B Application
Pantaleon Guatemalan Sugarcane Molasses-Based
LCFS Pathway for Ethanol
March 14, 2013**

Summary of the Sugarcane Molasses-Based Ethanol Pathway

Pantaleon Sugar Holdings (Bio-Etanol S.A) (“Pantaleon”), is a company based in Guatemala that produces and exports ethanol derived from sugarcane molasses. Sugarcane is harvested on company-owned and partnership farms, and then transported to the sugar mill. After the sugarcane has been crushed, all of the cane juice is sent to sugar production. A by-product of the sugar production process is molasses which is recycled into the production process to recover additional sugar crystals. After recovery of the optimum amount of crystalline sugar from the molasses, the remainder of the molasses byproduct stream is sent to the ethanol distillery for fermentation and distillation, resulting in the production of anhydrous ethanol. A portion of the molasses byproduct is also sold in the marketplace.

The lifecycle of the Pantaleon pathway begins with sugarcane cultivation and transport, followed by sugar and ethanol production. These processes largely parallel the Brazilian sugarcane-based¹ sugar and ethanol production processes in terms of farming methods, agricultural chemical use, sugar production, and in the fermentation technology used. The Pantaleon 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 Pantaleon pathway and the Brazilian sugarcane-based ethanol pathway is in the type of feedstock: Pantaleon uses molasses, a by-product from the sugar production process, whereas Brazilian producers largely use pure sugarcane juice for ethanol production. Ethanol produced from fermentation of the molasses is transported by truck to the western Guatemalan port of Puerto Quetzal, 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 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 Ethanol Fuel Produced by the Pantaleon Pathway

ARB staff has assessed the inputs provided by Pantaleon to determine the carbon intensity for the Well-to-Wheels (WTW) GHG emissions that result from the life cycle of the ethanol fuel production process, and eventual consumption of the ethanol in a vehicle for purposes of deriving motive power. Although sugar and molasses are products of the same agricultural, feedstock transport, and production processes, the GHG emissions from those activities must be allocated between the two products. The allocation method chosen by Pantaleon is the market allocation methodology in which the total upstream and sugar production emissions are allocated on the basis of the relative share of total sales revenues that accrue to each product (sugar and molasses) for each ton of fermentable sugars in cane juice that enters the sugar production process.²

Based on market price data for sugar and the by-product molasses (\$400 and \$150 per short ton, respectively), Pantaleon has determined that 14.46 grams of carbon dioxide-equivalent (g CO₂e/MJ fuel) of upstream and sugar production emissions should be allocated to the production of the by-product molasses. When these upstream and sugar production emissions are combined with ethanol production, transport, and distribution emissions, total well-to-tank (WTT) life cycle GHG emissions for the Pantaleon pathway are estimated to be 18.65 g CO₂e/MJ fuel.

While the Brazilian sugarcane pathway may include credits for surplus cogenerated electricity (0.96 kWh/gallon of ethanol) and exported to the public grid, in the case of the Pantaleon Pathway the applicable electricity cogeneration export credit must be determined differently. The reason is that, when all of the sugarcane juice is sent to sugar production, the sugarcane bagasse that is generated after the cane crush is assumed to belong to the sugar mill. The credit is therefore assumed to be proportional to the yield of ethanol (per ton of sugarcane) when all juice is sent to sugar production to the yield of ethanol (per ton of sugarcane) when only pure cane juice is sent to the ethanol plant for fermentation.³ This methodology ensures that the allocation of bagasse used for electricity production is consistent even when only pure sugarcane juice is used to produce ethanol. The resulting electricity cogeneration and surplus export credit is 1.12 g CO₂e / MJ of fuel produced. When applied to the WTT carbon

² Gopal, Anand R., and Kammen, Daniel M., 2009. "Molasses for ethanol: the economic and environmental impacts of a new pathway for the lifecycle greenhouse gas analysis of sugarcane ethanol," Gopal, Anand R. and Kammen, Daniel M., *Environ. Res. Lett.* 4 (2009) 044005 (5pp).

³ This ratio was found to be (2.30 gallons / 23.95 gallons) on a per short ton of sugarcane basis. The Co-Product Credit for surplus electric cogeneration and export is valued at 0.96 kWh / gallon of ethanol produced which results in a displacement of 11.64 g CO₂e / MJ of marginal electricity generation in Guatemala. The net credit is therefore (2.30 / 23.95) x 11.64 g CO₂e / MJ or 1.12 g CO₂e / MJ.

intensity (CI) of ethanol, this credit results in a net WTT CI of 17.53 g CO₂e/MJ. When life cycle emissions due to land use changes (LUC), and the addition of denaturant to the ethanol fuel are added to the WTT CI estimate, the final WTW CI for the Pantaleon pathway is estimated to be 22.75 g CO₂e / MJ of ethanol fuel produced. A summary of the disaggregated estimate for the Pantaleon pathway is presented in Table 1 below.

Table 1
Summary of Disaggregated WTW Emissions for the Pantaleon Pathway

Disaggregated Item	GHG Emissions: Sugarcane to Sugar (gCO₂e/MJ)	Allocated GHG Emissions: Molasses to Ethanol (gCO₂e/MJ)
Well -to-Tank (WTT) GHG Emissions		
<i>Market-Based Allocation Factor²</i>		0.76
Sugarcane Farming	3.76	2.87
Agricultural Chemicals Production	3.42	2.61
Sugarcane Farming, Agricultural Chemicals, and Straw Burning	13.87	10.58
Sugarcane Transport	3.17	2.41
Sugar Production	1.92	1.46
<i>Market-Based Allocation Factor</i>		1.00
Ethanol Production		1.96
Ethanol Transport and Distribution		2.23
Total Well-to-Tank (WTT) GHG Emissions	N/A	18.65
Electricity Cogeneration and Export Credit	(11.64)	(1.12)
Carbon in Fuel (1,000,000 Btu / mmBtu)	N/A	N/A
Total Well-to-Wheels (WTW) GHG Emissions	N/A	17.53
<i>Market-Based Allocation Factor for LUC</i>		0.096
Land Use Change	46.00	4.42
Denaturant		0.80
Final Well-to-Wheel (WTW) Carbon Intensity for Pantaleon Pathway (g CO₂e / MJ)	N/A	22.75

Staff notes that the impact of land-use-changes (LUC) on the Guatemalan sugarcane molasses-based ethanol pathway has not been determined. Until that value is estimated, staff proposes the use of an interim value calculated from the LUC value for Brazilian sugarcane ethanol. The proposed interim molasses ethanol value consists of the Brazilian value of 46 g CO₂e / MJ multiplied by the proportion of fermentable sugars in sugarcane juice that ends up in the molasses used as feedstock for the process. That proportion is determined to be 0.096. The result is a proposed interim value of 4.42 g CO₂e/MJ.⁴

The proposed Lookup Table entry for the Pantaleon pathway is presented in Table 2 below:

Table 2
Proposed Lookup Table Entry for Fuel/Feedstock

Fuel	Pathway Identifier	Pathway Description	Carbon Intensity Values (g CO ₂ e / MJ)		
			Direct Emissions	Land Use or Other Indirect Effects ⁴	Total
Ethanol	ETHM002	2B Application (Specific Conditions Apply): Guatemalan sugarcane molasses-based ethanol with average production processes and electricity co-product credit	18.33	4.42	22.75

Applicable Operating Conditions

1. Staff stipulates that in order for Pantaleon to sell ethanol in California using the fuel pathway described in this document, only the by-product molasses from Pantaleon’s sugar production process may be used as feedstock for the ethanol plant.
2. The CI for ethanol produced by the Pantaleon pathway is based on input provided by Pantaleon to determine the allocation factor applicable to upstream emissions (sugarcane farming, agricultural chemical use, estimated fraction of in-field straw (litter) burning, and sugarcane transport), as well as sugar production process emissions. If any of these input assumptions or parameters is changed, the disaggregated emissions estimate may no longer be valid. ARB must be

⁴ LUC factor of 46 g CO₂e / MJ x 0.096 fraction of fermentable sugars in molasses = 4.42 g CO₂e / MJ.

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

Staff Analysis and Recommendations

Staff has reviewed Pantaleon's application for certification of the Guatemalan sugarcane molasses-based pathway for the production of ethanol, and finds the following:

- Staff has replicated with reasonable accuracy, using Pantaleon's market-based allocation methodology, and the CA-GREET GHG lifecycle emissions modeling spreadsheet, and other input process parameters furnished by Pantaleon, the CI value being proposed for certification;
- Staff recognizes that the plant energy (process heat and electricity) consumption values reported for Pantaleon's process reflect cogeneration activities with surplus electricity export to the public grid;
- Staff agrees that the market-based method used to allocate GHG emissions to the molasses feedstock is valid and representative for the Pantaleon pathway.

On the basis of these findings, ARB staff recommends that Pantaleon's application for a Method 2B LCFS pathway be approved with a CI of 22.75 g CO_{2e} / MJ of ethanol fuel produced.