CARB LCFS Tier 2 Fuel Pathway Report
US Uncooked Used Cooking Oil Biodiesel

Prepared For:

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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 December 2011, which have been implemented since January 1, 2013. In late 2015 CARB re-adopted the LCFS and requires fuel suppliers to re-calculate the carbon intensity of their production via one of four methods, depending on the feedstock and the processing methods used. This report covers "uncooked" used cooking oil (UCO) biodiesel pathway.

Uncooked UCO is technically a Tier 2 pathway as the UCO rendering cells on the T1 calculator cells are not yellow background cells where the users can enter their own values. However the cells are not locked and it is possible to make adjustments in those cells. As the T1 calculator has all of the inputs in a single location, it has been used for this T2 pathway. This report documents the inputs and results for the Crimson Renewable Energy LP uncooked used cooking oil biodiesel, where the uncooked used cooking oil is produced in the U.S. but sourced outside of California.

While Crimson has been operating since late 2011, the Crimson Bakersfield Biodiesel plant has undergone nearly continuous improvements since 2012, including major process and equipment changes and additions in 2013, 2014 and 2015. As a result Crimson has increased its biodiesel production significantly from less than 3 mil gallons in 2012 to nearly [redacted] million gallons in 2015. These plant improvements and production increases have also resulted in consistent improvements in energy and chemical utilization per unit of biodiesel production and improvements in the mass yield of biodiesel produced per lb of feedstock. Thus Crimson's pathway application is for a provisional pathway based primarily on the last 6 months (July –December 2015) of operating data from the plant. The results are shown in the following tables.

Table ES- 1 Lifecycle GHG Emissions – Crimson US Uncooked UCO Biodiesel

Stage	Last 6 Months
	Emissions, g/MJ
Raw UCO Transportation	[redacted]
UCO Rendering	
Rendered Oil Transportation	
Biodiesel Production	
Biodiesel Transportation	
Tank to Wheels	
Indirect land Use Change	0.00
Total Carbon Intensity	13.10

Table ES- 2 Crimson Uncooked UCO Biodiesel CA-GREET 2.0 Results

Category	Last 6 Months
	Emissions, g/MJ
Feedstock Production	[redacted]
Biodiesel Production	[redacted]
Tank to Wheels	[redacted]
Indirect Land Use Change	0.0
Total Carbon Intensity	13.10

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1. INTRODUCTION

The California Air Resources Board approved the original Low Carbon Fuel Standard (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 December 2011, which have been implemented since January 1, 2013. In late 2015 CARB re-adopted the LCFS and requires fuel suppliers to re-calculate the carbon intensity of their production via one of four methods, depending on the feedstock and the processing methods used.

The LCFS is a key part of a comprehensive set of programs in California to reduce GHG emissions and other smog-forming and toxic air pollutants from the transportation sector by improving vehicle technology, reducing fuel consumption, and increasing transportation mobility options. All of these programs, including the LCFS, are in turn a part of California's overall effort to reduce GHG emissions. The LCFS is designed to decrease the carbon intensity of California's transportation fuel pool and provide an increasing range of low-carbon and renewable alternatives.

Uncooked UCO is technically a Tier 2 pathway as the UCO rendering cells on the T1 calculator cells are not yellow background cells where the users can enter their own values. However the cells are not locked and it is possible to make adjustments in those cells. As the T1 calculator has all of the inputs in a single location, it has been used for this T2 pathway. This report documents the inputs and results for the Crimson Renewable Energy LP uncooked used cooking oil biodiesel, where the UCO is produced in the United States but outside of California.

1.1 CRIMSON RENEWABLE ENERGY LP

Crimson Renewable Energy LP is a part of Crimson Midstream LP, a holding company with operations in petroleum pipelines, petro-chemicals transshipment and specialty asphalt products.

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 now 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'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.

The facility is shown in the following figures.

Figure 1-1 Crimson Renewable Energy LP Facility

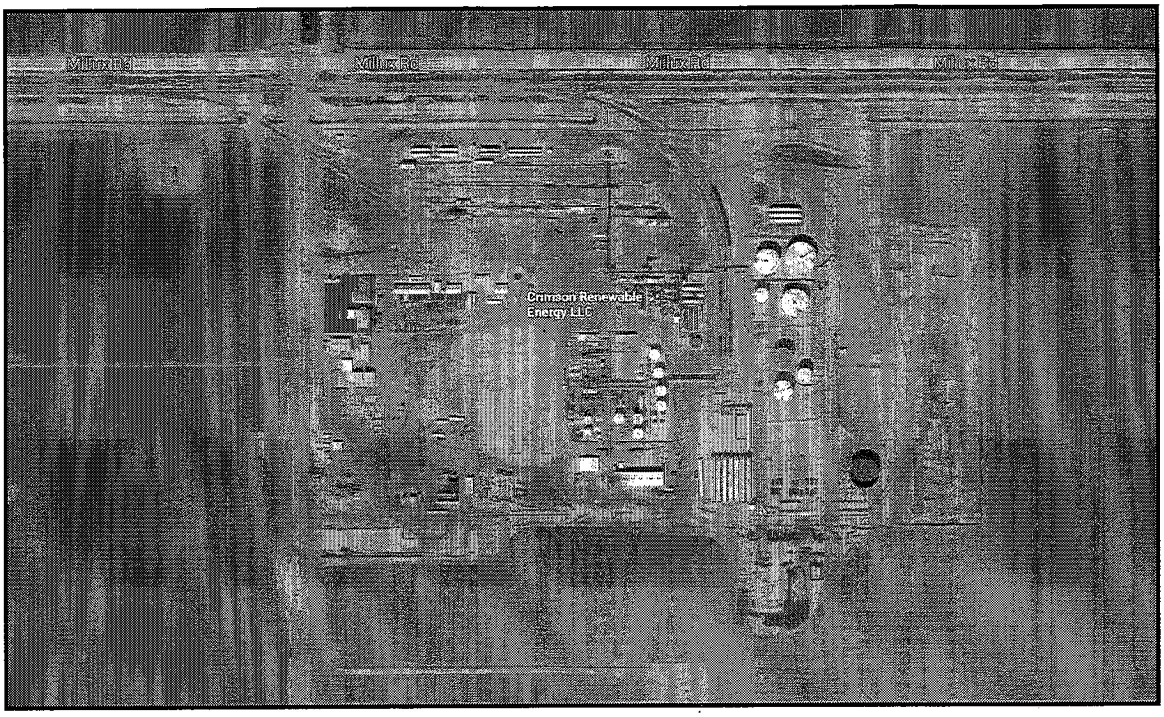
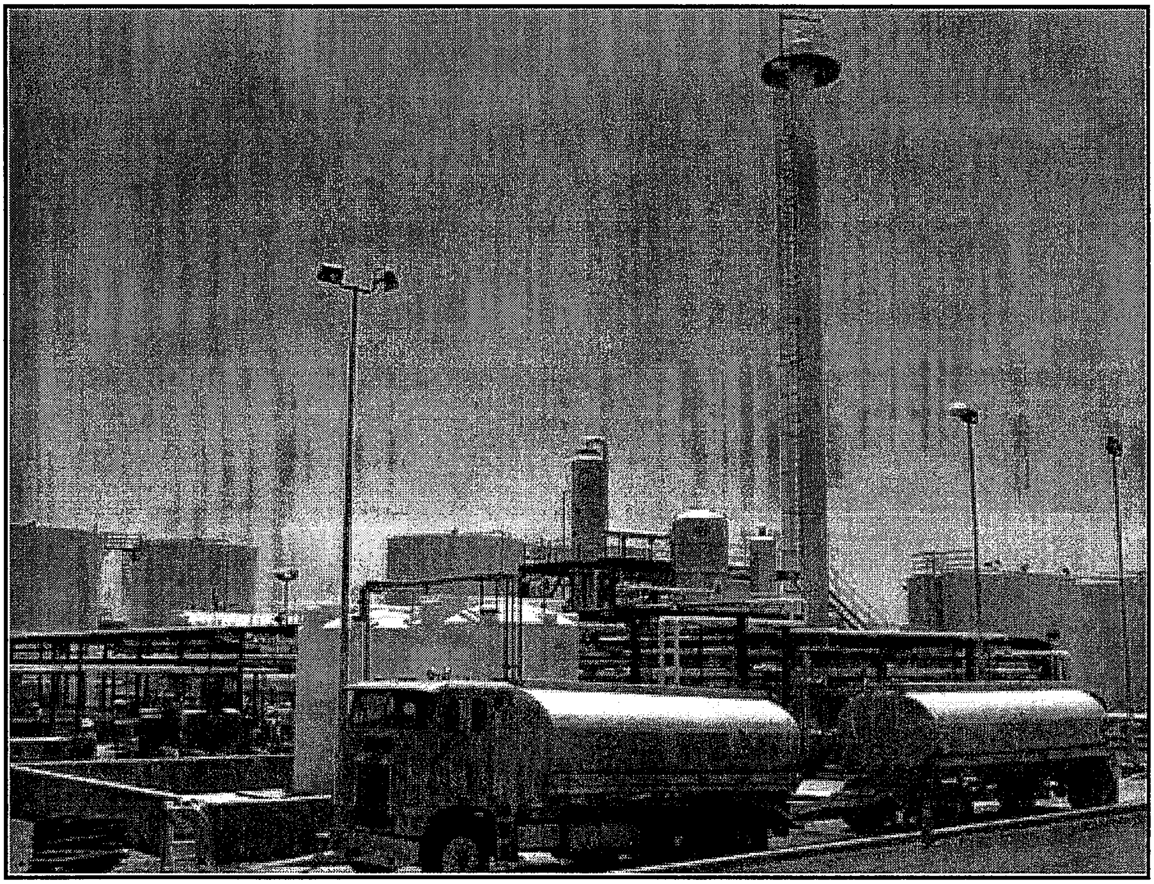


Figure 1-2 Crimson Renewable Energy LP



1.2 Model Set-Up

This report calculates the CI of Crimson Bioenergy biodiesel using "cooked" used cooking oil collected in the State of California. The biodiesel produced is delivered by truck to blending facilities in the State of California. The work uses the CA GREET 2.0 Tier 1 model for the work. The facility also utilizes or can utilize used cooking oil collected inside or outside of the State of California, tallow, and corn oil feedstocks but these are the subject of other CI reports.

The CA GREET 2.0 model was released September 29, 2015. It is set up as follows:

1. UCO biodiesel is selected in the drop down menu in row 7.
1. The regional electricity mix for feedstock in row 9 is set to "1-U.S. Ave MIX".
2. The regional electricity mix for fuel production in row 9 is set to "3-CAMX MIX".
3. In row 10, "U.S. Ave Crude" is selected for the feedstock and fuel production.

While Crimson has been operating since late 2011, the Crimson Bakersfield Biodiesel plant has undergone nearly continuous improvements since 2012, including major process and equipment changes and additions in 2013, 2014 and 2015. As a result Crimson has increased its biodiesel production significantly from less than 3 mil gallons in 2012 to nearly [redacted] million gallons in 2015. These plant improvements and production increases have also resulted in consistent improvements in energy and chemical utilization per unit of biodiesel production and improvements in the mass yield of biodiesel produced per lb of feedstock. Thus Crimson's pathway application is for a provisional pathway based, primarily on the last 6 months (July –December 2015) of operating data from the plant.

2. FEEDSTOCK

The feedstock for this pathway is "uncooked" used cooking oil collected in the state of California.

2.1 BIODIESEL YIELD

The Crimson biodiesel yield is an important input into the CI modelling. The weighted average yield for the year 2015 was [redacted] pounds biodiesel/pound of feedstock. The process improvements that have been implemented in 2015 impact mostly the energy use and not the biodiesel yield. Using the 12 month yield reduces the impact of measuring tank inventory levels.

2.2 UCO COLLECTION AND TRANSPORT

Crimson acquires the feedstock from a number of different uncooked UCO suppliers outside of California. Crimson tracks the cooked and uncooked UCO and their origin (from within California or elsewhere in the U.S. or form another country) separately.

2.3 UCO RENDERING

The suppliers of uncooked UCO separate the cooking oil from water and solids at temperatures from ambient up to 160 F using gravity separation. This differs from the suppliers of cooked UCO who process the material at temperatures from 160 to 450 F and use centrifuges and filters in addition to gravity.

The uncooked UCO requires much less energy for processing. CARB had previously published a pathway for uncooked UCO[1]. In this pathway the natural gas use was reduced from 963 BTU/lb to [redacted] BTU/lb and the electric power was reduced from 110 BTU/lb to [redacted] BTU/lb.

A check of the natural gas values can easily be made. The specific heat of cooking oil is about 0.58 BTU/lb F (it varies slightly depending on the oil). Water is 1.0 BTU/lb F. A mixture of 80% oil and 20% water would have a value of 0.66 BTU/lb F.

Increasing the temperature of the used cooking oil from 60 F to 160 F is a change in temperature of 100 F. The energy required to do this to the used cooking oil would be 66 BTU/lb. This is half of the value that CARB used in the earlier pathway. To be conservative the previous CARB values are used in this analysis.

2.4 RENDERED OIL TRANSPORTATION

In 2015, many different suppliers outside of California were used for the uncooked UCO. The transportation distances from individual suppliers ranged up to [redacted] miles. All of the material is delivered by rail.

The value used for modelling is [redacted] miles, to allow for year to year variation in the supply system.

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[1]Detailed California-Modified GREET Pathway for Biodiesel Produced in the Midwest from Used Cooking Oil and Used in California. 2011. http://www.arb.ca.gov/fuels/lcfs/2a2b/internal/15day-mw-uco-bd-rpt-022112.pdf

2.5 Feedstock CI

The CA GREET yellow cell inputs are summarized in the following table.

Table 2-1 CA GREET Feedstock Inputs

Description	Cell	Value
Biodiesel yield, lb biodiesel/lb rendered oil	B373	[redacted]
UCO Collection		
Collection energy, Btu/lb tallow	B377	[redacted]
Residual oil, %	B378	[redacted]
Diesel fuel, %	B379	[redacted]
Gasoline, %	B380	[redacted]
Raw UCO Transportation		
Rail miles	B384	[redacted]
Truck miles	B387	[redacted]
UCO Rendering Inputs		
Rendered oil used, lbs	B390	[redacted]
UCO Rendering		
Natural Gas	B399	[redacted]
Electricity	B402	[redacted]
Rendered Oil Transportation		
From rendering plant to port/yard to transport to CA or to BD plant		
HDD Truck Miles	B407	[redacted]
From rendering plant to BD plant		
Barge Miles	B410	[redacted]
Ocean Tanker Miles	B413	[redacted]
Rail Miles	B416	[redacted]
From railyard/port to CA BD plant		
HDD Truck Miles	B419	[redacted]

The CI for the feedstock calculated by the CA GREET 2.0 model is summarized in the following table.

Table 2-2 Crimson Renewables Feedstock CI

Stage	Value, g/MJ
Collection	[redacted]
Raw UCO Transportation	[redacted]
UCO Rendering	[redacted]
Rendered Oil Transportation	[redacted]
Total Feedstock CI	[redacted]

3. BIODIESEL PRODUCTION

The production of biodiesel requires energy and chemical inputs. The Tier 1 calculator has a number of required inputs for free fatty acid removal and for biodiesel production.

3.1 FFA REMOVAL

Crimson Renewable Energy LP does not have separate data for free fatty acid removal. The energy requirements and the impact on yield are included in the data entered for biodiesel production. The FFA removal energy use is therefore entered as zero in the model.

3.2 TRANSESTERIFICATION

The transesterification process requires energy and reactants. While Crimson has been operating for several years, the operations have been continually improving as shown in the following figure, which shows the natural gas and electric power requirements.

Figure 3-1 Crimson Energy Use

[redacted]

The annual average values for natural gas and electricity are shown in the following table.

Table 3-1 Crimson Energy use

Year	NG, BTU/lb (LHV)	Power, kWh/Lb.
2012	[redacted]	[redacted]
2013	[redacted]	[redacted]
2014	[redacted]	[redacted]
2015	[redacted]	[redacted]

The CI has been calculated using the data from the last six months of 2015. These are shown in the following table.

Table 3-2 Energy Modelling Inputs

Period	Natural gas, BTU/lb	Power, kWh/lb
Jul – Dec 2015	[redacted]	[redacted]

Crimson also uses methanol, sodium methylate, and critic acid in the production of the biodiesel. The consumption data for the same periods as the energy requirements are shown in the following table.

Table 3-3 Chemical Use Modelling Inputs

Period	Jul – Dec 2015
Methanol, BTU/lb	[redacted]
Sodium Methoxide, g/lb	[redacted]
Citric Acid, g/lb	[redacted]

The following table summarizes the energy and chemical inputs for the most recent six month modelling scenario.

Table 3-4 CA GREET Fuel Production Inputs Most Recent 6 Months

Description	Cell	Value
Biodiesel produced, lbs.	E373	[redacted]
FFA Removal		
Diesel fuel	E379	[redacted]
Natural gas	E380	[redacted]
Coal	E381	[redacted]
Electricity	E382	[redacted]
Transesterification		
Residual oil	E387	[redacted]
Diesel fuel	E388	[redacted]
Gasoline	E389	[redacted]
Natural gas	E390	[redacted]
Coal	E391	[redacted]
Liquefied petroleum gas	E392	[redacted]
Biomass	E393	[redacted]
Electricity (kWh/lb BD)	E394	[redacted]
Renewable natural gas	E395	[redacted]
N-hexane (a solvent from crude)	E396	[redacted]
Methanol	E397	[redacted]
Sodium hydroxide (grams)	E398	[redacted]
Sodium methoxide (grams)	E399	[redacted]
Hydrochloric acid (grams)	E400	[redacted]
Phosphoric acid (grams)	E401	[redacted]
Citric acid (grams)	E402	[redacted]

The CI calculated from the model for the fuel production stage are shown in the following table.

Table 3-5 Crimson Renewables Fuel Production CI

	Most Recent 6 Months
FFA Removal	[redacted]
Transesterification	[redacted]
Total	[redacted]

4. BIODIESEL TRANSPORT

Crimson distribute their biodiesel by truck from the plant to various facilities in central and southern California. The average transportation distance to the [redacted] blending points in the most recent quarter has been [redacted] miles. The 2016 delivery forecast for delivery to [redacted] blending locations is [redacted] miles. To allow for some flexibility the transportation distance has been assumed to be [redacted] miles. The model inputs are shown in the following table.

Table 4-1 CA GREET Fuel Transportation Inputs

Description	Cell	Value
Biodiesel Transportation		
BD from plant to port/yard or to blending term.		
HDD Truck Miles	E289	[redacted]
BD from railyard to CA		
Rail Miles	E292	[redacted]
BD from port to CA		
Ocean Tanker Miles	E295	[redacted]
Biodiesel Distribution		
From CA port/railyard to blending terminal		
HDD Truck Miles	E299	[redacted]

The calculated CI for the Biodiesel transportation for Crimson Renewables is 1.07 g/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 2.0 is 0.76 g CO_2eq/MJ.

6. Indirect Land Use Change

There are no indirect land use emissions associated with this feedstock.

7. SUMMARY

The emissions calculated for the individual stages are summed to determine the fuel cycle CI for the uncooked UCO biodiesel. The results for the uncooked UCO pathway are shown in the following table.

Table 7-1 Lifecycle GHG Emissions – US Uncooked UCO Biodiesel

Stage	Last 6 Months
	Emissions, g/MJ
Raw UCO Transportation	[redacted]
UCO Rendering	[redacted]
Rendered Oil Transportation	[redacted]
Biodiesel Production	[redacted]
Biodiesel Transportation	[redacted]
Tank to Wheels	[redacted]
Indirect land Use Change	[redacted]
Total Carbon Intensity	13.10

8. REFERENCES

CARB. 2011. Detailed California-Modified GREET Pathway for Biodiesel Produced in the Midwest from Used Cooking Oil and Used in California. http://www.arb.ca.gov/fuels/lcfs/2a2b/internal/15day-mw-uco-bd-rpt-022112.pdf