LCFS Carbon Intensities for POET's
Chancellor, SD Ethanol Plant
January 31, 2014

Summary

POET's Chancellor, SD dry mill ethanol plant is a 120 million gallon per year facility. POET-Chancellor started operation in 2003 with a capacity of 45 million gallons per year. The plant was expanded in 2006 to 120 million gallons per year. In 2007, POET-Chancellor added a solid fuel boiler to produce steam using a combination of various waste wood products and landfill gas from the local landfill. POET-Chancellor is currently utilizing corn and sorghum as a feedstock and producing mostly dry distiller's grains. The plant utilizes landfill gas (LFG) and waste wood in addition to natural gas (NG) and electricity as process fuel. The new pathway should be applicable to full production at 100% dry feed (DDGS, dry distiller's grain with solubles) operation strategy utilizing both corn and sorghum as feedstocks.

CARB's dry mill corn ethanol and sorghum ethanol carbon intensities (CI) are 97.56 and 96.26 gCO_2e/MJ ethanol, respectively. Table 1 below summarizes the CI of the Chancellor plant on both corn and sorghum, at 100% Dry Distiller's Grain (DDGS). All ethanol production and feedstock farming is Midwest based, they are modeled this way in the report.

When approved, POET Chancellor will have the ability to use both the corn and sorghum CI values while co-mingling corn and sorghum as feedstock for fermentation. On a daily basis, the sorghum and corn will be measured separately as it is entering the production plant. The ethanol produced from sorghum will be calculated using the yield allocated for sorghum, this ethanol will thus be recorded with its RIN as sorghum based ethanol. The corn based ethanol will be the same way.

Table 1. Summary of CIs for Chancellor (gCO2e/MJ)

Feedstock	Parameter		100% Dry DGs
Corn	Direct		33.88
	Land Use		30.00
	Total		63.88
Sorghum	Direct		37.50
	Land Use		30.00
	Total		67.50

There are several characteristics of this unique plant that allow the plant to produce ethanol with low GHG emissions.

1. When operated on corn, the plant has a yield of 2.88 gallons per bushel, which is higher than the 2.72 gal/bushel assumed by CARB for a corn ethanol plant. The higher yield reduces farming emissions (per MJ of ethanol), reduces

chemical emissions used in farming, reduces feedstock transport emissions, and reduces land use emissions.[1]

2. The landfill gas collection system was installed in a local landfill to provide process gas specifically to the plant. There is a dedicated pipeline from the landfill to POET-Chancellor, built and used specifically for transporting landfill gas to the facility, independent of the natural gas pipeline. The ethanol plant owns the credit for avoiding methane emissions from the landfill, creating a significant GHG benefit. Without the partnership between the landfill and POET-Chancellor the methane would not be collected.
3. Natural gas, electricity, landfill gas and wood energy are used for ethanol production. The use of both landfill gas and waste wood significantly reduces the natural gas needed to run the plant. Only natural gas and electricity are used in the DDGS drying process.

   Refer to PFD of Facility in REFERENCE documents. (Confidential Business Information)

Introduction

This document estimates carbon intensities (CI) for the plant operating on 100% corn, and operating on 100% sorghum, utilizing CARB's GREET model.

The report is organized into the following sections:

- Characteristics of Chancellor Plant
- GREET Modeling
- Summary of Total Emissions

Characteristics of Chancellor Plant

Inputs and outputs for the Chancellor plant for the last 2 years utilizing corn only as a feedstock are shown in Table 2 below (see the INVOICES7 Excel spreadsheet, tab: TABLE (Confidential business Information)). The plant produced [redacted] million gallons of ethanol in 2011 and [redacted] million gallons in 2012. The average ethanol yield for both years is 2.88 gal/bu, which is higher than CARB's assumption for corn ethanol of 2.72 gal/bu.

Co-products produced at the plant include dried distillers' grains (DDGS), wet cake, syrup, and oil. All values in Table 2 are reported in bone dry tons. The DDGS, wet cake, syrup, and most of the oil are sold as animal feed. Some oil is sold to produce biodiesel. In estimating the DDGS yield in lb/bu, we have summed the bone-dry DDGS, wet cake (bdt), and syrup (bdt), and divided by the bushels of corn produced.

[1] While the higher plant yield reduces land use emissions, current ARB policy is to use 30 gCO_2e/MJ for both corn and sorghum, regardless of ethanol plant yield, so that is what has been done in this report.

Table 2. Characteristics of the Chancellor Plant (Corn)			
Parameter	2011	2012	Average
Inputs			
Corn, bu	[redacted]	[redacted]	[redacted]
Natural gas, mmBTU	[redacted]	[redacted]	[redacted]
Electricity, kWh	[redacted]	[redacted]	[redacted]
Electricity, Landfill Gas, kWh	[redacted]	[redacted]	[redacted]
Landfill Gas, mmBTU	[redacted]	[redacted]	[redacted]
Dry+Wet Wood, mmBTU	[redacted]	[redacted]	[redacted]
Outputs			
Ethanol, gal	[redacted]	[redacted]	[redacted]
Dry distillers' grains, bone dry tons	[redacted]	[redacted]	[redacted]
Wet distillers' grains, bone dry tons	[redacted]	[redacted]	[redacted]
Total distillers' grains, bone dry tons	[redacted]	[redacted]	[redacted]
Fraction wet distillers grains	[redacted]	[redacted]	[redacted]
Syrup, bone dry tons	[redacted]	[redacted]	[redacted]
Corn oil, bone dry tons	[redacted]	[redacted]	[redacted]
Yields			
Ethanol yield, gal/bu	[redacted]	[redacted]	[redacted]
DG yield, lb/bu	[redacted]	[redacted]	[redacted]

DDGS, Wet Feed (WDG), syrup and oil bone dry tons were calculated using average moisture data collected daily. The following is a summary of the moisture content.

Table 3. Co-Product Moisture Content			
Parameter	2011	2012	Average
DDGS	[redacted]	[redacted]	[redacted]
Wet Cake – WDG	[redacted]	[redacted]	[redacted]
Syrup	[redacted]	[redacted]	[redacted]
Oil	[redacted]	[redacted]	[redacted]
*Average of plant empirical data	Monthly data are included in the INVOICES7 spreadsheet in the CO-PRODUCT MOISTURE Tab (Confidential business information)		

Natural gas and plant electricity is from the local grid. Natural gas is predominantly used for DDGS drying and emission thermal oxidation.

Table 4. Natural Gas Usage (Therms)			
Parameter	2011	2012	Average
Total Therms	[redacted]	[redacted]	[redacted]
Total mmBTU	[redacted]	[redacted]	[redacted]
* Based on 10 therms/mmBTU **From billing invoices ***All expressed as LHV	Monthly data are included in the INVOICES7 spreadsheet in the NATURAL GAS Tab (Confidential business information)		

Table 5: Electricity Usage (kWh)			
Parameter	2011	2012	Average
Total kWh	[redacted]	[redacted]	[redacted]
* From billing invoices	Monthly data are included in the INVOICES7 spreadsheet in the ELECTRICITY Tab (Confidential business information)		

The landfill gas is approximately 49% methane and 51% CO_2, and the heat content of the landfill gas is entirely due to methane. The methane content is measured online and reported on monthly billing statements. The landfill gas was converted to LHV.

Table 6. Landfill Gas Usage (mmBTU)			
Parameter	2011	2012	Average
Total mmBTU	[redacted]	[redacted]	[redacted]
*from billing invoices **All expressed as LHV	Monthly data are included in the INVOICES7 spreadsheet in the LANDFILL GAS DELIVERED Tab (Confidential business information)		

POET contracts for waste wood from various sources. Periodic analysis of the wood heat content is conducted; the heat content of the wood varies somewhat due to different types of wood being used. POET conservatively estimates the heat content of the wood as a percentage of the reported lower heating value (LHV). The wood energy content values are validated by comparing to the natural gas energy requirements.

Table 7. Wood Usage						
	2011		2012		Average	
Parameter	Wet	Dry	Wet	Dry	Wet	Dry
Total Tons	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total mmBTU	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
*from billing invoices and BTU content / pound estimate from testing, converted to LHV.			Monthly data are included in the INVOICES7 spreadsheet in the WOOD Tab (Confidential business information)			

All data collected for summary tables can be found more detailed in the INVOICES7 Excel spreadsheet (Confidential business information), each component (Corn, ethanol, landfill gas, etc) has its own tab.

GREET Modeling

AIR modified the California GREET model to estimate emissions by process, and to estimate emissions for the landfill gas and wood process fuel. We used the "Average" inputs from Table 8 for GREET modeling based on corn. For sorghum, we used the CARB default sorghum yield of 2.72 gal/bu to determine the amount of sorghum needed ([redacted] bu), and assumed the same process energy to produce ethanol from sorghum as from corn. [2]

Poet- Chancellor has no empirical data to validate the sorghum ethanol yield as sorghum is a future commodity feedstock. The small amount of sorghum the plant (co-mingled with corn) has processed is inadequate to legitimately estimate plant specific yield. POET Chancellor is using the default GREET sorghum yield of 2.72 gal/bu, this yield is further validated with (3) studies that display an ethanol yield of 2.80 gal/bu, 2.65 gal/bu and 2.72 gal/bu, the average being 2.72 gal/bu, we used 2.72 gal/bu in the GREET model. All studies are referenced below and included in the reference documentation:

POET (2012) Milo Trial Presentation part 2. *Internal research collect at POET in Laddonia, MO*, slide 7. (Confidential business information)

Wu, X et al. (2013) Evaluation of Nebraska Waxy Sorghum Hybrids for Ethanol Production. *Cereal Chemistry*, 90(3): 198-203. Yield listed on page 200, page 4 of pdf.

Yan, S. et al. (2011) Evaluation of Waxy Grain Sorghum for Ethanol Production. *Cereal Chemistry*, 88(6): 589-595. Yield listed on page 591.

We normalized to 100% dry distiller's grains (DDGS) using 2011/2012 empirical energy data.

Table 8 shows our estimate of plant energy to produce 100% dry DGs.

Table 8. 100% Dry DG Energy Analysis

Row	Parameter	Value	Note
1	NG per dry ton (BTU)	[redacted]	POET input from empirical data
2	Elec per dry ton (kWh)	[redacted]	POET input from empirical data

[2] CARB estimates the same total energy to process corn and sorghum; however, the yields (gal/bu) are also identical.

Row	Parameter	Natural Gas (mmBTU)	Electricity (kWh)	Note
A	2011/2012 Total Energy	[redacted]	[redacted]	Total energy needs 2011/2012 average
B	2011/2012 Energy for drying DDGS	[redacted]	[redacted]	DG tons*POET energy per ton
C	100% Dry Energy	[redacted]	[redacted]	Non DG energy, plus row above/(1-[redacted]) **2011/2012 was [redacted]% wet feed production

Row A shows the average 2011/2012 total energy used, this average represented producing [redacted]% Wet DG (WDG) and [redacted]% dry DG (DDGS). Row B shows the energy just for drying in 2011/2012. These numbers were calculated using the produced tons of DDGS and the NG/ton and kWh/ton factors provided by empirical data (row 1&2). This calculated energy for 2011/2012 average for drying was used to estimate the 100% dry energy requirements.

Rows C shows the estimated natural gas and electricity to produce 100% dry DGs, respectively.

The natural gas and electricity for 100% DDGS is obtained by increasing the energy for drying DDGS by dividing (row B) by [redacted] (1-0.[redacted]).

A detail analysis of this estimation is included in INVOICES7 Excel spreadsheet in the DG PRODUCED tab (Confidential business information).

As a reference, we have also provided data on inlet and outlet temperatures of the (4) natural gas fired ring dryers for the 2011/2012 time period. These numbers are located in INVOICE7 Excel spreadsheet in the DRYER TEMP DATA tab (Confidential Business Information).

The average, 100% dry energy values were input into the GREET model to estimate overall CIs by GREET.

The document Chancellor_CA_GREET_Modifications.docx explains all of the modifications to the GREET model. Instructions on how to run this modified model can be found in the document Chancellor_CA_GREET_Model_Operation.docx (Confidential business information).

Farming and Agriculture Chemical Emissions

These emissions were estimated with the default GREET model inputs, except that for corn we input the higher plant yield of 2.88 gal/bu. For sorghum, we used the default input of 2.72 gal/bu. Corn ethanol farming emissions are predicted by GREET at 5.36 gCO_2e/MJ, and agriculture chemical emissions (agriculture chemical plus agriculture chemical fugitive) are 28.58 gCO_2e/MJ. For sorghum, farming emissions are 10.78 gCO_2e/MJ, and agriculture chemical emissions are 27.85 gCO_2e/MJ.

Feedstock Transport

GREET default distances were used for corn transport. Sorghum for the plant can come from the region around the plant and/or areas including Kansas, Oklahoma, and/or Texas. These distances range from 15 to 1400 mi. While most sorghum would come from areas around the plant, for this analysis, we assumed sorghum was transported by rail an average distance of 500 mi, to account for some sorghum coming from other states. Distances assumed by transportation mode for sorghum are shown in Table 9.

Table 9. Sorghum Transport Distances Used in GREET	
MDT Transport Distance (mi)	10 (Default)
HDT Transport Distance (mi)	40 (Default)
Rail Transport Distance (mi)	500

Corn transport emissions are 2.08 gCO_2e/MJ and sorghum transport emissions are 4.44 gCO_2e/MJ.

Ethanol Production

Fuel production at POET uses four process fuels - landfill gas, natural gas, wood, and electricity from the grid. The remainder of this section discusses the emissions of each process fuel and feedstock.

Landfill Gas

The POET plant uses landfill gas from the Sioux Falls Regional Sanitary Landfill. The landfill is 11 miles from the plant. Landfill gas is collected at the landfill, processed, compressed, and piped to the POET plant. There is energy expended in collecting, processing, and transporting the gas to the plant.

The landfill has a well field that consists of gas extraction wells that are constructed both vertically and horizontally, a flare skid, a compressor system used to transmit the landfill gas to the POET ethanol plant, and monitoring equipment. The monitoring system includes flow meters, methane analysis equipment, and temperature data from the flare that shows methane destruction. The Sioux Falls landfill has a design capacity greater

than the 2.5 million Megagram (Mg) threshold that triggers federal regulations such as the New Source Performance Standards (NSPS), the Emission Guidelines (EG) and the National Emission Standard for Hazardous Air Pollutants (NESHAP), however, Tier II testing reported by a consultant in 2008 showed a NMOC emission rate of 21.1 Mg/year. The report further provides a maximum 5-year emission rate of 24.2 Mg/year. This emission rate is below the threshold of 50 Mg/year that requires gas collection and destruction by federal law. The gas collection system was installed in 2005-2006. It would not have been installed without the use of this gas by the POET plant. Further, there are no laws, regulations, or other requirements that require this facility to collect and destroy landfill gas. Consequently, the Chancellor plant should receive a credit for preventing the release of methane from the landfill.

In terms of the sustainability of gas production from the landfill, studies have been done of the projection of landfill gas from the site. These studies show steady-to-increasing gas supply through calendar year 2031. [3] [1]

Analysis of the LFG coming from the landfill indicates that it is about 51% methane and 49% CO_2, and that this varies somewhat. POET is invoiced for the LFG on the BTU content, and the BTU content of the LFG is entirely derived from methane. Thus, the quantity of methane delivered to Chancellor can be derived from the BTU content of the LFG delivered to Chancellor, with one adjustment. If the collection system were not in place, CARB estimates that 10% of the methane collected would form CO_2 in the soil cover. [2] Thus, the quantity of methane delivered to Chancellor should be reduced by 10% before estimating the methane-avoided credit. [4]

Total methane used at Chancellor was estimated two different ways: (1) by summing the monthly BTU values on the invoices from the landfill, and (2) by multiplying monthly LFG volume by methane fraction (also provided on invoices), and summing over all months. The two methods gave the identical result. These results are detailed in Attachment 1 and in the INVOICES7 Excel spreadsheet on the LANDFILL GAS DELIVERED tab (Confidential Business Information).

Further, the quantity of landfill gas was adjusted to the lower heating value (LHV) provided in the CA-GREET model.

There are three parts of the landfill analysis – estimating the methane-avoided credit, estimating the energy and emissions expended in processing and moving the gas to POET, and estimating the emissions of combustion of the methane. The GREET model was modified to estimate the emissions credit. These three parts are discussed below.

Methane-Avoided Credit

The methane-avoided credit is shown in Table 10 below, and is estimated per million BTU of landfill gas consumed, and then multiplied by total methane consumed (in

[3] See page 27 of the reference for projections to 2031

mmBTU). GREET was modified to estimate this credit using the following method. The methane is converted to KJ and then to moles burned using the enthalpy of the combustion reaction. The moles are then converted to grams of methane using the molecular weight, and then converted to CO_2e using the GREET methane multiplier of 25. This value is then discounted by 10% to account for methane that would have formed CO2 in the soil cover and by an additional 4%; 2% for processing leakage and an additional 2% for processing. The credit per mmBTU of landfill gas is 29,220 gCO_2e. When this is multiplied by the annual LFG use, and divided by the ethanol production (in mmBTU), we obtain a credit of ethanol of 27.70 gCO_2e/mmBTU of ethanol.

This calculation is detailed in a tab labeled CH4_Release_Avoidance in the GREET models (Confidential business information).

Table 10. Landfill Gas CH4 Release Avoidance Credit (corn, average 2011/2012)			
Parameter	Units	Value	Comments
LFG Use (CH_4)	mmBTU	1	LFG potentially burned but emitted instead
BTU to KJ Conversion Factor	KJ/BTU	1.055	GREET
Potential LFG Use (CH_4)	KJ	1.055E+06	Conversion to KJ from mmBTU
CH_4 Delta-H	KJ/mole	802.33	Enthalpy of $CH_4(g) + 2O_2(g) = CO_2(g) + 2H_2O(g)$ at 25C
Moles of CH4 emitted	Moles	1,315	Conversion to moles emitted instead of burned
CH_4 Molecular Weight	g/mole	16.043	GREET
CH_4 emitted	G	21,096	Conversion to grams emitted instead of burned
CH_4 to gCO_2e Conversion Factor	gCO_2e/gCH4	25	GREET
LFG CH_4 Emission Credit EF	gCO_2e/mmBTU	-[redacted]	LFG CH_4 credit EF when emitted instead of burned
10% Adjustment for soil cover	gCO_2e/mmBTU	-[redacted]	Credit multiplied by 90% for methane that would have converted to CO2 in the soil cover without the collection system
2% leakage adjustment	gCO_2e/mmBTU	-[redacted]	GREET2013
2% processing adjustment	gCO_2e/mmBTU	-[redacted]	GREET2013
LFG used at plant (either feedstock)	mmBTU/year	[redacted]	POET data
CO_2e emissions	gCO_2e/year	[redacted]	LFG CH_4 EF x LFG used
Ethanol production	mmBTU/year	[redacted]	[redacted] mgy, and GREET ethanol btu content of 76,330 BTU/gal
LFG CH_4 Emission Credit per mmBTU of ethanol produced	gCO_2e/mmBTU ethanol (g/MJ)	-29,220 (-27.70)	LFG credit per mmBTU of ethanol

Landfill Gas Processing and Transport to Chancellor

The landfill uses electricity to collect, process, compress, and transport LFG to Chancellor. The Landfill's electric utility bills were obtained for calendar years 2011 and 2012, which are shown in Table 11. [5] The two-year average is [redacted] kWh).

Table 11. Landfill Electricity Use (kWh)							
Date Due	Gas Compressor Bldg.-Pad Mount		Air-Compressor Bldg.		Total		
	2011	2012	2011	2012	2011	2012	Average
12-Feb	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Mar	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Apr	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-May	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Jun	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Jul	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Aug	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Sep	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Oct	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Nov	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Dec	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
12-Jan	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Total	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	Monthly data are included in the INVOICES7 spreadsheet in the LAND FILL GAS ELECTRICITY tab (Confidential business information).						

GREET was modified to input this value, and allow the GREET model to estimate the upstream emissions from this electric use assuming "Midwest" electricity. This value is estimated at 0.46 gCO2e/MJ for both corn and sorghum based on the annual LFG use.

LFG Combustion at Chancellor

Emissions for LFG combustion were estimated using GREET assuming the same emissions as natural gas combustion.

[5] No natural gas or LFG is used in processing landfill gas at the landfill.

Total Emissions from LFG
Total emissions from LFG are summarized in Table 12.

Table 12. Summary of LFG Emissions (g CO2e/MJ)	
Source	LFG Emissions Corn and Sorghum
LFG Combustion (with CO_2)	3.62
LFG Collection, Processing and Transport Electricity	0.46
CH_4 Avoidance Credit	-27.70
Total	-23.62

Natural Gas and Grid Electricity Use at Plant

Natural gas and grid electricity are both used as process fuels at the plant. GREET estimated the upstream emissions associated with these fuels. Midwest electricity was assumed. Natural gas and electricity emissions are also a function of the percent of dry DGs. Table 13 summarizes the natural gas and electricity emissions for corn and sorghum, at 100% dry DGs.

Table 13. Natural Gas and Electricity Emissions (gCO_2e/MJ)				
Feedstock	100% Dry			
	Nat Gas	Elec		
Corn and Sorghum	13.77	11.98		

Wood Transport and Combustion

The wood used in combustion for Chancellor is all waste wood that comes from downed trees, broken wood pallets, and other waste wood products. POET intends that no purpose-grown fuel wood be used as process fuel. The wood is collected by different vendors, and is shredded or chipped before being shipped to Chancellor. POET uses [redacted] BTU/lb for dry wood, and [redacted] BTU/lb for wet wood. These values were developed by testing the heat content of the wood, and discounting for known inefficiencies. They are also periodically checked against the natural gas energy usage.

The wood vendor estimates that the fuel expended to process or chip the wood is 2.10 gallons of diesel fuel per ton of wood.[6] We are assuming the use of a diesel reciprocating engine in GREET to perform this function. The average distance from the wood collection sites to Chancellor is estimated at 27.5 mi. AIR has modified GREET to estimate the wood processing as well as the wood transport to Chancellor.

Burning wood for fuel produces ash. The ash is transported to a landfill offsite for use as landfill cover. The landfill is a 107 mile one-way-trip from Chancellor. 15% of the wood mass is ash, and it is transported in 20-ton loads. GREET was modified to estimate ash

[6] Email from Mr. Chad Fodness of Mueller Pallets, LLC to Rachel Kloos, July 30, 2013. (Mueller Pallets, 27059 Mueller Place, Sioux Falls, SD, 57108. Phone: 605-368-2440. www.mpallets.com.

emissions, utilizing the same method as transporting feedstock to the plant. The estimate ash transport emissions are 0.03 g CO2e/MJ.

Wood emissions are summarized in Table 14. Total wood emissions are 0.56 gCO_2e/MJ.

Table 14. Summary of Wood Emissions (gCO2e/MJ)	
Parameter	Emissions, Corn and Sorghum
Wood Burning (with CO_2)	6.32
Wood CO_2 credit	-6.16
Processing	0.13
Transport to Chancellor	0.26
Ash Transport to Landfill	0.03
Total	0.58

Summary of Plant Emissions

A summary of the plant emissions is shown in Table 15. CARB also indicates that VOC bulk terminal emissions should be a part of ethanol production. These are 0.09 gCO2e/MJ.

Table 15. Ethanol Production Emissions (gCO_2e/MJ)		
Source	Corn and Sorghum	
	100% Dry	
LFG Credit	-23.62	
Wood	0.58	
Natural Gas	13.77	
Electricity	11.98	
Subtotal	2.71	
VOC Bulk Terminal	0.09	
Total	2.80	

Ethanol Transport and Distribution

Ethanol transport and distribution was estimated with California GREET. The transport distance from Chancellor to California (Los Angeles) was estimated at 2210 miles. The rail map from Chancellor to LA is illustrated in Attachment 1. Ethanol transport emissions are therefore estimated at 3.85 gCO_2e/MJ (both corn and sorghum).

Co-Products Credit

The co-product credit was estimated separately for corn and sorghum using the GREET model. The corn co-product credit is -9.59 gCO_2e/MJ and for sorghum is -13.02 gCO2e/MJ.

Land Use

The CARB corn ethanol land use value is 30 gCO_2e/MJ. Since CARB is continuing to evaluate the land use value of sorghum, the results are not yet available, and CARB requires the use of the corn value of 30 gCO_2e/MJ.

Summary of Total Emissions

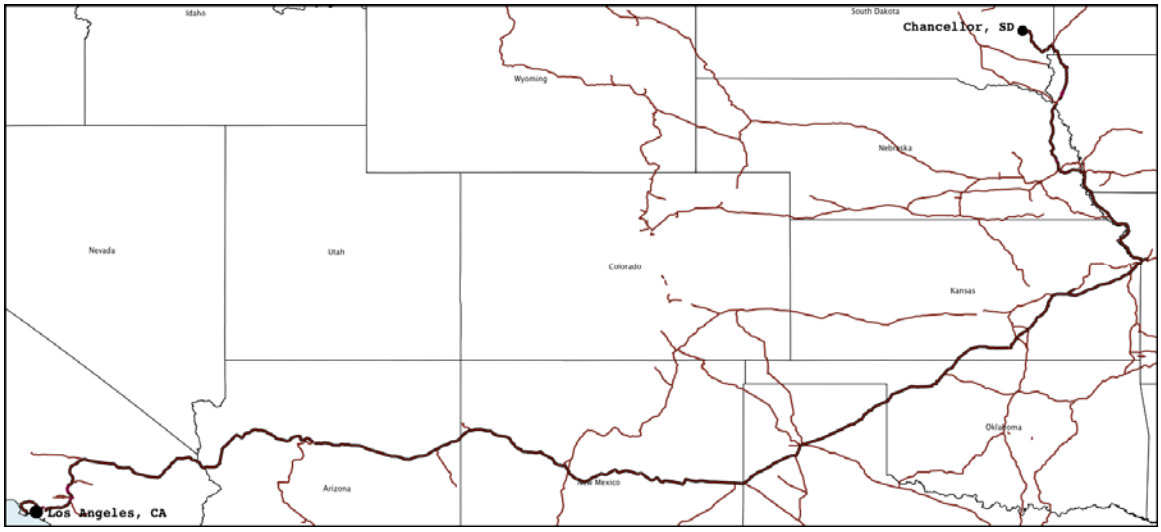
Total emissions of corn and sorghum for the Chancellor plant are shown in Table 16.

Table 16. Emissions Summary for Chancellor (gCO_2e/MJ)

Parameter	Corn		Sorghum	
	100% Dry DDGS		100% Dry DDGS	
Farming	5.36		10.78	
Ag Chemicals Production	28.58		27.85	
Feedstock Transportation	2.08		4.44	
Ethanol Production (with Bulk Term Losses)	2.80		2.80	
Ethanol T&D	3.85		3.85	
Co-Products Credit	-9.59		-13.02	
Denaturant	0.80		0.80	
Land Use	30.0		30.0	
Total Emissions	**63.88**		**67.50**	

References

1. Powerpoint presentation "Sustainable Waste Management", City of Sioux Falls, SD, July 12, 2013 (Confidential business information).
2. Proposed Low Carbon Fuel Standard (LCFS) Pathway for the Production of Biomethane from High Solids Anaerobic Digestion (HSAD) of Organic (Food and Green) Wastes, ARB, June 28, 2012.

Attachment 1

Rail Map Showing Ethanol Transport from Chancellor to California