Brazilian-Modified GREET Pathway for the Production of Ethanol from Sugarcane Molasses

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Date: May 29, 2013

Pathway Summary

This lifecycle analysis calculates the Carbon Intensity (CI) of molasses based ethanol production from Raízen Costa Pinto Mill. The production of raw sugar from sugarcane juice yields molasses as byproduct. Molasses is transferred by pipe to an ethanol distillery where it is converted into ethanol through molasses fermentation by *Saccaromyces cerevisiae* followed by distillation and dehydration processes when anhydrous is produced. The finished product is shipped to California by ocean tanker. The Carbon Intensity (CI) of this pathway is 1.13 grams of CO_2-equivalent greenhouse gas emissions per mega joule (g CO_2e/MJ) of ethanol produced on an anhydrous basis. When emissions associated with denaturant and land use change conversion are included the total CI is 14.67 g CO_2e/MJ.

The sugarcane cultivation, sugarcane transport, ethanol production, and finished fuel transport portions of this pathway aren´t different from those defined by ARB, then the defaults were used. Emissions associated with the production of the molasses feedstock are disaggregated from the emissions associated with the production of raw sugar. The energy consumption and greenhouse gas (GHG) generation are appropriately allocated between the molasses byproduct and sugar. The bulk of this pathway document, therefore, focuses on molasses production.

The Well-to-Tank (WTT) portion of this Life Cycle Analysis of Raízen´s Mill molasses to ethanol pathway includes all steps from sugarcane farming to final finished anhydrous ethanol. The Tank-to Wheels (TTW) portion includes actual combustion of the resulting fuel in a motor vehicle for motive power. Taken together, the WTT and the TTW analyses comprise a total Well-to-Wheel (WTW) analysis.

The CA_GREET model was used to calculate the entire fuel life cycle, from sugarcane farming to producing ethanol to combusting ethanol in an internal combustion engine. The results obtained from the California-modified GREET model (v1.8b, released December 2009) are reported in this document. Those results consist of the energy use and greenhouse gas (GHG) emissions from the production of ethanol using molasses which is a byproduct of raw sugar production. This pathway assumes that the ethanol produced is destined for use in motor vehicle fuels. Raizen proposed a mass-based allocation as determined by the fraction of Total Reducing Sugars (TRS) in byproduct molasses sent to distillery to the total TRS in cane juice at the factory gate (on a per ton of cane basis).The TRS consists in sucrose, glucose, fructose, and any other fermentable sugars.

Process configuration

Figure 1 describes Costa Pinto Mill´s molasses-to-ethanol process. Sugarcane is pressed to extract the sugarcane juice. The juice is refined into raw sugar. The molasses byproduct is transferred by pipe to the distillery where it is fermented and distilled to produce ethanol. Some of the molasses could be also sold into market or transferred to another Raízen´s facilities.

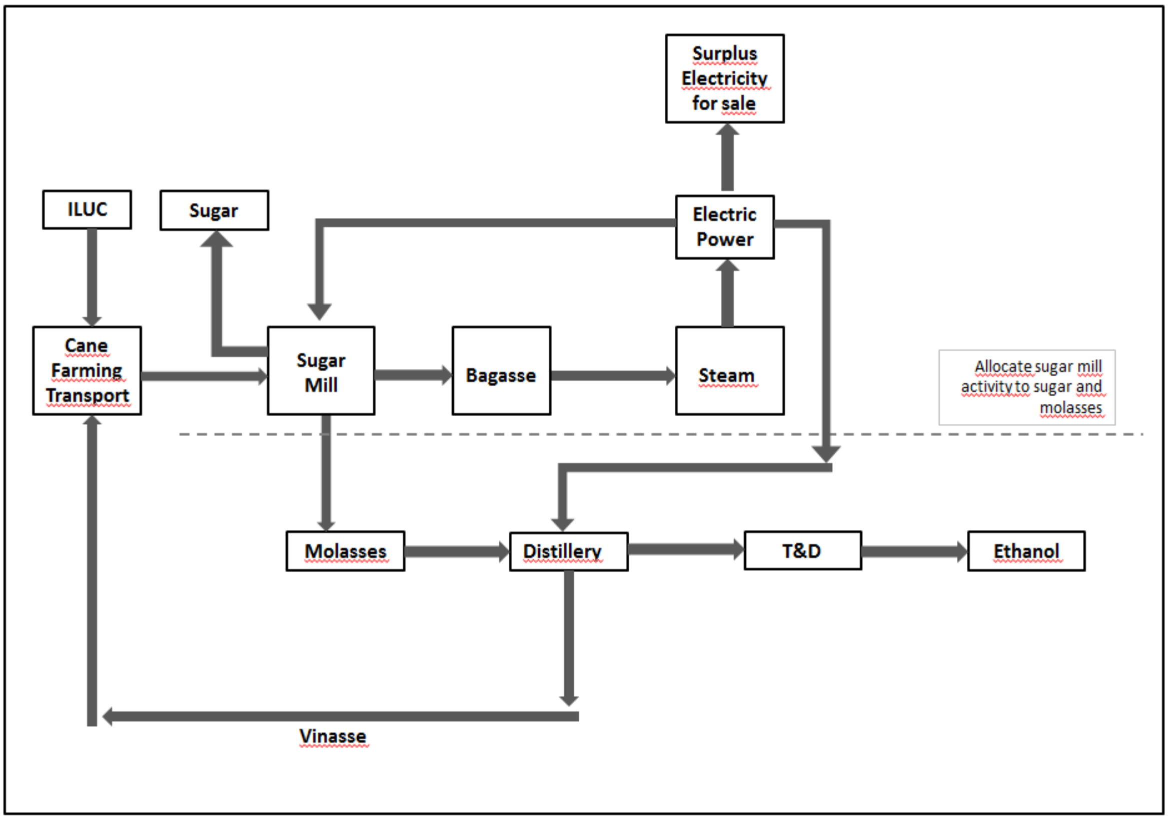

Figure 1. Molasses LCFS Pathway

Allocation of GHG Emissions between Sugar and Molasses

The feedstock for the ethanol produced under this pathway is a co-product of the sugar industry. Molasses – is sent to the distillery, where is fermented and distilled into anhydrous ethanol. Molasses is a low-value byproduct that is used by Raízen Mills to produce ethanol. The life cycle analysis tracks the energy inputs and emissions according to the value of the sugar that is converted to raw sugar and the sugar that is converted to molasses. Raízen tracks the molasses according to its sugar content, so the allocation procedure is straightforward.

Agricultural emissions from the cultivation of the sugarcane from which the raw sugar is produced are distributed between raw sugar and molasses. The allocation of inputs is complicated by several factors. The co-produced power must be allocated to both sugar and molasses production.

The allocation step subtracts the emissions that are associated only with the production of final raw sugar (which is not an ethanol feedstock) from the ethanol production totals. The agricultural and sugar production emissions that are allocated to the ethanol feedstock (molasses) are added to the emissions from the production and transport of ethanol. The result is the total life cycle emissions value for ethanol made from molasses.

Once the GHG emissions allocation methodology was defined, the following disaggregated emissions table was obtained:

Disaggregated Item	Value Reference	GHG Emissions: Sugarcane to Ethanol (gCO_2e/MJ)	Mass-Based Allocated GHG Emissions: Molasses to Ethanol (gCO_2e/MJ)
Well -to-Tank (WTT)	**See Worksheet "Allocation"**	**Raizen COPI Allocation**	**0.34**
Sugarcane Farming	See Worksheet "Cane Farming 1113" With Production Inputs for Raizen-COPI.	4.97	1.47
Agricultural Chemicals Use	See Worksheet "Cane Farming 1113" With Production Inputs for Raizen-COPI.	26.23	9.00
Straw Burning Emissions	See Worksheet "Straw Burning 1013" With Production Inputs for Raizen-COPI Mill.	22.74	0.71
- Less Credit for Mechanized Harvesting	Company Claimed Mechanization Level: 90.9 %	(20.67)	
Sugarcane Transport	See Worksheet "T&D"	3.71	1.27
Sugar Production	See Worksheet "Allocation" (Parameter S)	5.99	2.06
Summary of All Upstream of Ethanol Production Processes		**42.97**	**14.75**
Ethanol Production	See Worksheet "EtOH Prod" with Production Inputs for Raizen COPI		2.21
Ethanol Transport & Distribution	See Worksheet "T&D"		4.53
Addition o f Denaturant	Indonesian Molasses Pathway		0.80
	Well-to-Tank (WTT) Estimate Before Electricity Export Credit:		***22.29***
Electricity Cogeneration and Export Credit	See Worksheet "Cogen Exp Cr"		(21.86)
	Total Well-to-Tank (WTT) CI Estimate:		**0.43**
Tank-to-Wheels (TTW)			
Carbon in Fuel (2)	1,000,000 Btu / MMBtu Anhydrous Ethanol Produced		N/A
Land Use Change	See Worksheet "Prop ILUC"		46
	Final Well-to-Wheel (WTW) Estimate:		**46.43**

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Supporting Data and Calculations

1. Farming Inputs

Raízen provided farm level data for mix of harvesting method and actual average of truck loads for sugarcane transportation.

Straw Burning

Emissions from sugar cane straw burnt in field are based on Costa Pinto summary of mechanical and manual harvesting. The sugarcane is 9.1 % manually harvested. Raízen has indicated the level of straw burning for both mechanical and manual harvesting. Straw burning emissions are scaled to the GREET default. GIS shape files were provided for CARB data analisys.

2. Co-product electricity value

Raízen has provided actual data to support co-product electricity credit value.

3. Ethanol Transport

Transportation from the mill to the port is assumed by Diesel trucks and the mode of transport from Santos Port to Long Beach is assumed to be by Ocean Tanker over a distance of 7,384 nautical miles.

SEA DISTANCES - VOYAGE CALCULATOR (nautical miles)

Back to MAIN PAGE

Nr	Port	Time zone	Distance	Route via	Speed	Days		Costs		Arrival	Departure
						at Sea	in Port	at Sea	in Port		
1	Santos, Brazil	GMT -3.0					0		0.0		01.07.13 18:17
	to		7 384	Panama	10	30.8		0.0			
2	Long Beach, United States	GMT -8.0					0		0.0	01.08.13 08:17	01.08.13 08:17
	TOTAL		7 384			30.8	0	0	0		

Commence date: (dd.mm.yy) 01.07.13 18:17 OK Display ◉ By Leg ○ Continued Clear All Calculate

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