LIGA AGRICOLA INDUSTRIAL DE LA CAÑA DE AZUCAR
LAICA – COSTA RICA

Life Cycle Method 2B Pathway Report

Ethanol Dehydration Plant

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PORT TERMINAL OF PUNTA MORALES – PUNTARENAS, COSTA RICA

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LAICA: Life Cycle Method 2B Pathway Report

(LAICA – "Liga Agricola Industrial de la Caña de Azucar" of Costa Rica)

1. SUMMARY

This is the LAICA Pathway Report, for a fuel lifecycle GHG emissions pathway using the Method 2B Application Process described in "Establishing New Fuel Pathways under the California Low Carbon Fuel Standard Procedures and Guidelines for Regulated Parties" report by ARB (California Air Resources Board) issued on March 25, 2010. We include in this report, data and documents necessary to support the results obtained.

LAICA requires a pathway for our ethanol dehydration plant located at Punta Morales on Puntarenas of Costa Rica, specifically in the Gulf of Nicoya in the Central Pacific where it has a terminal port. At our facility, we convert Brazilian hydrous sugarcane ethanol to anhydrous ethanol using molecular sieves, in a similar process used by modern ethanol production facilities worldwide, including in the U.S. and Brazil. Our facility uses residual oil (same as fuel oil or Bunker C # 6) and electricity for its process energy. With the bunker, produces steam that is used to generate the most of the electricity (cogeneration) required by the plant, for the rectification column and the superheaters, previously to entering in the molecular sieves.

In addition, the study is based on the CA-GREET Model Pathway for Brazil Sugarcane Ethanol, according to CA_GREET Model v1.8b released on December 2009. "A Well-To-Tank (WTT)[1] life cycle analysis of a fuel (or blending component of fuel) pathway includes all steps from feedstock production to final finished product. Tank-To-Wheel (TTW) analysis includes actual combustion of fuel in a motor vehicle for motive power.

[1] *See CARB Report "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" September 23, 2009, Version 2.3.*

Together WTT and TTW analysis are combined together to provide a total Well-To-Wheel (WTW) analysis.

A life cycle analysis model called the **G**reenhouse gases, **R**egulated **E**missions, and **E**nergy use in **T**ransportation (GREET) developed by Argonne National Laboratory has been used to estimate the energy use and greenhouse gas (GHG) emissions associated with the entire pathway of producing ethanol from Brazilian sugarcane, transporting it via ocean tanker to a California port, distributed and finally used in a lightduty vehicle in California".

As LAICA has a dehydration plant it using hydrous alcohol from Brazil (feedstock), in our case, at the results of this model will be adding CO_2 emissions from transport to the plant, the dehydration process and its output as anhydrous ethanol to California. In conclusion, this pathway include ocean transport of hydrous ethanol to Costa Rica, dehydration in our plant and ocean transport of anhydrous ethanol to California. The pathway provided by ARB, unchanged as to Brazilian process (sugarcane farming, hydrous ethanol production and fuel use).

Emphasizing the statement before, we request CARB's approval of this pathway such that the carbon intensity from our facility will be added to the carbon intensity of the Brazilian sugarcane ethanol that we process and that sum will be the carbon intensity of the resulting denatured ethanol used as a transportation fuel in California. The CARB LCFS regulations stipulate that only pathways lower in carbon intensity value than the main pathway that they deviate from can use the Method 2A application. Because our pathway increases the overall carbon intensity of the Brazilian sugarcane ethanol pathway, we are following the Method 2B application process. However, our pathway is clearly a sub-pathway of the Brazilian sugarcane ethanol pathways because, except for the few points of deviation summarized below, our pathway is identical to the Brazilian sugarcane ethanol Well-to-Wheel (WTW) lifecycle analysis.

The final carbon intensity of the LAICA Dehydration Plant pathway is **11.31 gCO2e/MJ** based on the CA-GREET model and results obtained by CARB from the CA-GREET model in its WTW analysis of the Brazilian Ethanol Pathway.

In the following sections of our report, we present the data and documentation for a new pathway under Method 2B. Several parts of this information that we consider Confidential Business Information have been clearly marked as such on each page, but are not included in the non-confidential version of the application. In this application, the points where elements of Confidential Business Information have been removed from the text or accompanying tables are indicated so as to inform the public that the complete application to the ARB contained additional information to support this application, but that such information is considered by us to be Confidential Business Information.

2. LAICA PLANT INFORMATION

Below are presented the most important data, of our facility.

a) Plant location. Punta Morales Port on Puntarenas, Costa Rica.

b) Main activities. Laica export by this port, raw sugar cane and molasses, in addition to the hydrous ethanol import for its dehydration plant and the subsequent export of the anhydrous ethanol.

c) Process technology. Laica use rectification for extraction fusel and water, and then use molecular sieves adsorption for the ethanol dehydration. The dehydration process was designed by Katzen International Inc, from Cincinnati, Ohio – USA.

d) Feedstock. The principal feedstock is brazilian hydrous ethanol. Its grade or concentration is normally 95% by volume, with the remainder is water (5%).

e) Plant capacity. LAICA's plant capacity is 620,000 L/day (54,050,000 gal/year, 330 day/year) of anhydrous ethanol at 99.8% ethanol strength.

f) Process fuel. We use residual oil (bunker C or fuel oil 6) and electricity. The electricity is produced with the steam in the turbine-generator (73%) and the rest is from the public service (ICE, Instituto Costarricense de Electricidad).

In addition we use a small portion of electricity that is provided by the ship's diesel for hydrous ethanol pumping, from the ship to the shore tanks in the terminal.

3. PROCESS DESCRIPTION

The hydrous alcohol is received from the ocean tanker, stored in tanks and then fed to the rectifier column. In this column is also fed, the fluid coming from the molecular sieves regeneration to recover excess of ethanol containing.

The rectifier column is used for extract the fusel and water and to give higher output in the vaporized alcohol 96%, which goes to the superheaters and then into the molecular sieves.

In the molecular sieves, a system is operating while the other one is in regeneration. From these molecular sieves, the anhydrous alcohol is sent to methanol concentration column (which operates only if necessary, actually is out of service) and the spirits of regeneration that leads to the rectifier column. Then, the anhydrous ethanol is cooled and stored in appropriate tanks, to which is sent by gravity toward the ship, for export to California.

4. PROCESS FLOW DIAGRAM

The process flow diagram is considered Confidential Business Information.

5. CARBON INTENSITY (CI) OF THE LAICA DEHYDRATION PLANT

In this section shows the CI values for the dehydration plant, according to the emissions sources that we have, these are: residual oil (bunker), electricity, diesel for pumping the hydrous ethanol from the ocean tanker to the shore tanks and finally, the transport and distribution.

5.1 Emissions from Residual Oil

It is very important to mention the production of bunker includes extraction of crude oil, refining process and transport, the corresponding values are calculated for the CA_GREET Model and shows in the Table 1.

Table 1. Emissions from Residual Oil Production

Pollulant	Crude Oil	Res. Oil Refining	Industrial Boiler	Fuel Oil WTT + Fuel Combustion
Energy (Btu/mmBtu)				
Total energy	40,582	75,057	1,000,000	1,115,639
Fossil fuels	40,582	75,057	1,000,000	1,115,639
Coal	123	7,928	0	8,051
Natural gas	27,907	28,498	0	56,406
Petroleum	12,552	38,630	1,000,000	1,051,182
Emissions (g/mmBtu)				
VOC	4.194	2.821	0.907	7.921
CO	11.234	4.225	15.764	31.224
CH4	90.548	5.160	3.240	98.949
N2O	0.072	0.058	0.360	0.490
CO2	3,675	5,492	85,045	94,212
GHG (g/mmBtu)	5,991	5,654	85,261	96,906
GHG (gCO_2e/MJ))	5.7	5.4	80.8	91.9
CA_GREET Cells	Petroleum B183:B196	Petroleum J183:J197	EF! J6:J14	Sum

5.2 Emissions from the Dehydration Plant

The dehydration plant use residual oil (fuel oil 6 from Recope, public company which sells) and electricity as the energy for the process. The electricity (73%) is produced with the steam in the turbogenerator (at inlet pressure of 280 psi and 125 psi as outlet pressure) and the rest is from the public service (ICE, 27%). In addition we use a small portion of electricity, it is provided by the ship's diesel for hydrous ethanol pumping, from the ship to the shore tanks in the terminal. To calculate the GHG emissions, the information and data from the plant were combined with GREET default values. A residual oil utility boiler was used to determine the emission factors and the US Average region was assumed for the electricity resource mix.

As mentioned, energy use for the facility is fuel oil No. 6 and electricity. The fuel oil is used to electric cogeneration and to provide process heat and the electricity is used to operate pumps, fans, compressors and controls. The electricity number no includes the amount of electricity necessary to transfer the hydrous ethanol by pump from the ocean tanker to the dehydration facility, this calculation is presented separately. Note that the energy required for pumping is a small fraction of the total power used at the facility.

For transfer of the anhydrous ethanol from the dehydration plant to the ocean tanker, is not necessary to pump because the ship's loading is made by gravity.

The diesel calculation for generate electricity for pumping the hydrous ethanol, from the ship to the shore tanks, is considered Confidential Business Information and are not included in this non-confidential version of the application.

Another factor to evaluate in the emissions of the dehydration plant is the energy use and its distribution, within the total energy for ethanol production. The components of this distribution are residual oil and diesel (from the ship) consumption and electricity demand. Based on this information, we can to calculate the energy consumption and emissions for each stage. ***But these data are not included in this non-confidential version of our application because is Confidential Business Information.***

Then applying the emissions factors of the CA-GREET Model and the necessary conversion factors, to these values, we can to obtain the results of emissions for VOC, CO, CH_4, N_2O and CO_2 due to residual oil, diesel and electricity, in terms of g/mmBtu or gCO_2e/MJ. In this manner the total value for the dehydration plant is 7.923 gCO_2e/MJ, without transportation as observed in the next table.

Table 5. LAICA Ethanol Dehydration Carbon Intensity

CI (g CO2e/MJ)			
Residual Oil	Electricity	Diesel	Dehydration
7.800	0.111	0.012	7.923

We present all results in a detailed table at the end of the Transport and Distribution section.

6. EMISSIONS FROM ETHANOL TRANSPORTATION

Emissions for the transport from Santos, Brazil to Puntarenas, Costa Rica and Puntarenas, Costa Rica to California, USA are detailed in this section, so for hydrous as anhydrous ethanol. Furthermore here includes an additional distance due to deviation from Puntarenas to Punta Morales and next its departure from Punta Morales to Puntarenas in route to California.

6.1 Calculation of Emissions for the Additional Distance

About the additional distance to the Punta Morales port, we must indicate that there 8,753 miles denote via Costa Rica, and the 8,684 miles denote straight from Brazil to California. Therefore, the input of 69 miles (8,753 - 8,684) were entered into the cell M1420 of T&D_Flowcharts to get 0.017 gCO_2e/MJ for this additional miles (see the LAICA CA_GREET Model). The emissions of 0.017 gCO_2e/MJ came from additional transportation of hydrous ethanol from Brazil to Costa Rica and the transportation of anhydrous from Costa Rica to CA. This calculation only computes the carbon intensity that is generated from the increase in mileage from the direct ocean transport route. With this result, the accumulative emissions from LAICA are presented in Table 6.

Table 6. LAICA Carbon Intensity for Additional Transport			
CI (g CO2e/MJ)			
Dehydration	Additional Distance (miles)	Additional Transport CI	Subtotal CI
7.923	69	0.017	7.940

6.2 Transport and Distribution

The transport and distribution emissions were calculated using average distances traveled between ethanol production, dehydration and distribution terminals for the facility. These distances were determined by using the Sea Distances-Voyage Calculator located at http://www.sea-distances.com. The approximate distance from Brazil to California via Costa Rica is 7,611 nautical miles. As the pathway proposed here is California an appropriate baseline for each transportation segment is determined and shown in the following table.

Table 7. Ocean Transport Distances for LAICA Dehydration Plant		
Ocean Transport Distances	**Nautical Miles**	**Statute Mile**
Santos, Brazil to Puntarenas, Costa Rica	4,937	5,678
Puntarenas, Costa Rica to Los Angeles	2,508	2,884
Puntarenas, Costa Rica to San Francisco	2,841	3,267
Average from Puntarenas to LA and SFO	2,674	3,075
Brazil to California via Costa Rica	7,611	8,753
Brazil to California, Direct	7,551	8,684
Difference	60	69

To calculate the transportation distance for our plant, the statute mile distances from Santos, Brazil to the dehydration facility and the average from the dehydration facility to Los Angeles and San Francisco, CA were determined.

With the data provided in the Table 7 taking as the correct distance 8,753 statute miles from Brazil to California (via Costa Rica) and introducing this value in the cell M1420 (AC1416) of T&D_Flowcharts of the CA_GREET LAICA Model, we obtain a value of 3.366 gCO_2e/MJ for the ethanol transportation. A results summary for the ethanol transport is shown in the Table 8.

Table 8. LAICA Carbon Intensity for Total Transport		
CI (g CO2e/MJ)		
Additional Transport CI	T & D	Total Transport
0.017	3.366	3.383

7. SUMMARY OF THE TOTAL PROCESS OF CARBON INTENSITY

In Table 9 we present a summary of total results for the CI values in LAICA Dehydration Plant.

Table 9. Process Carbon Intensity for LAICA Plant								
	Anhydrous	Residual	Electricity	Diesel	T&D	TOTAL		
	Ethanol	Oil				g/mmBtu	gGHGe/mmBtu	g/MJ
Btu/gal	*Confidential Business Information*							
Energy: mmBtu/mmBtu	*Confidential Business Information*				*Confidential Business Information*			
GHG: g/mmBtu								
VOC	30.03	30.01	0.01	0.01	22.29	52.32	163.08	0.15
CO	2.70	2.62	0.06	0.02	6.98	9.68	15.22	0.01
CH4	8.41	8.17	0.23	0.01	3.64	12.05	301.27	0.29
N2O	0.04	0.04	0.00	0.00	0.08	0.12	36.48	0.03
CO2	8,038.34	7,914.70	110.95	12.70	3,356.11	11,394.45	11,394.45	10.80
Convert to g CO_2e/MJ	7.92	7.80	0.111	0.012	3.366	11.29		11.29
Additional Distance								0.02
TOTAL CI	(g CO2e/MJ)							11.31

See cells E220:E231 to K220:K231 in page EtOH from LAICA CA_GREET Model

The total value is 11.31 gCO_2e/MJ and correspond to the sum of the partial values for residual oil, electricity, diesel, additional distance and transport and distribution. Furthermore, we include the emissions of VOC, CO, CH_4, N_2O and CO_2 in each case.

8. INPUT SHEET FOR THE LAICA CA_GREET MODEL

The results presented in this report are based upon the values shown by the input sheet in Table 10.

LAICA INPUT DATA FOR CA-GREET MODEL				
WORKSHEET	CELL REFERENCE	INPUT	UNITS	LAICA VALUE
Regional LT	C2	Region for analysis		U. S. Average
Fuel_Prod_TS	H291	Ethanol feedstock	%	0%
Fuel_Prod_TS	CU271	Total Energy	Confidential Business Information	
Inputs	E247	Electricity	Confidential Business Information	
Inputs	E246	Residual oil	Confidential Business Information	
Fuel_Prod_TS	CZ263 (CY257)	Proportion straw burnt	%	0%
EtOH	CY148	Share of residual oil	Confidential Business Information	
T&D Flowcharts	M1420	Ocean Tanker Transport	miles	8,753
T&D Flowcharts	R1427	Fuel Transportation in US	miles	100
T&D Flowcharts	W1421	Fuel Distribution in US	miles	50

9. COMPLEMENTARY INFORMATION

The calculations and detailed values for ocean tanker transport, transportation in US and distribution in US are shown in Tables 11-1, 11-2 and 11-3 that present below.

Table 11-1. Energy Consumption and Emissions	
Brazillian Sugarcane EtOH Dehydration T&D	
EtOH Transportation and Distribution	
Production inputs	
Urban emission share	0.0%
Loss factor	1.001
	Per mmBtu
Total energy	41,102
Fossil fuels	41,102
Coal	373
Natural gas	2,318
Petroleum	38,410
Total Emissions: grams/mmBtu of fuel throughput, except as noted	**Per mmBtu**
VOC	2.543
CO	6.981
CH4	3.636
N2O	0.079
CO2	3,356.112
CO2 from Land use change	
VOC from bulk terminal	6.667
VOC from refueling station	13.082
Urban emissions: grams/mmBtu of fuel throughput, except as noted	**Per mmBtu**
VOC	0.017
CO	0.015

See cells DA141 to DA186 in page EtOH of CA_GREET LAICA Model

Table 11-2. Energy Consumption and Emissions of Feedstock and Fuel Transportation			
Feedstock/Fuel	**Ethanol produced in CBI, and used in U.S.**		
Transportation Mode	**Ocean Tanker**	**Truck**	**Truck**
Urban Emission Share	0.0%	0.0%	0.0%
Distance (Miles, one-way)	7,611	100	50
Share of Fuel Type Used:			
Diesel	0%	100%	100%
Residual Oil	100%		
Ethanol		0%	0%
Energy Intensity: Btu/ton-mile			
Origin to Destination	32	1,028	1,028
Back-Haul	29	1,028	1,028
Energy Consumption: Btu/mmBtu of fuel transported			
Total energy	25,608	10,329	5,165
Fossil energy	25,608	10,329	5,165
Coal	185	126	63
Natural gas	1,295	682	341
Petroleum	24,128	9,521	4,761
Total Emissions: grams/mmBtu fuel transported			
VOC	2.034	0.339	0.170
CO	4.725	1.504	0.752
CH4	2.302	0.889	0.445
N2O	0.049	0.020	0.010
CO2	2150	804	402
Urban Emissions: grams/mmBtu of fuel transported			
VOC	0.001	0.011	0.005
CO	0.004	0.007	0.004

See cells II/IJ/IK 90 to II/IJ/IK128 in page T&D of CA_GREET LAICA Model

Table 11-3. Summary of Energy Consumption and Emissions for Each Fuel		
	Dehydration EtOH (as a transportation fuel, produced in CBI and used in U.S.)	
Stage	Ethanol Transportation	Ethanol Distribution
Percentage of fuel Transported by a Given Mode		
Ocean tanker	100.0%	
Barge	0.0%	
Pipeline	0.0%	
Rail	0.0%	
Truck	100.0%	100.0%
Energy Consumption: Btu/mmBtu of fuel transported		
Total energy	35,937	5,165
Fossil energy	35,937	5,165
Coal	310	63
Natural gas	1,977	341
Petroleum	33,650	4,761
Total Emissions: grams/mmBtu of fuel transported		
VOC	2.37	0.17
CO	6.23	0.75
CH4	3.19	0.44
N2O	0.07	0.01
CO2	2,954.19	401.92
Urban Emissions: grams/mmBtu of fuel transported		
VOC	0.01	0.01
CO	0.01	0.00

See cells DQ/DR 135 to DQ/DR 161 in page T&D of CA_GREET LAICA Model