Detailed Trestle-Modified CA-GREET Pathway for CERC 2.70

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"**XXX**" indicates where confidential business information has been redacted.

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SUMMARY

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Trestle-Modified California-GREET Model Pathway for CERC 2.70

This report describes Trestle's lifecycle analysis of its proposed fuel pathway, CERC 2.70 **XXX** . A Well-to-Tank (WTT) Life Cycle Analysis of a fuel (or blending component of fuel) pathway includes all steps from feedstock production to final finished product. Tank-to-Wheel (TTW) analysis includes actual combustion of fuel in a motor vehicle for motive power, which is not described in this document. Together WTT and TTW analysis are combined to provide a total Well-To-Wheel (WTW) analysis.

A Life Cycle Analysis Model called the Greenhouse gases, Regulated Emissions, and Energy use in Transportation (GREET) was developed by Argonne National Laboratory to calculate the energy use and Greenhouse gas (GHG) emissions associated with ethanol production from corn production through final consumption within a blended transportation fuel. With assistance from Life Cycle Associates, California Air Resources (CARB) staff modified the original GREET model to create a California specific model termed the CA-GREET model to evaluate energy and emissions from corn ethanol production for use in the California fuel market. Trestle Energy LLC further modified CA-GREET model to evaluate the energy and emissions impacts of its proprietary CERC fuel pathway, which **XXX** directly reduce field emissions in feedstock production **XXX**. This Trestle-Modified CA-GREET model, which accompanies this document, forms the basis of this LCA report. It calculates the energy use and greenhouse gas (GHG) emissions associated with a WTW analysis for the CERC pathway.

This document provides detailed calculations, assumptions, and other necessary information to calculate the energy requirements and GHG emissions for proprietary aspects of the CERC pathway based on the report of 'Detailed California-Modified GREET Pathway for Corn Ethanol', which provides details of energy and inputs required to produce dry and wet mill corn ethanol from corn grown in Mid-Western United States and transported to California blending terminals.

Upon discussion with California Air Resources Board ("CARB") staff, it was deemed advisable to organize this lifecycle analysis according to the industry sector in which lifecycle impacts occur. As such impacts herein are organized into those that occur strictly within agricultural systems supplying biofuel feedstock and those that occur outside the agricultural sector.

The CERC pathway prevents field carbon emissions equivalent to avoiding the decomposition of 2.70 kilograms of biomass per bushel of corn grain feedstock for ethanol production **XXX** . As a result, field emissions to the atmosphere **XXX** are permanently and irreversibly prevented in fields producing biofuel feedstock. **XXX**

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XXX

This lifecycle analysis report quantifies lifecycle carbon intensity impacts associated with avoided field emissions equivalent to preventing the decomposition of 2.70 kilograms biomass per bushel of corn grain (kg/bu). **XXX** . The accompanying Trestle-Modified CA-GREET model computes energy and emissions impacts for reduced field emissions **XXX** . Actual field emissions avoidance **XXX** will vary across feedstock-producing fields, depending on economic and environmental (e.g., sustainability) considerations; however, integrating varying field-specific rates across multiple fields (e.g., using mass balance accounting) enables a pre-specified rate (e.g., equivalent to 2.70 kg/bu) to be consistently achieved on an average basis.

Reducing field emissions according to the CERC pathway requires changes to agricultural management practices used for biofuel feedstock production. Relative to conventional corn farming, as characterized in the Corn Ethanol Pathway analyzed by ARB, these changes entail additional use of farm equipment **XXX** , additional chemical inputs **XXX** . Accounting for both decreased field emissions and increases in energy use and emissions associated with increased inputs to production is provided in Section 3 of Appendix A.

Other changes embodied in the CERC pathway, relative to established corn ethanol fuel pathways, may be viewed as resulting from activities that occur outside the agricultural sector. **XXX** Accounting for energy and emissions impacts of the CERC pathway that may be viewed as resulting from activities outside the agricultural sector is provided in Section 4 of Appendix A.

XXX

Energy and emissions impacts from these activities, which arguably occur outside the agricultural sector, are assigned to associated ethanol products via system expansion. Lifecycle accounting for these impacts is provided in Section 4 of Appendix A.

Net energy and GHG emission impacts from implementing the CERC pathway at both wet mill and dry mill ethanol facilities are summarized in Section 5 of Appendix A.

All other aspects of the ethanol production process are assumed to be consistent with those characterized in CARB's existing corn ethanol fuel pathway analyses (e.g., CARB 2009). LCA computations associated with these processes are not reproduced in this LCA. These include crop cultivation, production of agricultural chemicals, corn transport, ethanol production, and ethanol transportation and distribution (T&D). **XXX** Figure 1 outlines the LCA components (both novel and non-novel) that comprise the CERC pathway.

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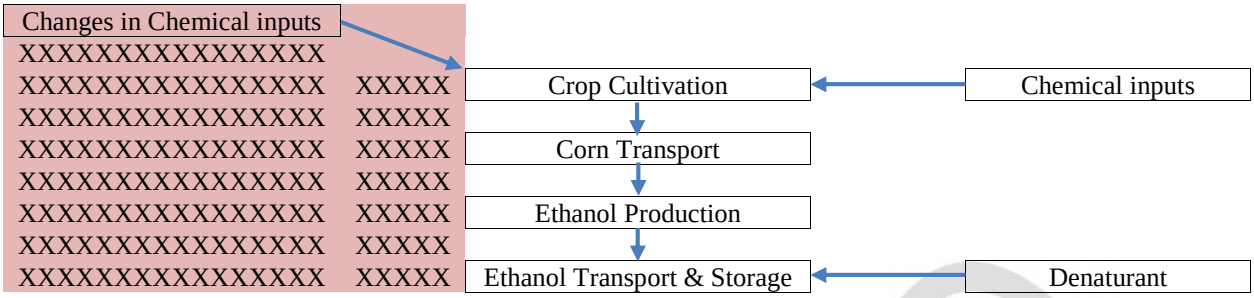

Figure 1. WTT Components for the CERC pathway. LCA components documented in this report are highlighted in red.

Several general descriptions and clarification of terminology used throughout this document are:

- Btu/mmBtu is the energy input necessary, measured in British Thermal Units (Btu) to produce one million Btu of a finished (or intermediate) product. This description is used consistently in CA-GREET for all energy calculations.

- gCO2e/MJ provides the total greenhouse gas emissions on a CO2 equivalent basis per unit of energy (MJ) for a given fuel. Methane (CH4) and nitrous oxide (N2O) are converted to a CO2 equivalent basis using IPCC global warming potential values of 25 and 298 g/gCO2e, respectively (see Table 3.02), and are included in the total CO2e emissions values.

- CA-GREET assumes that VOC and CO are converted to CO2 in the atmosphere and includes these pollutants in the total CO2 value using carbon mass ratios of 3.12 and 1.58, respectively (see Table 3.03).

- Note that rounding of values to appropriate significant digits has not been performed in all tables provided in this document. Instead the number of digits displayed reflects the number of digits in analogous tables within the corn ethanol pathway report (CARB 2009).

Table A below summarizes the fuel cycle energy inputs by LCA component (Btu/mmBtu) in Midwest ethanol plants. Table B summarizes the associated GHG emissions and emissions intensities (gCO2e/MJ) in Midwest ethanol plants. The Tables present energy and emission results relative to the energy content (LHV) of anhydrous ethanol. The results are provided for both dry mill and wet mill plants. Complete details of all energy consumption and GHG emissions computations are provided in Appendix A.

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Table A. Dry and Wet Mill Energy Use by Stage in Midwest

Corn Ethanol WTW Components	Dry Mill	
	Energy (Btu/mmBtu)	%Energy contribution
Well-to-Tank		
Corn Farming	75,436	
Energy Inputs for Ag Chemicals	165,703	
Corn Transportation	28,814	
Ethanol production	1,434,648	
Ethanol T & D	34,667	
Co-products (DGS)	-81,617	
XXX	**XXX**	
Change in Ag chemicals	**XXX**	
Avoided field emission	**XXX**	
Impacts outside Ag Sector	**XXX**	
Total well-to-tank	**XXX**	**XXX**
Tank-to-wheel		
Anhydrous Ethanol	1,000,000	
Total tank-to-wheel	1,000,000	**XXX**
Total well-to-tank	**XXX**	

Note: Original LCA appears to have an error in the value indicated for total well-to-tank energy use. The published value is 1,672,994, while the values given in the original Table A sum to 1,700,456.

Table B. GHG Emissions Summary for Dry and Wet Mill Corn Ethanol in Midwest

Corn ethanol fuel cycle components	Dry Mill	
	GHG (gCO2e/MJ)	% GHG contribution
Well-to-Tank		
Corn Farming	5.65	
GHG emissions from Ag Chemicals	30.20	
Corn Transportation	2.22	
Ethanol production	38.30	
Ethanol T & D	2.70	
Co-products (DGS)	-11.51	
XXX	0.37	
Change in Ag chemicals	0.36	
Avoided field emission	-20.08	
Impacts outside Ag Sector	1.34	
Total well-to-tank	**49.55**	**100%**
Total tank-to-wheel	**0.00**	
Total well-to-wheel	**49.55**	**100%**
Net well-to-wheel CI impact	**-18.01**	

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Table C provides WTW GHG emissions for U.S. average dry mill and wet mill ethanol produced in Midwest ethanol plants based on the calculations detailed in Table B above and on results presented in the original fuel pathway report (CARB 2009). The original pathway report (CARB 2009) defines five sub-pathways for corn ethanol produced in the Midwest. Results for the Midwest sub-pathways are reported in Table C for illustration purposes, but complete details of the associated calculations are not described in this document.

Four carbon intensity values are provided for each sub-pathway. The first represents conventional anhydrous ethanol, as defined in the original fuel pathway report (CARB 2009). The second represents anhydrous ethanol produced according to the CERC pathway, which reflects the net impacts computed in Table B. The third includes accounting for denaturant added to the ethanol, as specified in the original fuel pathway report (CARB 2009). The fourth includes an emissions factor of **30 g/MJ** for indirect land use change emissions, as determined by CARB. Details of these calculations are available in Chapter 4 and Appendix C of the original fuel pathway report (CARB 2009).

Table C. GHG Emissions Summary for Various Midwest Corn Ethanol Sub-pathways

Scenario	**Technology**	**Ethanol Prod**	**Original Anhydrous**	**New Anhydrous**	**New Denatured**	**New CI with 30 g/MJ ILUC**
Ave Mid-West Dry Mill, Dry DGS	80% dry & 20% wet mill	Av. Mid Western	67.60	49.45	50.25	80.25
Ave Mid-West Wet Mill	60% NG & 40% coal	Av. Mid Western	74.30	55.60	56.40	86.40
Ave Mid-West Dry Mill, Wet DGS	NG	Av. Mid Western	59.30	41.29	42.09	72.09
Mid-West Dry Mill, Dry DGS	80% NG, 20% biomass	Av. Mid Western	62.80	44.79	45.59	75.59
Mid-West Dry Mill, Wet DGS	80% NG, 20% biomass	Av. Mid Western	56.00	37.99	38.79	68.79
Mid-West Average	Mix (80%dry mill & 20% wet mill)	N/A	68.60	50.45	51.25	81.25

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APPENDIX A

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SECTION 1. USER-DEFINED INPUTS

The Trestle-Modified CA-GREET model incorporates several user-defined parameters. **XXX** The quantity of field emission avoided is defined as a function **XXX**. This can be specified within a range **XXX** equivalent to 2.15 to 15.05 kg biomass per bushel of kernels ("kg/bu") **XXX**. In this document, we present model results for 2.70 kg/bu, **XXX** .

Table 1.01 User-defined inputs

	XXX	**XXX**
A	**XXX**	**XXX**
B	**XXX**	**XXX**
C	**XXX**	**XXX**
D	**XXX**	**XXX**
E	**XXX**	**XXX**

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SECTION 2. PARAMETERS NOT FOUND IN CA-GREET MODEL

This section presents the parameters that are needed in the calculation of CERC pathway but not available in the currently published version of the CA-GREET model.

Table 2.01 Pathway-specific model parameters

Parameter		Value	Reference
	XXX	**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**
	XXX	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**
G	**XXX**	**XXX**	**XXX**
H	**XXX**	**XXX**	**XXX**
I	**XXX**	**XXX**	**XXX**
J	**XXX**	**XXX**	**XXX**
K	**XXX**	**XXX**	**XXX**
L	**XXX**	**XXX**	**XXX**
M	**XXX**	**XXX**	**XXX**
N	**XXX**	**XXX**	**XXX**
O	**XXX**	**XXX**	**XXX**
P	**XXX**	**XXX**	**XXX**
	Factors for converting to CO2e		
Q	CO2 (gCO2 e/g)	1	
R	VOC (gCO2 e/g)	3.117	
S	CO (gCO2 e/g)	1.577	
T	CH4 (gCO2 e/g)	25	
U	N2O (gCO2 e/g)	298	
V	C (gCO2e/g)	3.667	

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SECTION 3. CHANGES IN AGRICULTURAL SYSTEMS FOR BIOFUEL FEEDSTOCK PRODUCTION

3.1 Energy Use for Changes in Agricultural Management

This section presents the additional energy consumption from farming inputs **XXX** to avoid field emissions **XXX**. Consistent with CARB (2009), corn is considered for the purposes of this document to be average Midwestern U.S. crop. The CA-GREET model calculates energy inputs **XXX** based on the quantity of diesel fuel required. The quantity of diesel fuel used **XXX** is defined **XXX** in CA-GREET model 1.8b. The total energy input (Table 3.01) associated with this diesel fuel use is defined according to the assumptions in CARB 2009. **XXX**

*Table 3.01 Total energy input **XXX***

	Source	Basis / formula	Energy (Btu XXX)
A	Direct diesel use	**XXX**	**XXX**
B	Total energy for diesel use	**XXX**	**XXX**

3.2 GHG Emissions from Changes in Agricultural Management

As noted in CARB 2009, CA-GREET 1.8b calculates carbon dioxide (CO2), methane (CH4) and nitrous oxide (N2O) emissions for each component of the pathway and uses IPCC Global Warming Potentials (GWPs) to calculate CO2 equivalent values (CO2e) for methane and nitrous oxide (see Table 3.02). Volatile organic compounds (VOCs) and carbon monoxide are converted to CO2 equivalent values based on their carbon mass ratio and the carbon mass ratio of CO2 (see Table 3.03), reflecting oxidation of these compounds to CO2 in the atmosphere. These values are listed in Section 2 and used to calculate the total GHG emissions in Sections 3 and 4. **XXX** The values in Table 3.02 and Table 3.03 are used in Table 3.04.

Table 3.02. GWPs for greenhouse gases

Factor	GHG Species	GWP (relative to CO2)
A	CO2	1
B	CH4	25
C	N2O	298

Table 3.03. Carbon ratios and CO2 equivalents for CO and VOCs

Factor	Species	Carbon ratio	CO2e
D	VOC	0.85	3.12
E	CO	0.43	1.58

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F	CO2	0.27	1.00

*Table 3.04. GHG emissions **XXX***

Factor	Emissions	Basis / formula	gCO2e XXX
G	Diesel tractor VOC	**XXX**	**XXX**
H	Diesel tractor CO	**XXX**	**XXX**
I	Diesel tractor CH4	**XXX**	**XXX**
J	Diesel tractor N2O	**XXX**	**XXX**
K	Diesel tractor CO2	**XXX**	**XXX**
L	**Total CO2e emissions**	A*K+B*I+C*J+D*G+E*H	**24,555**

3.3 Energy Use from Changes in Chemical Inputs for Agricultural Chemicals

This section presents computations of the additional energy required by changes in the chemical inputs to agricultural production required to accommodate changes in agricultural management **XXX** to avoid field emissions. Computations are consistent with those **XXX** in CA-GREET 1.8b, **XXX**. It is assumed that no additional pesticides are required **XXX**. Computation of WTT energy requirements based on the assumptions in CA-GREET 1.8b are provided in Table 3.05. **XXX**.

*Table 3.05. Energy use from changes in agricultural chemicals [btu **XXX**]*

	Chemical Type	Basis / formula	Energy use
A	Nitrogen Fertilizer	**XXX**	**XXX**
B	Phosphate Fertilizer	**XXX**	**XXX**
C	Potash	**XXX**	**XXX**
D	**Total energy use from additional chemicals**		**XXX**

3.4 GHG Emissions from Changes in Chemical Inputs for Agricultural Chemicals

This section presents computations of additional GHG emissions effects **XXX**. The computations are consistent with those provided in CA-GREET 1.8b **XXX .**

*Table 3.06 GHG emissions from changes in agricultural chemicals [grams / **XXX**].*

	GHG type	Nitrogen fertilizer		Phosphate fertilizer		Potash	
		Value	Source	Value	Source	Value	Source
A	VOC	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
B	CO	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
C	CH4	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
D	N2O	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**
E	Field N2O	**XXX**	**XXX**				
F	CO2	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**	**XXX**

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G	**Total**	**XXX**	**XXX**	**XXX**
H	**Total (CO2e)**	**29,447**		

3.5 Energy Use and GHG Emissions from Avoided Field Emissions

This section presents computations of energy and GHG emission implications of avoiding field emissions **XXX** at fields producing biofuel feedstock. Avoiding field emissions is assumed to have no impacts on energy requirements, beyond those characterized above. **XXX**

Table 3.07 GHG emissions from avoided biogenic emission.

		Formula/basis	Value
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**Total GHG (gCO2e XXX)**	**XXX**	**XXX**

XXX

*Table 3.08 Energy input and GHG emissions **XXX***

		Formula/basis	Value
XXX	**XXX**	**XXX**	**XXX**
XXX	**XXX**	**XXX**	**XXX**
XXX	**XXX**	**XXX**	**XXX**
XXX	**XXX**	**XXX**	**XXX**
XXX	**XXX**	**XXX**	**XXX**
XXX	**XXX**	**XXX**	**XXX**
R	**Total GHG (gCO2e XXX)**	**XXX**	**XXX**

3.7 Net Agricultural Sector Energy Use and GHG Emissions Impacts

This section presents computations of the net energy use for changes in agricultural systems to implement CERC in biofuel feedstock production. This represents the total energy use within the agricultural sector component of the biofuel lifecycle. Lifecycle energy use **XXX** is

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computed in Tables 3.01, 3.05, and 3.08. Lifecycle energy use per million Btu of ethanol is computed in Table 3.09 **XXX** .

Table 3.09 Total agricultural sector energy use to avoid field emissions.

Parameter		Formula / Basis	Value
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**
G	**XXX**	**XXX**	**XXX**
H	Ethanol yield-dry mill	Cell C43, EtOH sheet, CA-GREET1.b	2.72
I			
J	Ethanol LHV (MJ/gal)	Cell N21, Fuel_Specs sheet, CA-GREET1.b	76,330
K	Conversion factor	MJ per mmBtu	1055
M	Energy for **XXX** Dry Mill (Btu/mmBtu ethanol)	(A+C) * D * E / F * G / H / J * K	4,765
N	Energy for changes in Ag Chemicals-Dry Mill (Btu/mmBtu ethanol)	B * D * E / F * G / H / J * K	4,385
O			
P			

Lifecycle GHG emissions **XXX** is computed for **XXX**, changes in agricultural chemicals, avoided field emissions, and **XXX** in Tables 3.04, 3.06, 3.07, and 3.08, respectively. Lifecycle GHG emissions per MJ of ethanol are computed in Table 3.10 **XXX .**

Table 3.10 Ag sector GHG emissions from avoiding field emissions.

Parameter		Formula / Basis	Value
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**
G	**XXX**	**XXX**	**XXX**
H	**XXX**	**XXX**	**XXX**

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I	Ethanol yield-dry mill	Cell C43, EtOH sheet, CA-GREET1.b	2.72
J			
K	Ethanol LHV (MJ/gal)	Cell N21, Fuel_Specs sheet, CA-GREET1.b	76,330
L	GHGs for **XXX** -Dry Mill (gCO2e/mmBtu ethanol)	(A+C) * E * F / G * H / I / K	0.37
M	GHGs for changes in Ag chemicals-Dry Mill (gCO2e/mmBtu ethanol)	B * E * F / G * H / I / K	0.36
N	Avoided field GHG emissions – Dry Mill (gCO2e/mmBtu ethanol)	D * E * F / G * H / I / K	-20.08
O	GHGs for **XXX** -Wet Mill (gCO2e/mmBtu ethanol)	(A+C) * E * F / G * H / J / K	0.38
P			
Q			

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SECTION 4. NET ENERGY USE AND GHG EMISSIONS OUTSIDE THE AGRICULTURAL SECTOR FROM CERC

XXX

Table 4.01 ***XXX***

	XXX	**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**
G	**XXX**	**XXX**	**XXX**

Table 4.02 ***XXX***

	XXX	**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**
G	**XXX**	**XXX**	**XXX**
H	**XXX**	**XXX**	**XXX**
I	**XXX**	**XXX**	**XXX**
J	**XXX**	**XXX**	**XXX**
K	**XXX**	**XXX**	**XXX**
L	**XXX**	**XXX**	**XXX**
M	**XXX**	**XXX**	**XXX**
N	**XXX**	**XXX**	**XXX**
O	**XXX**	**XXX**	**XXX**
P	**XXX**	**XXX**	**XXX**
Q	**XXX**	**XXX**	**XXX**
R	**XXX**	**XXX**	**XXX**
S	**XXX**	**XXX**	**XXX**
T	**XXX**	**XXX**	**XXX**
U	**XXX**	**XXX**	**XXX**
V	**XXX**	**XXX**	**XXX**
W	**XXX**	**XXX**	**XXX**
X	**XXX**	**XXX**	**XXX**

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Y	**XXX**	**XXX**	**XXX**
Z	**XXX**	**XXX**	**XXX**
AA	**XXX**	**XXX**	**XXX**
BB	**XXX**	**XXX**	**XXX**
CC	**XXX**	**XXX**	**XXX**

XXX

Table 4.03 ***XXX***

XXX		**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**

Table 4.04 ***XXX***

	XXX	**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**
G	**XXX**	**XXX**	**XXX**
H	**XXX**	**XXX**	**XXX**
I	**XXX**	**XXX**	**XXX**
J	**XXX**	**XXX**	**XXX**
K	**XXX**	**XXX**	**XXX**
L	**XXX**	**XXX**	**XXX**
M	**XXX**	**XXX**	**XXX**
N	**XXX**	**XXX**	**XXX**
O	**XXX**	**XXX**	**XXX**
P	**XXX**	**XXX**	**XXX**
Q	**XXX**	**XXX**	**XXX**
R	**XXX**	**XXX**	**XXX**
S	**XXX**	**XXX**	**XXX**
T	**XXX**	**XXX**	**XXX**
U	**XXX**	**XXX**	**XXX**
V	**XXX**	**XXX**	**XXX**

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W	**XXX**	**XXX**	**XXX**
X	**XXX**	**XXX**	**XXX**
Y	**XXX**	**XXX**	**XXX**

XXX

Table 4.05 XXX

XXX		**XXX**	**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**	**XXX**
B	**XXX**		**XXX**	**XXX**
C	**XXX**		**XXX**	**XXX**
D	**XXX**		**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**	**XXX**
G	**XXX**	**XXX**	**XXX**	**XXX**

XXX

Table 4.06 ***XXX****.*

	XXX	**XXX**		**XXX**
		XXX	**XXX**	
A	**XXX**	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**	
G	**XXX**	**XXX**	**XXX**	
H	**XXX**	**XXX**	**XXX**	
I	**XXX**	**XXX**	**XXX**	
J	**Total GHG emissions**	**XXX**		**XXX**

XXX

Table 4.07 ***XXX***

XXX	**XXX**	**XXX**	**XXX**	**XXX**
R	**XXX**	**XXX**	**XXX**	**XXX**

REDACTED

S	XXX	XXX	XXX	XXX
T	XXX	XXX	XXX	XXX
U	XXX	XXX	XXX	XXX
V	XXX	XXX	XXX	XXX
W	XXX	XXX	XXX	XXX

XXX

Table 4.08. ***XXX***

XXX		**XXX**	**XXX**
AA	XXX	XXX	XXX
BB	XXX	XXX	XXX
CC	XXX	XXX	XXX
DD	XXX	XXX	XXX
EE	XXX	XXX	XXX
FF	XXX	XXX	XXX

Table 4.09. XXX

Factor	Description	Source	Value	Units
A	XXX	XXX	XXX	XXX
B	XXX	XXX	XXX	XXX
C	XXX	XXX	XXX	XXX
D	XXX	XXX	XXX	XXX
E	XXX	XXX	XXX	XXX
F	XXX	XXX	XXX	XXX
G	XXX	XXX	XXX	XXX
H	XXX	XXX	XXX	XXX
I	XXX	XXX	XXX	XXX
J	XXX	XXX	XXX	XXX
K	XXX	XXX	XXX	XXX
L	XXX	XXX	XXX	XXX
M	XXX	XXX	XXX	XXX
N	XXX	XXX	XXX	XXX
O	XXX	XXX	XXX	XXX
P	XXX	XXX	XXX	XXX

REDACTED

Q	**XXX**	**XXX**	**XXX**	**XXX**

XXX

Table 4.10. ***XXX***

XXX		**XXX**	**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**	**XXX**

XXX

XXX

Table 4.11. ***XXX***

XXX		**XXX**	**XXX**	**XXX**
A	**XXX**	**XXX**	**XXX**	**XXX**
B	**XXX**	**XXX**	**XXX**	**XXX**
C	**XXX**	**XXX**	**XXX**	**XXX**
D	**XXX**	**XXX**	**XXX**	**XXX**
E	**XXX**	**XXX**	**XXX**	**XXX**
F	**XXX**	**XXX**	**XXX**	**XXX**

XXX

REDACTED

SECTION 5. RESULTS

5.1 Net Energy use for Ethanol with CERC 2.70

This section presents the net energy use for ethanol produced with CERC at a rate equivalent to 2.70 kg per bushel of biofuel feedstock. Results presented in this section integrate values computed in Sections 3 and 4 of this report with values presented in the lifecycle assessment of corn ethanol pathways published by CARB in 2009.

Results are presented separately for wet and dry mill ethanol plants because the energy profile of ethanol production varies by plant type and because the net impacts of CERC implementation depend on ethanol plant yield (gal/bushel of kernels), which varies by plant type. Table 5.01 presents the calculation of energy use for ethanol production by lifecycle stage assuming CERC implementation at a rate equivalent to avoiding biogenic emissions from 2.70 kg of biomass per bushel of corn grain feedstock for ethanol production **XXX** . Impacts of other rates of implementation can be evaluated with the Trestle-Modified CA-GREET model.

Table 5.01 Net energy use for CERC at Midwest dry mill and wet mill ethanol plants (Btu/mmBtu)

Corn Ethanol WTW Components	Source	Dry Mill
Well-to-Tank		
Corn Farming	CARB 2009, Table A	75,436
Ag Chemicals	CARB 2009, Table A	165,703
Corn Transportation	CARB 2009, Table A	28,814
Ethanol production	CARB 2009, Table A	1,434,648
Ethanol T & D	CARB 2009, Table A	34,667
Co-products (DGS)	CARB 2009, Table A	-81,617
XXX	**XXX**	**XXX**
Change in agricultural chemicals	**XXX**	**XXX**
Reduced field emission	**XXX**	**XXX**
Impacts outside Ag Sector	**XXX**	**XXX**
Total well-to-tank	**XXX**	**XXX**
Tank-to-wheel		
Anhydrous Ethanol	CARB 2009, Table A	1,000,000
Total tank-to-wheel	**CARB 2009, Table A**	**1,000,000**
Total well-to-wheel	**XXX**	**XXX**

REDACTED

5.2 Net GHG Emissions for Ethanol with CERC 2.70

This section presents the net GHG emissions for ethanol produced with CERC at a rate equivalent to 2.70 kg per bushel of biofuel feedstock. Results presented in this section integrate values computed in Sections 3 and 4 of this report with values presented in the lifecycle assessment of corn ethanol pathways published by CARB in 2009.

Results are presented separately for wet and dry mill ethanol plants because the GHG emissions profile of ethanol production varies by plant type and because the net impacts of CERC implementation depend on ethanol plant yield (gal/bushel of kernels), which varies by plant type. Table 5.02 presents the calculation of GHG emissions for ethanol production by lifecycle stage assuming CERC implementation at a rate equivalent to avoiding biogenic emissions of 2.70 kg of biomass per bushel of corn grain feedstock for ethanol production **XXX**. Impacts of other rates of implementation can be evaluated with the Trestle-Modified CA-GREET model.

Table. 5.02 Net GHG emissions for CERC at Midwest dry mill and wet mill ethanol plants (gCO2e/MJ)

Corn ethanol fuel cycle components	**Source**	**Dry Mill**
Well-to-Tank		
Corn Farming	CARB 2009, Table B	5.65
Ag Chemicals	CARB 2009, Table B	30.20
Corn Transportation	CARB 2009, Table B	2.22
Ethanol production	CARB 2009, Table B	38.30
Ethanol T & D	CARB 2009, Table B	2.70
Co-products (DGS)	CARB 2009, Table B	-11.51
XXX	“L” & “O”, Table 3.10	0.37
Change in agricultural chemicals	“M” & “P”, Table 3.10	0.36
Avoided field emission	“N” & “Q”, Table 3.10	-20.08
Impacts outside Ag Sector	“E” & “F”, Table 4.11	1.34
Total well-to-tank	**Sum of above**	**49.55**
Total tank-to-wheel	**CARB 2009, Table B**	**0.00**
Total well-to-wheel	**Well-to-Tank + Well-to-Wheel**	**49.55**
Net well-to-wheel CI impact	**Sum of novel lifecycle components**	**-18.01**

5.3. XXX

XXX

REDACTED