Public Version

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Method 2A Sub-Pathway Life-Cycle Analysis Report

Trenton Agri Products, LLC

Summary of CA-GREET Model Inputs, Structure Changes, and Carbon Intensity Results

SUMMARY

This pathway report summarizes details on two (2) proposed sub-pathways for corn ethanol under the Low Carbon Fuel Standard (LCFS). The CA-GREET model (version 1.8b, December 2009) was used to assess the life-cycle emissions of greenhouse gases for these pathways which represent different operating scenarios for the Trenton Agri Products, LLC (TAP) Trenton, Nebraska ethanol plant. This report supports the proposed modifications to the existing pathways. Both the proposed sub-pathways to ethanol from corn have carbon intensities approximately 10 gCO_2e/MJ less than the reference pathway, meeting the 5 gCO_2e/MJ improvement required for a pathway modification.

TRENTON AGRI PRODUCTS PRODUCTION PROCESS

TAP is proposing a set of new dry grind corn ethanol sub-pathways under the LCFS to reflect the particular processes employed at its ethanol production facility. TAP's plant is a 40 million gallon per year (MMGPY) nameplate ethanol plant that is permitted to produce 50 MMGPY. The plant converts locally sourced grain to ethanol using ICM's dry grind process.

The plant is most similar to the following existing pathways entitled "Midwest, Dry Mill, Dry DGS, NG" and "Midwest; Dry Mill; Wet DGS". Technically, the plant uses the same standard corn dry mill ethanol process as the referenced pathways – but has lower energy use intensity. The plant produces dried distillers grains and solubles (DDGS) as well as wet distillers grains and solubles (WDGS). WDGS contains much higher moisture content than DDGS, approximately 65%. TAP combusts natural gas in the DDGS Dryer when producing DDGS. The consumption of natural gas as a process fuel is lower than the rate used in the reference pathways; therefore the development of new plant-specific sub-pathways is warranted.

Table 1 presents energy data specific to the 2010-2011 operating period which are representative of the proposed sub-pathways. These are compared to both reference pathways. These normalized metrics are supported with plant operating data submitted along with this application.

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Table 1: Process Energy and Yield Summary ("gallon" refers to an anhydrous gallon of ethanol, BTUs of thermal energy usage shown on LHV)

	Dry DGS		*Wet DGS*	
	Proposed Pathway – 100% Natural Gas, 100% DDGS	***Reference Pathway –*** Midwest; Dry Mill; Dry DGS, NG	***Proposed Pathway –*** 100% Natural Gas, 100% WDGS	***Reference Pathway –*** Midwest; Dry Mill; Wet, DGS
Yield (gallon / bushel)	[redacted]	2.72	[redacted]	2.72
Natural Gas Consumption (Btu / gallon)	[redacted]	89.8% * 36,000 = 33,330	[redacted]	89.8% * 36,000 = 33,330
Grid Electricity Consumption (Btu / gallon)	[redacted]	(100% - 89.8%) * 36,000 = 3,670	[redacted]	(100% - 89.8%) * 36,000 = 3,670

DESCRIPTION OF FIELD-TO-WHEELS FUEL LIFE-CYCLE

The CA-GREET life-cycle energy and greenhouse gas model has been used to conduct an analysis for TAP to compute the full life-cycle inventory of GHG emissions generated as a result of the project activity, and is in conformance with the CARB methodology. These emission sources include both direct and indirect sources throughout each sector of the supply chain. The primary GHG emission results presented in this report are normalized to a standard unit of gCO2e/MJ (LHV) of fuel ethanol produced.

This study provides TAP with a greenhouse gas life-cycle assessment of the fuel ethanol life-cycle from "field-to-wheels" to support the CARB Method 2A process and validating the claim that the fuel achieves at least a 5 gCO2e/MJ reduction from the reference pathway in the Lookup Table.

Figure 1 shows a simplified production process illustrating the basic life-cycle production process of corn ethanol, including all of the major inputs and processes. Embodied emission factors for all of the inputs are known and are not detailed any further. The emissions occurring at each stage of the production life-cycle are summed. This greenhouse gas life-cycle assessment is meant to capture more than 95% of the life-cycle emissions occurring within the entire supply chain.

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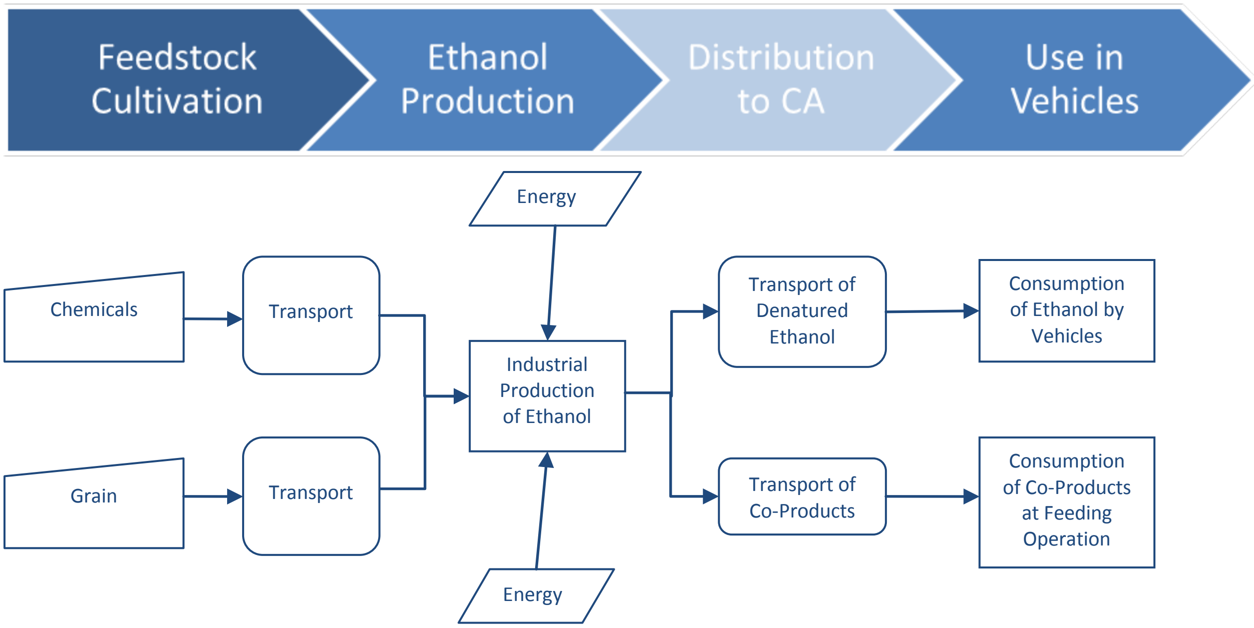
Figure 1: Ethanol Production Process Map



FEEDSTOCK CULTIVATION

TAP utilizes corn to produce ethanol via natural fermentation. CA-GREET defaults were used for the agricultural practice parameters in the analysis of TAP's product, no changes to the default CA-GREET agricultural inputs were made.

COMBUSTION EQUIPMENT

TAP utilizes the following types of equipment at the biorefinery to produce process steam, oxidize volatile organic compounds and to dry distiller's grains.

Equipment	***Capacity***	***Fuel***	***Use***
Thermal oxidizer/HRSG	99 MMbtu/hr	Natural Gas	Destruction of VOCs
Rotary Dryer	30 MMBtu/hr	Natural Gas	Drying of distillers grains

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NON-FEEDSTOCK INPUTS

The ethanol production process requires additional chemicals and enzyme as inputs in order to maintain balance in the process. TAP uses the following chemicals in the production process:

- Caustic Soda – Clean In Place (CIP)
- Alpha-amylase – enzyme that is used for liquefaction of corn starch slurry
- Gluco-amylase – enzyme that is used for saccharification of starch to fermentable sugar
- Sulfuric Acid - pH adjustment
- Urea – supplement for yeast growth
- Yeast – fermentation microorganism to convert sugar to ethanol
- Sulfamic Acid – Clean In Place (CIP)
- Ammonia – pH adjustment, nitrogen source for yeast growth
- Ammonium bisulfite – control acetaldehyde emissions from scrubber

TRANSPORTATION

TAP's suppliers are generally located within a 20 mile radius of the plant, but a detailed supplier survey has not been conducted so the default CA-GREET model inputs have been assumed for the inbound transport of corn. The CA-GREET assumption is that corn supplier's truck grain over a distance of 50 miles to the plant.

Finished products transported from the production facility include ethanol and distillers grains. Again, the default CA-GREET model inputs have been used which include ethanol shipments by rail and truck to blending terminals located in California. The transportation distances are summarized below.

	One Way Distance (miles)	***[source]***
Corn from farm to plant	50	CA-GREET default
Ethanol by rail to CA	1,400	CA-GREET default
Ethanol by truck to CA	40	CA-GREET default

PROPOSED PATHWAY DESCRIPTIONS

The plant will produce a mixture of DDGS and WDGS. Due to producing a mixture, TAP is proposing two (2) sub-pathways consisting of 100% DDGS and 100% WDGS. The amount of DDGS produced directly affects the percentage of natural gas utilized at the facility. The proposed pathways are illustrated in Table 2.

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Table 2: Pathway Descriptions

Sub-Pathway Descriptions
Midwest; Dry Mill, 100% DDGS, NG **Midwest; Dry Mill, 100% WDGS, NG**

Actual plant data from the 2010 and 2011 operating years have been used to develop the proposed sub-pathways. During this period, the plant produced 5% DDGS and 95% WDGS. As the plant's thermal energy load is highly dependent on the amount of co-product drying that occurs, it is necessary to understand the dryer's energy load in order to extrapolate total plant energy consumption. Data from the plant's process designer, ICM, Inc., has been provided to support this and show that dryer gas consumption is [redacted] Btu/gal (HHV) for 100% DDGS and 0 Btu/gal (HHV) for 100% WDGS. These are converted to LHV and used to estimate the current dryer gas load at the 2010-2011 period average co-product shares; then the calculated dryer gas load is subtracted from the total plant thermal energy load. This result is the gas consumption required for process steam production, which is held constant. Furthermore, TAP has observed that additional electricity required to run the dryers amounts to approximately [redacted] kWh/gallon when producing 100% DDGs vs 100% WDGS. Table 3 presents the total plant thermal energy load for the annual average and two disaggregated cases.

Table 3: Plant thermal energy load for 100% DDGS and 100% WDGS cases (BTUs shown on LHV)

	2010/11 TAP Average	*100% DDGS*	*100% WDGS*
DDGS Production (lb/gal)	[redacted]	[redacted]	[redacted]
WDGS Production (lb/gal)	[redacted]	[redacted]	[redacted]
Natural Gas Consumption (Btu/gal)	[redacted]	[redacted]	[redacted]

INPUTS & MODIFICATIONS to CA-GREET 1.8b

This section summarizes the specific input values which have been used to run the CA-GREET model to develop carbon intensity results for the proposed sub-pathways. While the scope of the analysis is well-to-wheels, modifications from the CA-GREET default corn ethanol pathways are only necessary for the inbound corn transportation and biorefinery operations.

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BIOREFINERY

Table 4 presents the specific modifications that have been made to the CA-GREET model pertaining to the biorefinery efficiency. The data below has been derived from annual aggregate data provided by TAP. Cumulative energy usage data has been provided and is normalized by gallon in the model.

Table 4: Biorefinery Operations Input Modifications

Modified Parameter	***CA-GREET Cell Reference***	***TAP – 100% DDGS***	***TAP – 100 % WDGS***	***Midwest Average***
Yield (gallon/bushel)	Fuel_Prod_TS!D277	[redacted]	[redacted]	2.72
DDGS Yield (lb dry matter /gallon)	ETOH C101	[redacted]	[redacted]	5.64
Total Plant Energy Use (Btu/gallon)	Fuel_Prod_TS!L277	[redacted]	[redacted]	36,000
Natural Gas Use (% fuels, Btu/gallon)	Inputs!C255	[redacted]	[redacted]	92.7% * 36,000 = 33,372
Grid Electricity Use (% total, Btu/gallon)	Inputs!C247	[redacted]	[redacted]	(100% - 92.7%) * 36,000 = 2,628

CARBON INTENSITY RESULTS

The carbon intensity for the two (2) proposed sub-pathways is summarized in Table 5. The Direct Emissions include all sources of emissions from Field-to-Tank plus denaturant and combustion, while the total value also includes indirect land use change (30.0 gCO_2e/MJ) Both Well-to-Tank direct emissions results, indirect effects from denaturant combustion and ILUC impacts (30.0 CO_2e/MJ) are included in the proposed sub-pathways. These pathways represent approximate net reductions in life-cycle GHG emissions from the reference pathway of 10.01 and 10.11 gCO_2e/MJ for the dry and wet proposed sub-pathways, respectively.

Table 5: Proposed Sub-Pathways for Trenton Agri Products, LLC

Sub-Pathway Description	***Direct Emissions including denaturant & combustion (gCO_2e/MJ)***	***Total Carbon Intensity Including ILUC (gCO_2e/MJ)***	***Reduction from Reference pathway (gCO_2e/MJ)***
Midwest, Dry Mill, 100% DDGS, NG	58.39	88.39	68.4 – 58.39 = 10.01
Midwest, Dry Mill, 100 % WDGS, NG	49.99	79.99	60.1 – 49.99 = 10.11

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SUPPORTING DOCUMENTATION

The following documents have been provided along with this application package and support the process yields and energy consumption inputs used in the CA-GREET model for the sub-pathways.

- **TAP Construction Permit –** Issued February 24, 2012.
- **TAP Ethanol Plant Process Flow Diagram**

[redacted]

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