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CARB LCFS Fuel Pathway Report
Crimson Renewable Energy LLC Biodiesel

Crimson Renewable Energy LLC
17731 Millux Rd,
Bakersfield, CA 93311
United States

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EXECUTIVE SUMMARY

The California Air Resources Board approved the original LCFS regulation in April 2009 as a discrete early action measure under the California Global Warming Solutions Act of 2006 (AB 32). In addition, the Board subsequently approved amendments to the LCFS in 2011, 2015, and in late 2018. In 2019 CARB developed new simplified calculators for determining the CI of transportation fuels. The new calculator for biodiesel and renewable diesel is much more flexible than the CA GREET 2.0 Tier 1 calculator. The new calculators are required to be used from January, 1, 2019 and by the beginning of 2021 all plants had to resubmit applications.

The new calculator presents the CI for multiple feedstocks simultaneously. The new calculator does require input data in a different format than the previous CA GREET 2.0 Tier 1 and Tier 2 calculators.

Crimson Renewable Energy LLC has been producing biodiesel for a number of years. The plant has recently been expanded with the addition of a new processing line that uses a different production process. This report accompanies a CARB Application for a provisional Carbon Intensity determination for the corn oil, animal fat, and used cooking oil biodiesel produced by both production lines at the expanded plant.

The emissions calculated for the individual stages are summed to determine the fuel cycle CI. The results for the Crimson Renewable Energy LLC biodiesel pathways are shown in the following table.

Table ES- 1 Lifecycle GHG Emissions – Crimson Renewable Energy LLC Biodiesel

Feedstock	Corn Oil	Animal Fat	Soy Oil	Canola	Others1 International UCO Standard Energy	UCO 1 Zero Energy	UCO 2 Low Energy	UCO 3 Std Energy
Stage	gCO_2e/MJ							
Feedstock Production	Confidential business information has been redacted by the applicant.							
Fuel Production	Confidential business information has been redacted by the applicant.							
Transportation	Confidential business information has been redacted by the applicant.							
Indirect Land Use	0.00	0.00	29.10	14.50	0.00	0.00	0.00	0.00
Tailpipe Emissions	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Biodiesel	29.14	33.16	61.43	57.77	34.72	15.92	16.74	21.29

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1. INTRODUCTION

The California Air Resources Board approved the original LCFS regulation in April 2009 as a discrete early action measure under the California Global Warming Solutions Act of 2006 (AB 32). In addition, the Board subsequently approved amendments to the LCFS in 2011, 2015, and in late 2018. For 2019 CARB have developed new simplified calculators for determining the CI of transportation fuels. The new calculator for biodiesel and renewable diesel is much more flexible than the CA GREET 2.0 Tier 1 calculator. The new calculators are required to be used from January, 1, 2019 and by the beginning of 2021 all plants had to resubmit applications.

The new calculator presents the CI for multiple feedstocks simultaneously. The new calculator does require input data in a different format than the previous CA GREET 2.0 Tier 1 and Tier 2 calculators.

This report accompanies a CARB Application for a Carbon Intensity determination for the corn oil, animal fat, soy oil, canola oil and used cooking oil biodiesel produced by the plant.

1.1 CRIMSON RENEWABLE ENERGY

Crimson Renewable Energy LLC is a part of Crimson Renewable Energy Holdings.

Crimson Renewable Energy completed its first biodiesel production facility, located in Bakersfield, California, in 2009. This plant is one of the largest of its kind in California. It was upgraded during 2010 and 2011 to handle a wider variety of raw materials including ultra-low carbon feedstocks such as used cooking oils, waste animal fats, and waste corn oil derived from ethanol production. It has a production capacity of 24 million USG per year. Crimson began biodiesel production at this facility in 2011.

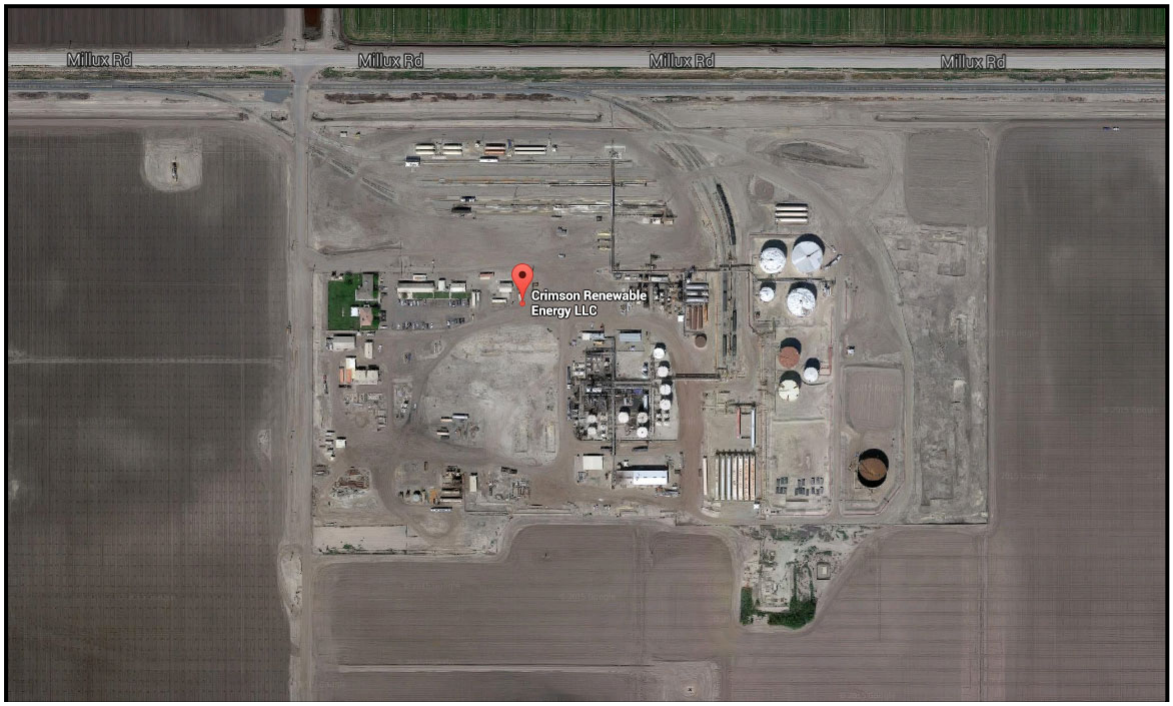
Crimson has invested significant resources in designing and testing its own innovative biodiesel production process. Crimson's biodiesel production process is a closed loop, continuous system that minimizes emissions and waste products, and does not create unpleasant odors or high noise levels. Crimson biodiesel production plants feature the application of new technologies and systems for feedstock pre-treatment, transesterification (the chemical process for making methyl esters), glycerin processing and methanol recovery.

Crimson's biodiesel production facility is designed to process multiple types of feedstock ranging from vegetable oils to algae oil to waste cooking oils and animal fats. The Crimson Bakersfield Biodiesel Production Plant uses primarily waste animal fats, used cooking oils and corn oil from distillers grains to produce an ultra-low carbon biodiesel. Crimson works with a variety of feedstock suppliers but in all instances, they strive to work with suppliers who are committed to sustainable practices. Whenever possible, Crimson endeavors to work with in state suppliers.

In 2021 Crimson completed the construction of an additional processing unit (RepCat) at the facility. This new processing line uses a different process and it can be operated as an integrated facility.

The original facility is shown in the following figure.

Figure 1-1 Crimson Renewable Energy LLC Facility



The RepCat facility is shown in the following figure.

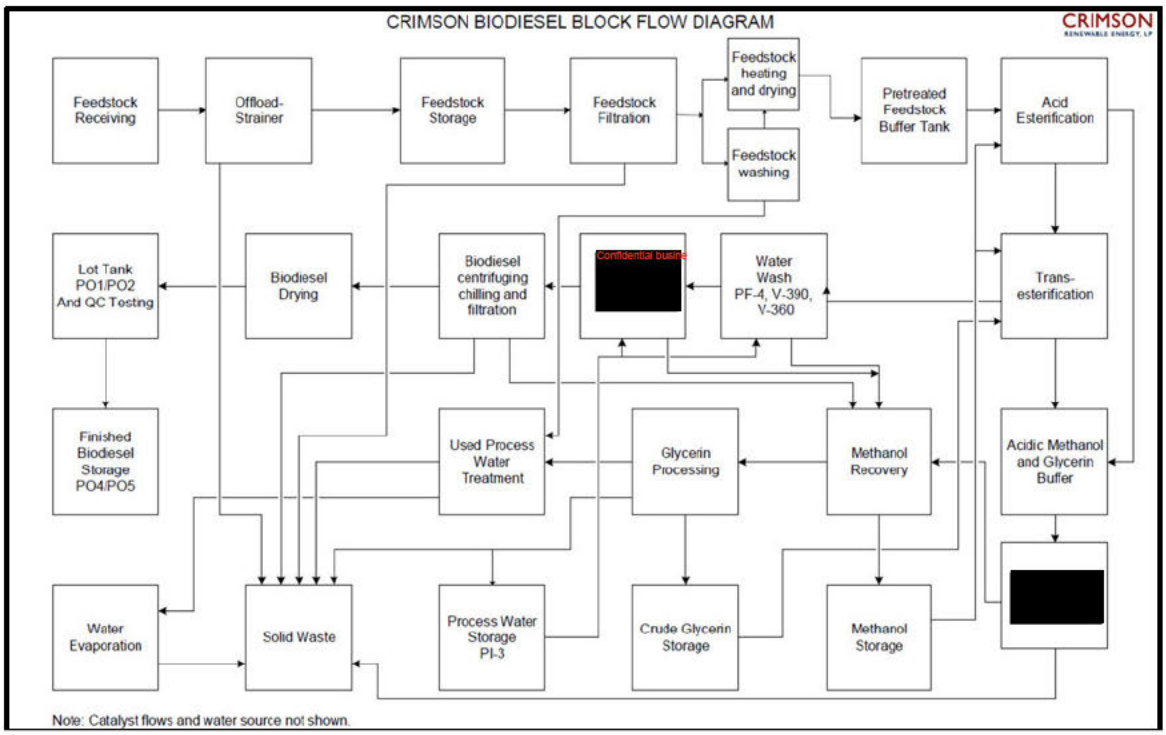
Figure 1-2 Crimson Renewable Energy LLC RepCat

1.2 BIODIESEL PROCESS

The original Crimson production process employs both acid esterification and transesterification so that both triglycerides and free fatty acids can be converted into biodiesel. This results in a high biodiesel yield in spite of the high free fatty acid levels of the incoming feedstocks. The plant processes mostly used cooking oil, with some distillers' corn oil, and animal fats processed from time to time.

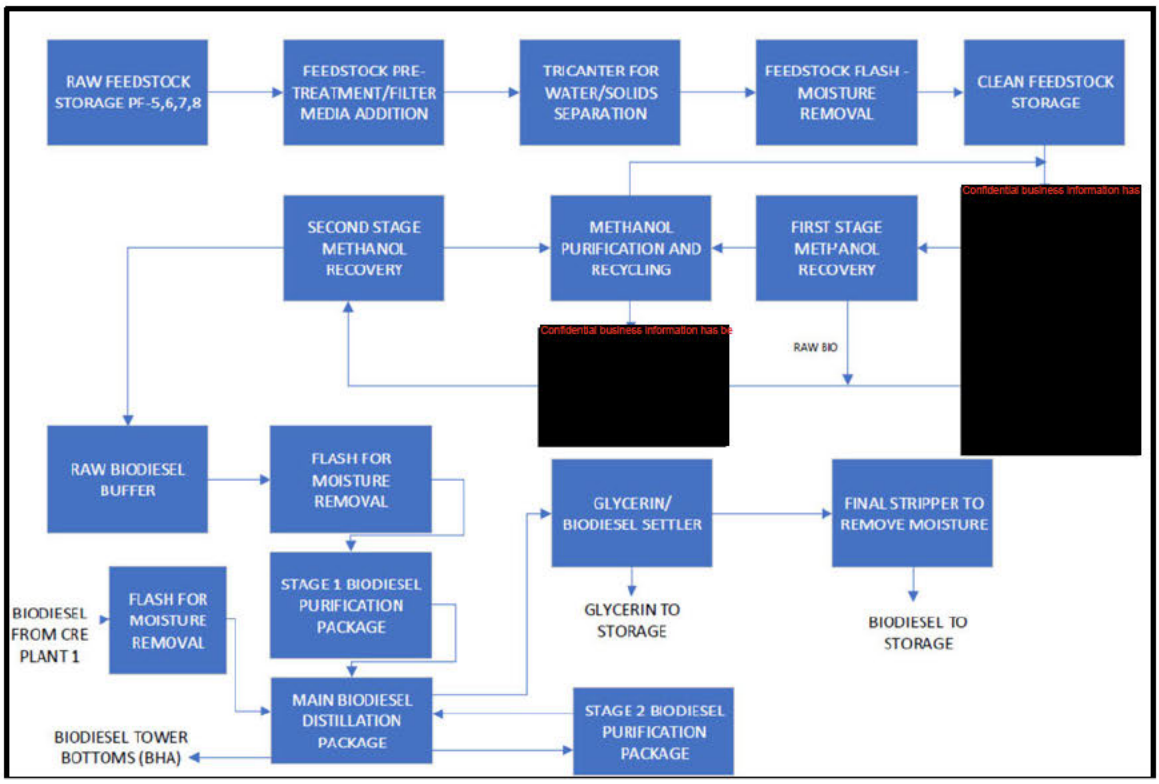
The original Crimson process is shown in the following figure.

Figure 1-3 Original Crimson Process Block Flow Diagram



The RepCat process is based on a patented sustainable technology using a [redacted] in biodiesel production. This important process step increases product quality while reducing the consumption of operating materials. The block flow diagram for the new processing line (RepCat) is shown in the following figure.

Figure 1-4 New Crimson Process Block Flow Diagram



There are some interconnections between the two process lines so the carbon intensity of the biodiesel produced is calculated for the combined facilities.

1.3 Model Set-Up

Since the catalyst and some of the chemicals are different than those included in the Tier 1 simplified calculator this is a Tier 2 application. The combined facility can be modelled with a slightly modified Tier 1 simplified calculator. The standard version of the simplified calculator that was supplied by CARB has been used for this work.

The values that are location dependent and are set with drop down menus are:

1. The plant zip code places the plant in the CAMX e-grid. In the simplified calculator it is the 3-CAMX Mix.[1]
2. The regional crude oil mix is US Average Crude
3. The regional natural gas source is US Average NG.

Other model inputs are entered on other sheets in the model. These are described in the following sections.

[1] https://www.epa.gov/sites/production/files/2018-08/power_profiler_zipcode_tool_2016_6_14_18._v8.xlsx

2. FEEDSTOCK

Each feedstock for the plant is entered on a separate sheet in the simplified calculator. For Crimson Renewable Energy the feedstock data is entered on the following sheets.

1. Corn Sorghum Oil
2. Tallow 1
3. UCO 3 – Standard Energy Rendering
4. UCO 1 – Zero Energy Rendering
5. UCO 2 – Low Energy Rendering
6. Soy oil
7. Canola Oil
8. International UCO

UCO 1 and UCO 2 are low energy user defined pathways. The other pathways use the CA GREET default values.

2.1 DISTILLERS' CORN OIL

Biodiesel is produced from distillers' corn oil. The corn oil is received both by truck, from nearby ethanol plants, and by rail car from ethanol plants that are further away. The moisture content of the corn oil is determined at the plant and the monthly average values are entered into the calculator. The average moisture content of the corn oil is recorded and the monthly average is entered in the calculator.

The monthly receipts by mode of transport are shown in the previously uploaded "Support Files" folder in the file "A - Primary Data sheet for GREET".

2.2 ANIMAL FAT

The biodiesel is also produced from animal fat (Tallow 1). The new process has the ability to handle high FFA feedstocks better than the original process so the quantities of animal fats processed has increased.

The default energy for rendering is assumed for this pathway.

Animal fat is all received by rail and by truck. The rail and truck distances are recorded for each shipment. The average value for each month has been recorded and entered into the calculator for each month. The average moisture content of the tallow is recorded and the monthly average is entered in the calculator. The monthly receipts by mode of transport are shown in the previously uploaded "Support Files" folder in the file "A - Primary Data sheet for GREET".

2.3 USED COOKING OIL STANDARD ENERGY UCO 3

Biodiesel is produced from used cooking oil that uses the standard rendering energy. This material is received by truck and by rail. The moisture content of the material is measured at the plant and the monthly average value is used in the calculator. The monthly receipts by

mode of transport are shown in the previously uploaded “Support Files” folder in the file “A - Primary Data sheet for GREET”.

2.4 Used Cooking Oil Zero Rendering Energy– UCO 1

The next used cooking oil pathway is for zero energy rendering and low transportation distance to the biodiesel plant. Crimson Renewable Energy has a number of suppliers who are in this category. The monthly receipts by mode of transport are shown in the previously uploaded “Support Files” folder in the file “A - Primary Data sheet for GREET”.

The rendering emissions for this user defined pathway are zero g CO_2eq/MJ.

2.5 Used Cooking Oil Low Rendering Energy – UCO 2

Biodiesel is produced from used cooking oil that uses the low rendering energy. This material is received by truck. The moisture content of the material is measured at the plant and the monthly average value is used in the calculator. The monthly receipts by mode of transport are shown in the previously uploaded “Support Files” folder in the file “A - Primary Data sheet for GREET”.

The rendering emissions for this user defined pathway are 18.29g CO_2eq/lb of oil.

2.6 Soy Oil

Biodiesel is produced from soy oil. This material is received by rail. The moisture content of the material is measured at the plant and the monthly average value is used in the calculator. The monthly receipts by mode of transport are shown in the previously uploaded “Support Files” folder in the file “A - Primary Data sheet for GREET”.

2.7 Canola Oil

Biodiesel is produced from canola oil. This material is received by rail. The moisture content of the material is measured at the plant and the monthly average value is used in the calculator. The monthly receipts by mode of transport are shown in the previously uploaded “Support Files” folder in the file “A - Primary Data sheet for GREET”.

2.8 International Used Cooking Oil – Standard Energy

Biodiesel is produced from used cooking oil from international sources that use the standard rendering energy. This material is received by truck transloaded to ocean vessel. The moisture content of the material is measured at the plant and the monthly average value is used in the calculator. The monthly receipts by mode of transport are shown in the previously uploaded “Support Files” folder in the file “A - Primary Data sheet for GREET”.

Rendering energy and truck and ocean vessel transport uses CARB supplied default values.

2.9 Summary

The feedstock emissions for the five pathways are shown in the following table.

Table 2-1 Feedstock Summary

Feedstock	G CO_2eq/MJ
Corn Oil	Confidential bus
Animal Fat	Confidential bus
Soy oil	Confidential bus
Canola oil	Confidential bus
Others1, International UCO	Confidential bus
UCO 1, zero energy	Confidentia
UCO 2, low energy	Confidentia
UCO 3, standard energy	Confidentia

3. BIODIESEL PRODUCTION

The production of biodiesel requires energy and chemical inputs. The calculator has a number of required inputs for biodiesel production. These include data on the co-products. These are discussed below.

3.1 MASS INPUTS AND OUTPUTS

The feedstock processed is automatically calculated by the calculator based on receipts and changes in the inventory levels. The production of biodiesel is determined in a similar manner to the feedstock, opening and closing inventories are recorded along with biodiesel sales. The facility also processes sales of third-party biodiesel. When third-party biodiesel is added to the biodiesel ship tanks that also store Crimson-produced biodiesel, the volume of sales sourced from third-party volumes is subtracted form total sales.

All production from the plant is measured by a volume meter and temperature corrected to 60F.

The yield is calculated from the input data. It is [redacted] biodiesel/lb of feedstock.

3.2 ENERGY REQUIREMENTS

The plant purchases natural gas and electricity from the local utilities.

3.2.1 Natural Gas

The natural gas purchased is billed in therms (99,976 BTU). 10.0024 therms is one million BTU. The invoice values divided by 10.0024 are entered into the calculator.

3.2.2 Electricity

The electric power is billed in kWh. There are three uses of power, Plant 1, RepCat and power for the nitrogen plant.

3.3 CHEMICALS

The RepCat plant uses different chemicals than a typical biodiesel plant. In order to accommodate this, a separate calculator has been developed to calculate the emissions associated with the chemicals. The emission factors for the chemicals are all taken from the CA GREET 3.0 model and are discussed below.

3.3.1 Methanol

The carbon intensity of pure methanol in the CA GREET 3.0 calculator is 6,221 grams/gallon. This can be determined by zeroing out the methanol input into the CA GREET calculator and determining the change in GHG emissions.

3.3.2 Sodium Methylate

The sodium methylate (sodium methoxide) carbon intensity is taken from the CA GREET 3.0 model. This is an input for the biodiesel production process so the emission factor can be

determined by zeroing this value and determining the change in the biodiesel production emissions. The emission factor is 49 g CO_2eq/pound.

Sodium methylate is purchased in a solution of methanol. So the methanol portion of the purchase is separated and added to the methanol purchases before the emissions for methanol and sodium methylate are calculated.

3.3.3 Citric Acid

The citric acid carbon intensity is taken from the CA GREET 3.0 model. The emission factor is found on the Ag Inputs sheet in column EN. The CO_2eq is calculated from the values in rows 57 to 67 using the GPS on the fuel spec sheet. The emission factor is 659 g CO_2eq/pound of citric acid.

3.3.4 Sodium Hydroxide

The sodium hydroxide carbon intensity is taken from the CA GREET 3.0 model. The value is found on the Enzymes_Yeast sheet in cell F109. The emission factor is 1,087 g CO_2eq/pound. This is the emission factor for 100% sodium hydroxide. The plant uses a diluted form and the emission factor is multiplied by the concentration used.

3.3.5 [redacted]

The emission factor for this chemical is on the catalyst sheet, column [redacted] the CA GREET 3.0 model. The GHG emissions have to be calculated, from the [redacted]

3.3.6 [redacted]

These emissions are found on the Ag Inputs sheet in [redacted] The value is [redacted] The reporting of [redacted] concentration as [redacted] equivalents is an old chemistry tradition. To convert to [redacted] concentration the following steps are taken.

[redacted]

So one gram of [redacted] is equivalent to [redacted] of [redacted] the emission factor is [redacted] CO_2eq/gram of phosphoric acid. The process uses a [redacted] concentration so the emission factor should be [redacted]. This is [redacted] g CO_2eq/pound.

3.3.7 Sulphuric Acid

The sulphuric acid carbon intensity is taken from the CA GREET 3.0 model. The emissions are found on the Ag Inputs sheet, column BH, row 92 to 102. The emission factor is 22 g CO_2eq/pound.

3.3.8 Chemical Summary

The sum of the emissions of all of the chemicals is divided by the energy content of the biodiesel produced to arrive at a g CO_2/MJ value. This value is entered in cell L167 on the BD production sheet. The methanol opening and closing inventories and purchases are not entered in the simplified calculator as they are entered in the chemical calculator.

The chemical consumption values for all of the chemicals are shown in the previously uploaded "Support Files" folder in the file "A - Primary Data sheet for GREET".

The calculated carbon intensity for the chemicals is [redacted] CO_2eq/MJ. This value is almost the same value that would be produced with just the methanol consumption and the standard emission factor for biodiesel chemicals.

3.4 CO-PRODUCTS

The plant produces four co-products, crude glycerine, refined glycerine, distillation bottoms, and FCO. The quantities produced are shown in the following table.

Table 3-1 Co-products Produced

3.4.1 Crude Glycerine

The crude glycerine sales are corrected for the glycerine moisture content and the moisture free volume is entered into the calculator.

3.4.2 Distilled Glycerine

The RepCat plant produces a distilled glycerine product. One sample of this has been tested for energy content. The results were 7,659 BTU (LHV)/pound. A factor of 95% is applied to this value since it is a single sample. This value (7,276) is entered in cell P49 on the BD production sheet.

3.4.3 Distillation Bottoms

The RepCat plant can distill the biodiesel and thus produce distillation bottoms. The single sample produced an energy content of 16,429 BTU/pound (LHV). Ninety five percent of this is 15,608 which is entered in cell M49.

3.4.4 FCO

FCO was tested, the energy content was 15,762 BTU/pound (LHV). Ninety five percent of this is 14,974 which is entered in cell N49.

4. BIODIESEL TRANSPORT

Crimson distributes their biodiesel by truck from the plant to various facilities in central and southern California. The average transportation distance is [redacted] miles. This produces distribution emissions of 0.47 g CO_2eq/MJ.

5. TANKS TO WHEELS

The tank to wheels emissions are the same for all biodiesel fuels. This emission category calculates the methane and nitrous oxide emissions associated with the combustion of biodiesel in the vehicle. The value in CA GREET 3.0 is 0.76 g CO_2eq/MJ.

6. INDIRECT LAND USE CHANGE

Crimson feedstocks soy oil and canola oil have indirect land use change emissions associated with them.

7. SUMMARY

The emissions calculated for the individual stages are summed to determine the fuel cycle CI. The results for the Crimson Renewable Energy biodiesel pathways are shown in the following table.

Table 7-1 Lifecycle GHG Emissions – Crimson Renewable Energy Biodiesel

Feedstock	Corn Oil	Animal Fat	Soy Oil	Canola	Others1 International UCO Standard Energy	UCO 1 Zero Energy	UCO 2 Low Energy	UCO 3 Std Energy
Stage	gCO_2e/MJ							
Feedstock Production	Confidential business information has been redacted by the applicant.							
Fuel Production	Confidential business information has been redacted by the applicant.							
Transportation	Confidential business information has been redacted by the applicant.							
Indirect Land Use	0.00	0.00	29.10	14.50	0.00	0.00	0.00	0.00
Tailpipe Emissions	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
Biodiesel	29.14	33.16	61.43	57.77	34.72	15.92	16.74	21.29