# Method 2A Sub-Pathway Life-Cycle Analysis Report

## Husker Ag, LLC

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

### SUMMARY

This pathway report summarizes details on one (1) proposed sub-pathway for corn ethanol under the Low Carbon Fuel Standard (LCFS). The CA-GREET model (version 1.8b, December 2009) was modified to assess the life-cycle emissions of greenhouse gases for the pathway which represents the average operating scenarios for the Husker Ag, LLC (Husker) Plainview, Nebraska ethanol plant. This report supports the proposed modifications to the existing pathway. The proposed pathway represent approximate net reductions in life-cycle GHG emissions from the respective reference pathway of 16.48 $gCO_2e/MJ$ for DDGS and MDGS combined. The pathway achieves the 5.0 $gCO_2e/MJ$ or greater improvement required for Method 2A applications.

### HUSKER AG PRODUCTION PROCESS

Husker is proposing a new dry grind ethanol sub-pathway under the LCFS to reflect the particular processes employed at its ethanol production facility. Husker's plant is a 70 million gallon per year (MMGPY) nameplate ethanol plant that is permitted to produce 76 MMGPY. The plant converts corn to ethanol using ICM's dry grind process.

The plant is most similar to the following existing reference pathway entitled "Corn; Midwest; Dry Mill; Dry DGS; NG". Technically, the plant uses the same standard dry mill ethanol process as the reference pathway – but with lower process energy use and higher ethanol yields. Husker's facility is a much newer plant than what ARB's reference plant data set is based and is much more energy efficient as numerous process improvements have been adopted by the industry over time. The plant produces a combination of dry distiller's grains and solubles (DDGS) as well as modified distillers grains and solubles (MDGS). MDGS contains approximately 50% moisture, by weight. Husker uses natural gas in the dryer when producing both DDGS and MDGS. The consumption of natural gas as a process fuel is lower than the rate used in the reference pathway; therefore the development of new plant-specific sub-pathways is warranted.

Husker is supplying data in Table 1 as documented evidence of the baseline yield and energy performance of the plant and these are compared with their respective 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 for Corn Ethanol ("gallon" refers to an anhydrous gallon of ethanol, BTUs of thermal energy usage shown on LHV)**

| | ***Husker Historical Average –*** 100% Natural Gas, 100% DDGS | ***Husker Historical Average –*** 100% Natural Gas, 100% MDGS | ***Husker Historical Average –*** 100% Natural Gas, Average % of DDGS and MDGS | ***Reference Pathway –*** Corn; Midwest; Dry Mill; Dry DGS; NG |
|---|---|---|---|---|
| **Yield (gallon / bushel)** | [redacted] | [redacted] | [redacted] | 2.72 |
| **Natural Gas Consumption (Btu / gallon)** | [redacted] | [redacted] | [redacted] | 89.8% * 36,000 = 32,330 |
| **Grid Electricity Consumption (Btu / gallon)** | [redacted] | [redacted] | [redacted] | (100% - 89.8%) * 36,000 = 3,670 |
| **DGS Yield (lbs Dry Matter/gallon)** | [redacted] | [redacted] | [redacted] | 5.34 |

## 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 Husker 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 Husker 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 5.0 gCO2e/MJ GHG reduction from the reference pathway.

Figure 1 shows a simplified production process illustrating the basic life-cycle production process of grain 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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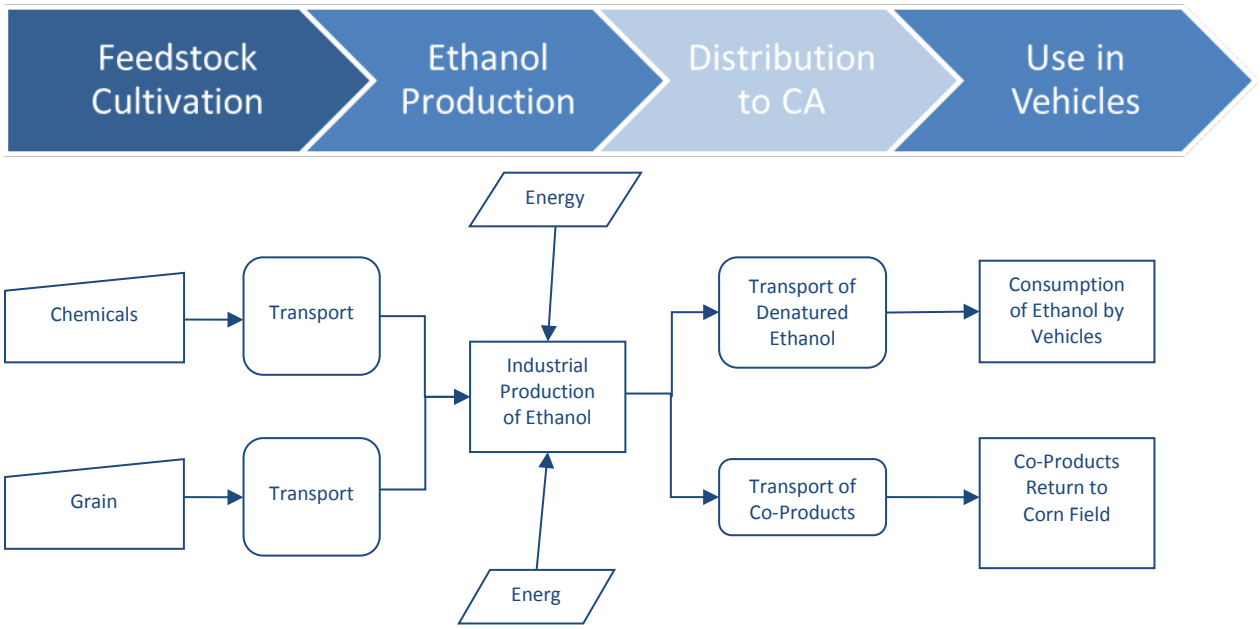
**Figure 1: Ethanol Production Process Map**




## FEEDSTOCK CULTIVATION

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

## COMBUSTION EQUIPMENT

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

**Table 2: Husker Combustion Equipment**

| ***Equipment*** | ***Capacity*** | ***Fuel*** | ***Use*** |
|---|---|---|---|
| **TO/HRSG #1** | 99 MMBtu/hr | Natural Gas | Destruction of VOCs, production of process steam |
| **TO/HRSG #2** | 125 MMBtu/hr | Natural Gas | Destruction of VOCs, production of process steam |
| **Dryer #1** | 40 MMBtu/hr | Natural Gas and Methane | Drying of distillers grains |
| **Dryer #2** | 42 MMBtu/hr | Natural Gas and Methane | 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. Husker uses the following chemicals in the production process:

- Caustic Soda – Clean In Place (CIP)
- Alpha-amylase – enzyme that is used for liquefaction of grain 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)
- Ammonium bisulfite – control acetaldehyde emissions from scrubber

As of November 2013, Husker no longer uses anhydrous ammonia for [redacted] in the process.

## TRANSPORTATION

A detailed supplier survey has not been conducted, so the default CA-GREET model inputs have been assumed for the inbound transport of grain. The CA-GREET assumption is that 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.

**Table 3: Transportation Distances**

| | ***One Way Distance (miles)*** | ***[source]*** |
|---|---|---|
| **Grain from farm to plant** | 50 | CA-GREET default |
| **100% Ethanol by rail to CA** | 1,400 | CA-GREET default |
| **70% Ethanol by HDD truck to terminal** | 40 | CA-GREET default |
| **100% Ethanol by HDD truck to terminal** | 50 | CA-GREET default |

## PROPOSED PATHWAY DESCRIPTIONS

The plant produces a mixture of DDGS and MDGS. Due to producing a mixture, Husker is proposing one (1) sub-pathway consisting of an average production amount of DDGS and MDGS. The amount of DDGS and MDGS produced does not vary greatly. If the averages were to vary significantly, the natural gas usage could be affected. The proposed pathway is illustrated in Table 4.

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**Table 4: Pathway Descriptions**

| *Sub-Pathway Description* |
|---|
| **Husker, Ethanol from Corn, Midwest, Dry Mill, Combination of Dry DGS and Modified DGS, NG** |

Actual plant data from the 2011 and 2012 operating years have been used to develop the proposed sub-pathways. During this period, the plant produced [redacted] DDG, [redacted] MDG and [redacted] corn oil as co-products by dry-matter content. While corn oil is sold separately into other markets, for purposes of modeling life-cycle GHG emissions, the corn oil is assumed to be sold with the MDG and WDG products.

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. The plant's process designer, ICM, Inc., estimates that dryer natural gas consumption is [redacted] Btu/gal (HHV) for [redacted] DDGS and [redacted] Btu/gal (HHV) for [redacted] MDGS. Further, ICM estimates that electricity consumption for the dryer system is [redacted] kWh per [redacted] lbs of water evaporated from the DGS.

Two year average co-product production rates are used to estimate the weighted-average thermal and electrical energy use for the dryer system. This energy use is then allocated to the DDGS and MDGS pathways based on their relative energy use and relative production rates. Table 5 presents the total plant thermal and electrical energy load for the annual average and two disaggregated cases.

**Table 5: Co-product production rates and plant thermal energy load for DDGS and MDGS cases (BTUs shown as LHV)**

| | *2011/12 Husker Average* | *100% DDGS Equivalent* | *100% MDGS Equivalent* | *Average DDGS/ MDGS Equivalent* |
|---|---|---|---|---|
| **DDGS Production (lbs /gal) @ 10% m.c.** | [redacted] | [redacted] | [redacted] | [redacted] |
| **MDGS Production (lbs /gal) @ 65% m.c.** | [redacted] | [redacted] | [redacted] | [redacted] |
| **Corn Oil Production (lbs /gal) @ 0% m.c.** | [redacted] | [redacted] | [redacted] | [redacted] |
| **Dry Matter DGS equivalent (lbs /gal)** | [redacted] | [redacted] | [redacted] | [redacted] |
| **Natural Gas Consumption (Btu/gal)** | [redacted] | [redacted] | [redacted] | [redacted] |
| **Electricity Consumption (Btu/gal)** | [redacted] | [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 pathway is only necessary for the inbound grain transportation and biorefinery operations.

### BIOREFINERY

Table 6 presents the specific modifications that have been made to the corn CA-GREET model pertaining to the biorefinery efficiency. The data below has been derived from two years of actual operating data.

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**Table 6: Biorefinery Operations Input Modifications (for Corn Ethanol pathways) ("gallon" refers to an anhydrous gallon of ethanol, BTUs of thermal energy usage shown on LHV)**

| *Modified Parameter* | *CA-GREET Cell Reference* | *Husker – Average DDGS/ MDGS* | *Midwest Average Dry Mill, NG, Dry DGS* |
|---|---|---|---|
| Yield (gallon/bushel) | Inputs!C235 | [redacted] | 2.72 |
| DGS Yield (lbs dry matter /gallon) | EtOH!C101 | [redacted] | 5.34 |
| Total Plant Energy Use (Btu/gallon) | Inputs!C253 | [redacted] | 36,000 |
| Natural Gas Use (% fuels, Btu/gallon) | Inputs!C255 | [redacted] | 89.8% * 36,000 = 32,330 |
| Grid Electricity Use (% total, Btu/gallon) | Inputs!C247 | [redacted] | (100% - 89.8%) * 36,000 = 3,670 |

## CARBON INTENSITY RESULTS

The carbon intensity for the proposed sub-pathway is summarized in Table 7. The Direct Emissions include all sources of emissions from Well-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 and indirect effects from denaturant combustion and ILUC impacts (30 $CO_2e/MJ$) are included in the proposed sub-pathway. The proposed pathway represents approximate net reductions in life-cycle GHG emissions from the reference pathway of 16.48 $gCO_2e/MJ$ for the combination of DDGS and MDGS.

**Table 7: Proposed Sub-Pathways for Husker Ag, LLC**

| *Sub-Pathway Description* | *Direct Emissions including denaturant & combustion ($gCO_2e/MJ$)* | *Total Carbon Intensity Including ILUC ($gCO_2e/MJ$)* | *Reduction from Reference pathway ($gCO_2e/MJ$)* |
|---|---|---|---|
| **Husker, Ethanol from Corn, Midwest, Dry Mill, Combo Dry DGS and Modified DGS, NG** | 51.92 | 30.00 | 98.4 – 81.92 = 16.48 |

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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.

- **Husker Air Quality Permit –** Issued June 25, 2010
- **Husker Ethanol Plant Process Flow Diagram**
- **2011 – 2012 Northeast Nebraska Public Power District Electric Bills–** These documents contain information that Husker Ag, LLC deems confidential.
- **2011 - 2012 Kinder Morgan Interstate GTLLC Natural Gas Bills -** These documents contain information that Husker Ag, LLC deems confidential.
- **Husker RFS2 Independent Third Party Engineer Report** - This document contains information that Husker Ag, LLC deems confidential.
- **Husker 2011-2012 Production Data Spreadsheet –** This document contains all of the historical energy use and plant production along with calculations to develop CA-GREET inputs. This document contains information that Husker Ag, LLC deems confidential.
- **Husker Utility Summary 2011_2012 –** This document contains information that Husker Ag, LLC deems confidential.
- **Husker_ca_greet1.8b_dec09_corn_100%_DDGS -** CA-GREET model containing inputs and results for sub-pathways producing ethanol from corn and 100% DDGS of total co-products by dry matter. This document contains information that Husker Ag, LLC deems confidential.
- **Husker_ca_greet1.8b_dec09_corn_100%_MDGS -** CA-GREET model containing inputs and results for sub-pathways producing ethanol from corn and 100% MDGS of total co-products by dry matter. This document contains information that Husker Ag, LLC deems confidential.

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