ERI SOLUTIONS INC.

Method 2A Sub-Pathway Life-Cycle Analysis Report

WE Hereford, LLC

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

SUMMARY

This pathway report summarizes details on four (4) proposed sub-pathways for corn and sorghum ethanol under the Low Carbon Fuel Standard (LCFS). The CA-GREET model (version 1.8b, December 2009) for corn and sorghum, which was prepared ARB, was modified to assess the life-cycle emissions of greenhouse gases for these pathways which represent different operating scenarios for the WE Hereford, LLC (WEH) Hereford, Texas ethanol plant. This report supports the proposed modifications to the existing pathways. The corn pathways represent approximate net reductions in life-cycle GHG emissions from their respective reference pathways of 15.05 and 10.59 gCO_2e/MJ for MDGS and WDGS. The sorghum pathways represent approximate net reductions in life-cycle GHG emissions from their respective reference pathways of 14.44 and 7.85 gCO2e/MJ for the MDGS and WDGS. These pathways achieve the 5 gCO_2e/MJ or greater improvement required for Method 2A applications.

WE HEREFORD PRODUCTION PROCESS

WEH is proposing a set of new dry grind ethanol sub-pathways under the LCFS to reflect the particular processes employed at its ethanol production facility. WEH's plant is a 100 million gallon per year (MMGPY) nameplate ethanol plant that is permitted to produce 120 MMGPY. The plant converts corn and sorghum to ethanol using ICM's dry grind process.

The plant is most similar to the following existing reference pathways entitled "Corn; Midwest; Dry Mill; Dry DGS; NG" and "Corn, Midwest; Dry Mill; Wet, DGS; NG" and "Sorghum; Midwest; Dry Mill; Dry DGS; NG" and "Sorghum; Midwest; Dry Mill; Wet DGS; NG". Technically, the plant uses the same standard dry mill ethanol process as the reference pathways – but with lower process energy use and higher ethanol yields. White Energy's Hereford 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 modified distillers grains and solubles (MDGS) as well as wet distiller's grains and solubles (WDGS). WDGS contains approximately 65% moisture while MDGS contains approximately 50% moisture, by weight. WEH uses natural gas in the dryer when producing MDGS. 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.

WEH is supplying data in Table 1 and Table 2 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.

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)

	Modified DGS		***Wet DGS***	
	WEH Historical Average – 100% Natural Gas, 100% MDGS	***Reference Pathway –*** Corn; Midwest; Dry Mill; Dry DGS; NG	***WEH Historical Average –*** 100% Natural Gas, 100% WDGS	***Reference Pathway –*** Corn; Midwest; Dry Mill; Wet, DGS; NG
Yield (gallon / bushel)	[redacted]	2.72	[redacted]	2.72
Natural Gas Consumption (Btu / gallon)		89.8% * 36,000 = 32,330		22,430
Grid Electricity Consumption (Btu / gallon)		(100% - 89.8%) * 36,000 = 3,670		3,670
DGS Yield (lb Dry Matter/gallon)		5.64		5.64

Table 2: Process Energy and Yield Summary for Sorghum Ethanol ("gallon" refers to an anhydrous gallon of ethanol, BTUs of thermal energy usage shown on LHV)

	Modified DGS		***Wet DGS***	
	WEH Historical Average – 100% Natural Gas, 100% MDGS	***Reference Pathway –*** Sorghum; Midwest; Dry Mill; Dry DGS; NG	***WEH Historical Average –*** 100% Natural Gas, 100% WDGS	***Reference Pathway –*** Sorghum; Midwest; Dry Mill; Wet, DGS; NG
Yield (gallon / bushel)	[redacted]	2.72	[redacted]	2.72
Natural Gas Consumption (Btu / gallon)		89.8% * 36,000 = 32,330		22,430
Grid Electricity Consumption (Btu / gallon)		(100% - 89.8%) * 36,000 = 3,670		3,670
DGS Yield (lb Dry Matter/gallon)		5.64		5.64

WEH is proposing new ethanol fuel pathways be structured using these two year average values plus a conservative margin for each CI model parameter. These margins are intended to set the CI for WEH's ethanol higher than the 2 year average value thus ensuring that WEH will be able to meet its operating obligations in the event that plant yield or efficiency suffers unexpectedly. To set a more conservative CI, the ethanol and co-product yields are decreased, while the energy use is increased. The proposed values are shown in Table 3. WEH also expects to add corn oil separation at some point in the near future and this will increase electricity consumption, this increase is captured by the proposed margin shown in Table 3.

Table 3: Development of conservative operating parameters for proposed pathways

	2011-2012 Average	*Buffer*	*Proposed Values*
EtOH Yield (Anhydrous gal/bu)	[redacted]	-0.521%	[redacted]
DDG Yield (lb d.m./gal)		-2.500%	
Steam Generation Gas (HHV Btu/gal)		2.500%	
Dryer Gas (HHV Btu/gal)[1]		2.500%	
Electrical (kWh/gal)		7.000%	

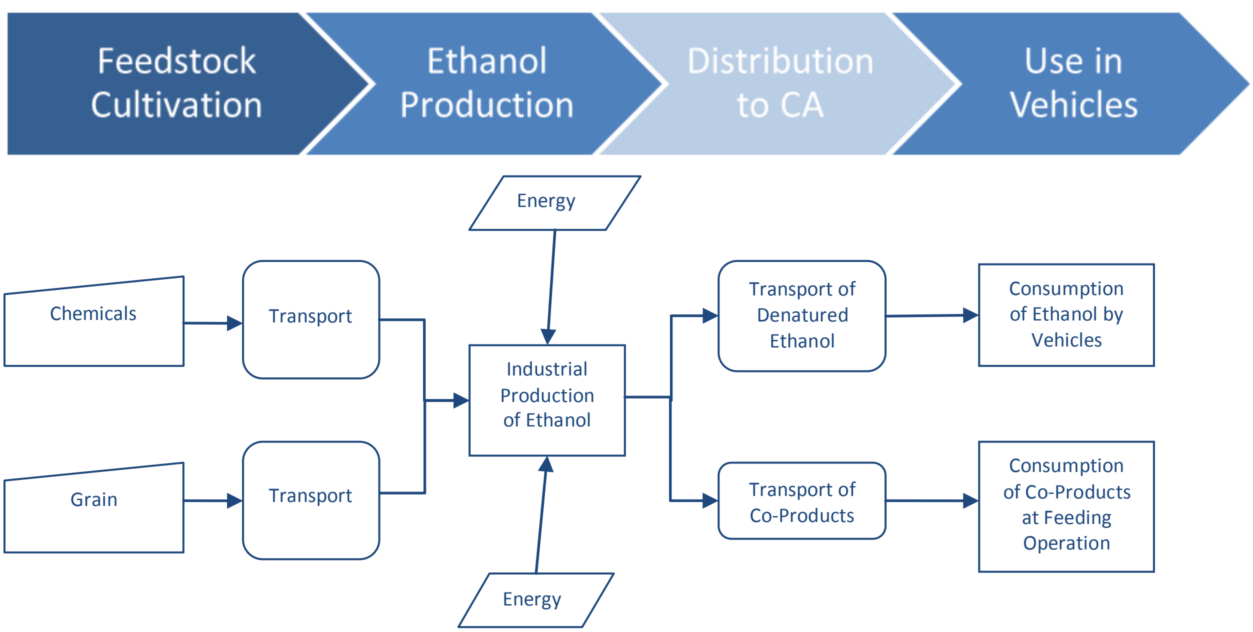
DESCRIPTION OF FIELD-TO-WHEELS FUEL LIFE-CYCLE

The CA-GREET life-cycle energy and greenhouse gas model has been used to conduct an analysis for WEH 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 WEH 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 GHG reduction from the reference pathways.

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.

Figure 1: Ethanol Production Process Map



[1] Only applicable when producing Modified Distillers Grains and Solubles

FEEDSTOCK CULTIVATION

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

COMBUSTION EQUIPMENT

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

Table 4: WEH Combustion Equipment

Equipment	*Capacity*	*Fuel*	*Use*
Regenerative Thermal Oxidizer (RTO)	10 MMbtu/hr	Natural Gas	Destruction of VOCs, production of process steam
Dryers (2)	45 MMBtu/hr (each)	Natural Gas	Drying of distillers grains
Package Boilers (2)	120 MMBtu/hr (each)	Natural Gas	Production of process steam

NON-FEEDSTOCK INPUTS

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

- Caustic Soda
- Alpha-amylase
- Gluco-amylase
- Sulfuric Acid
- Urea
- Yeast
- Sulfamic Acid
- Ammonia
- Sodium bisulfite
- Hydrochloric acid

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 5: 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 will produce a mixture of MDGS and WDGS. Due to producing a mixture, WEH is proposing four (4) sub-pathways consisting of 100% MDGS and 100% WDGS for both feedstocks, sorghum and corn. The amount of MDGS produced directly affects the percentage of natural gas utilized at the facility. The proposed pathways are illustrated in Table 6.

Table 6: Pathway Descriptions

Sub-Pathway Descriptions
WEH, Ethanol from Corn, Midwest, Dry Mill, Modified DGS, NG
WEH, Ethanol from Corn, Midwest, Dry Mill, Wet DGS, NG
WEH, Ethanol from Sorghum, Midwest, Dry Mill, Modified DGS, NG
WEH, Ethanol from Sorghum, Midwest, Dry Mill, Wet DGS, NG

Actual plant data from the 2011 and 2012 operating years plus a conservative margin have been used to develop the proposed sub-pathways. During this period, the plant produced ##% MDG and ##% WDG and ##% syrup. While syrup is sold separately into the animal feed market, a small portion of the syrup is blended into the WDG. For purposes of modeling life-cycle GHG emissions, the syrup 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 for these two drying cases. The plants process designer, ICM, Inc., estimates that dryer natural gas consumption is [redacted] Btu/gal (HHV) for 100% MDGS and [redacted] Btu/gal (HHV) for 100% WDGS. The MDGS dryer natural gas rate has been set to [redacted] Btu/gal (HHV) in the proposed pathways. These consumption rates are converted to LHV and used to estimate the current dryer gas load at the 2011-2012 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. Table 7 presents the total plant thermal energy load for the annual average and two disaggregated cases.

Table 7: Co-product production rates and plant thermal energy load for 100% MDGS and 100% WDGS cases (BTUs shown on LHV)

	2011/12 WEH Average	*Margin*	*Proposed for 100% MDGS*	*Proposed for 100% WDGS*
MDGS Production (lb/gal) @ 50% m.c. **WDGS Production (lb/gal) @ 65% m.c.** **Syrup Production (lb/gal) @ 65% m.c.**	[redacted]	-2.5% -2.5% -2.5%	[redacted]	[redacted]
Dry Matter DGS equivalent (lb/gal) **Natural Gas Consumption (Btu/gal)**	[redacted]	 +2.5%	[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 and sorghum ethanol pathways are only necessary for the inbound grain transportation and biorefinery operations.

BIOREFINERY

Table 8 and Table 9 present the specific modifications that have been made to the corn and sorghum CA-GREET models pertaining to the biorefinery efficiency. The data below has been derived from two years of actual operating data and using conservative margins discussed above.

Table 8: 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*	*WEH – 100% MDGS*	*WEH – 100 % WDGS*	*Midwest Average*
Yield (gallon/bushel)	Inputs!C235	[redacted]	[redacted]	2.72
DGS Yield (lb dry matter /gallon)	EtOH!C101			5.64
Total Plant Energy Use (Btu/gallon)	Inputs!C253			36,000
Natural Gas Use (% fuels, Btu/gallon)	Inputs!C255			92.7% * 36,000 = 33,372
Grid Electricity Use (% total, Btu/gallon)	Inputs!C247			(100% - 92.7%) * 36,000 = 2,628

Table 9: Biorefinery Operations Input Modifications (for Sorghum Ethanol pathways) ("gallon" refers to an anhydrous gallon of ethanol, BTUs of thermal energy usage shown on LHV)

Modified Parameter	*CA-GREET Cell Reference*	*WEH – 100% MDGS*	*WEH – 100 % WDGS*	*Midwest Average*
Yield (gallon/bushel)	Inputs!D235	[redacted]	[redacted]	2.72
DGS Yield (lb dry matter /gallon)	EtOH!AF101			5.64
Total Plant Energy Use (Btu/gallon)	Inputs!E253			36,000
Natural Gas Use (% fuels, Btu/gallon)	Inputs!E255			92.7% * 36,000 = 33,372
Grid Electricity Use (% total, Btu/gallon)	Inputs!E247			(100% - 92.7%) * 36,000 = 2,628

CARBON INTENSITY RESULTS

The carbon intensity for the four (4) proposed sub-pathways is summarized in Table 10. 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-pathways. The corn pathways represent approximate net reductions in life-cycle GHG emissions from their respective reference pathways of 15.05 and 10.59 gCO_2e/MJ for MDGS and WDGS. The sorghum pathways represent approximate net reductions in life-cycle GHG emissions from their respective reference pathways of 14.44 and 7.85 gCO2e/MJ for the MDGS and WDGS.

Table 10: Proposed Sub-Pathways for WE Hereford, 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)*
WEH, Ethanol from Corn, Midwest, Dry Mill, Modified DGS, NG	53.35	83.35	98.4 – 83.35= 15.05
WEH, Ethanol from Corn, Midwest, Dry Mill, Wet DGS, NG	49.51	79.51	90.1 – 79.51 = 10.59
WEH, Ethanol from Sorghum, Midwest, Dry Mill, Modified DGS, NG	52.60	82.60	97.04 – 82.60 = 14.44
WEH, Ethanol from Sorghum, Midwest, Dry Mill, Wet DGS, NG	48.76	78.76	86.61 – 78.76 = 7.85

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.

- **WEH Air Quality Permit –** Issued April 5, 2013
- **WEH Ethanol Plant Process Flow Diagram**
- **2011 – 2012 Xcel Energy Electric Bills–** These documents contain information that WE Hereford, LLC deems confidential.
- **2011 - 2012 Natural Gas Bills and Usage Reports (Various Vendors) -** These documents contain information that WE Hereford, LLC deems confidential.
- **WEH RFS2 Independent Third Party Engineer Report** - This document contains information that WE Hereford, LLC deems confidential.
- **WEH 2011 - 2012 Fuel Production Records –** This document contains information that WE Hereford, LLC deems confidential.
- **WEH 2011 – 2012 Input Values 07-10-2013 –** This document contains all of the historical energy use and plant production along with calculations to develop CA-GREET inputs.
- **WEH_ca_greet1.8b_dec09_sorghum_100%_MDGS -** CA-GREET model containing inputs and results for sub-pathways producing ethanol from sorghum and 100% MDGS of total co-products by dry matter. This document contains information that WE Hereford, LLC deems confidential.
- **WEH_ca_greet1.8b_dec09_sorghum_100%_WDGS -** CA-GREET model containing inputs and results for sub-pathways producing ethanol from sorghum and 100% WDGS of total co-products by dry matter. This document contains information that WE Hereford, LLC deems confidential.
- **WEH_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 WE Hereford, LLC deems confidential.
- **WEH_ca_greet1.8b_dec09_corn_100%_WDGS -** CA-GREET model containing inputs and results for sub-pathways producing ethanol from corn and 100% WDGS of total co-products by dry matter. This document contains information that WE Hereford, LLC deems confidential.