Highwater Ethanol, LLC
Lamberton, Minnesota Corn Ethanol Production
Life Cycle Analysis Report

1. Introduction

Highwater Ethanol, LLC (Highwater) is a natural gas-fired, dry grind, corn ethanol plant in Lamberton, Minnesota that has been operating since August 14, 2009. The plant was designed by ICM, Inc. with a nameplate production capacity of 50 million gallons per year (MMgal/yr). Highwater is currently permitted in Minnesota Pollution Control Agency (MPCA) Air Emission Permit No. 12700053-003 to produce 58.0 MMgal/yr of undenatured ethanol. Highwater also produces dried distiller's grains with solubles (DDGS, approximately 10-15% moisture), modified distiller's grains with solubles (MDGS, approximately 35-40% moistrue), and corn oil.

Highwater has estimated the direct lifecycle carbon intensity (CI) of its production process using the California Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (CA-GREET) model, version 1.8b.

2. Feedstock Production Summary

The majority of Highwater's corn feedstock comes from local farms (within 50 miles of the plant). All corn is delivered to the plant by truck. Based on the CA-GREET model results, the CI due to feedstock production and transportation is as follows:

	CA-GREET Model Output	With Corn Loss Factor (1.0005)	IPCC Factors (gCO_2e/g)	$gCO_2e/MMBtu$	gCO_2e/MJ
CO_2	15,305	15,313	1	15,313	14.5
CH_4	18.1	18.1	25	453	0.43
N_2O	41.6	41.6	298	12,401	11.8
			Total:	28,166	26.7

3. Fuel Production Summary

In the dry mill process, corn is delivered to the facility, it is screened to remove any unwanted debris, and then the kernel is ground into coarse flour, referred to as meal, in a hammermill. The meal is then cooked to prepare the starch for fermentation. During the cooking process, corn oil is separated from the mash. The cooked mash is transferred to a fermentation tank where yeast converts available starch to ethanol.

The fermented mash is pumped into a multi-column distillation process, where additional heat is applied, and the columns utilize the differences in the boiling points of ethanol and water to boil off and separate the ethanol, resulting in hydrous ethanol (ethanol with approximately 5 percent water by volume). The stillage, the residue from the distillation process, is pumped out from the bottom of the columns into centrifuges. The hydrous ethanol is dehydrated as it is passed through a molecular sieve to remove excess water, resulting in anhydrous ethanol. Denaturant is added to the ethanol to make it unfit for human consumption, and it is placed in storage. The Highwater Ethanol Production Fuel Process is shown in Attachment 6 of this Method 2A application.

The modeled CI is based on actual ethanol yield, total energy consumption and energy consumption by fuel type. The actual values are based on plant operation from September 2012 to August 2014. Model inputs are annual averages for the two year period. Production and energy use data is presented separately in a table called Highwater Ethanol Production and Energy Use Summary. The CI due to fuel production as follows:

	CA-GREET Model Output	**IPCC Factors (gCO_2e/g)**	**$gCO_2e/MMBtu$**	**gCO_2e/MJ**
CO_2	28,607	1	28,607	27.1
CH_4	50.6	25	1,265	1.20
N_2O	0.28	298	83.4	0.08
		Total:	29,955	28.4

4. Ethanol Yield

Monthly corn use (bushels) and denatured ethanol production (gallons) from September 2012 through August 2014 were used to calculate a two year annual average denatured ethanol yield (gallons/bushel), an input used in the CA-GREET model for the Highwater Ethanol pathway. Production data is Confidential Business Information, and is included in Attachment 3 of this Method 2A application.

5. Power Consumption

Power consumption used in the CI calculations is based on electricity purchase receipts for the two year period from September 2012 to August 2014. There are four electric meters at the plant that are each billed separately for each month. The service provider, meter number, and item metered are provided in the following table.

Service Provider	**Meter Number**	**Item Metered**
South Central Electric Association	708	Water Supply Well 1
Redwood Electric Cooperative	4778	Plant Gate
Redwood Electric Cooperative	HWE	Main Plant Substation
Redwood Electric Cooperative	8353	Water Supply Well 2

The total electrical use in kilowatt hours (kWh) is converted to million British thermal units (MMBtu) based on a conversion factor of 3.40951×10^{-3} MMBtu/kWh.

$$kWh * 3.40951 \times 10^{-3}\ MMBtu/kWh = MMBtu$$

The two-year annual average electricity consumption was used to calculate electricity use per gallon (kWh/gallon), total energy use (Btu/gallon), and the portion of total energy use that is electricity (%), inputs that are used in the CA-GREET model for the Highwater Ethanol pathway. Electricity purchase receipts are Confidential Business Information, and are included in Attachment 2 of this Method 2A application.

6. Natural Gas Consumption

The thermal needs of the plant are met by combustion of natural gas. Natural gas consumption used in the CI calculations is based on natural gas invoices from U.S. Energy for the two year period from September 2012 to August 2014. The invoices report monthly natural gas use in

Decatherms (MMBtu, High Heating Value, or HHV). Low heating value (LHV) is derived from HHV by multiplying by 90% as follows:

$$\text{MMBtu (HHV)} * 0.9 = \text{MMBtu (LHV)}$$

The two-year annual average natural gas consumption was used to calculate natural gas use per gallon (Btu/gallon) and total energy use (Btu/gallon), inputs that are used in the CA-GREET model for the Highwater Ethanol pathway. Natural gas invoices are Confidential Business Information, and are included in Attachment 2 of this Method 2A application.

7. Pathway CI Summary

The CARB LCFS reference pathway is ETHC004, Ethanol from Corn, Midwest; Dry Mill; Dry DGS, NG, as described in the February 27, 2009 “Detailed California-Modified GREET Pathway for Corn Ethanol”. The total lifecycle CI including indirect land use change (ILUC) of the reference pathway is 98.3 grams of carbon dioxide equivalent per Mega joule (g CO2-e/MJ). Tables 1, 2, and 3 in Attachment 4 of this Method 2A application show the CI for the reference pathway, the model input values for the Highwater Ethanol pathway, and the CI for the Highwater Ethanol pathway, respectively.

After adjusting the CA-GREET model for Highwater operational parameters, the calculated CI of the proposed pathway is 85.9 g CO2-e/MJ.