New Leaf Biodiesel Production from Various Feedstocks-Redacted

Prepared by Stefan Unnasch, Life Cycle Associates, LLC

Date Submitted: January 31, 2016

Location of Headquarters:
New Leaf Biofuel
2285 Newton Ave.
San Diego, CA 92113

Location of Biofuel Production Facility:
New Leaf Biofuel
2285 Newton Ave.
San Diego, CA 92113
Latitude: 32.6952266
Longitude: -117.13984040000003

Period of Analysis

This analysis is based on facility operating data, process invoices, and audited reports covering the period from January 2013 to December 2015 inclusive.

Fuel Pathway Information

Fuel	Feedstocks	Production Process Technology	LCFS Pathway Requested
Biodiesel	Rendered UCO Self-Rendered UCO	Transesterification	Biodiesel

Primary Point of Contact

Name: Stefan Unnasch
Company Affiliation: Life Cycle Associates
Title: Managing Director

Address: 884 Portola Road
Suite A11,
Portola Valley
CA 94028

Phone Number: +1.650.461.9048
Email address: Unnasch@lifecycleassociates.com

1. Summary

Life Cycle Associates determined the carbon intensity for two used cooking oil (UCO) to biodiesel pathways for the New Leaf Biofuel facility. The evaluation supports compliance with ARB's Low Carbon Fuel Standard (LCFS). Table 1 outlines the documents submitted in support of the application. The CI results are is 15.39 g CO_2e for rendered UCO delivered to NLB and 8.74 g CO_2e/MJ for UCO that is collected and rendered (self-rendering) at New Leaf.

Table 1. Method 2A2B application supporting documentation and file list

	Document	Confidentiality	Comments
X	Pathway life cycle analysis report	Includes confidential business information	
X	CA-GREET model spreadsheet and results	Includes confidential business information	
X	Process flow diagrams covering the complete production process, including all inputs (feedstocks, process energy, etc.) and outputs (finished fuel, co-products, wastes, etc.)	Includes confidential business information	Included in the independent engineering report.
X	A comprehensive list of all stationary combustion-powered equipment associated with the production facility. List entries should name the equipment, briefly describe its function, identify the fuel or fuels used, and quantify fuel use on a per gallon of finished fuel produced basis	Includes confidential business information	
X	Equipment technical specifications.	Includes confidential business information	Included in the engineering report
X	Production process schematics, technical drawings flow diagrams, maps, or other graphical representations (other than/in addition to the required process flow diagram).	Includes confidential business information	Included in the independent engineering report.
X	Third party engineering report	Includes confidential business information	
X	Spreadsheets, data files, and similar files documenting the calculations behind the fuel life cycle analysis.	Includes confidential business information	
X	All operating permits issued by the local air pollution control authority (required).		Air Quality permit

2. Fuel Pathway Summary

A Well-To-Tank (WTT) fuel cycle analysis for New Leaf Biofuel's biodiesel pathway includes all steps from feedstock production to biodiesel use. Tank-to-wheel (TTW) analysis includes fuel combustion in a vehicle. Together, WTT and TTW analysis are combined to provide a total well-to-wheel (WTW) analysis that determined the fuel cycle greenhouse gas emissions, termed carbon intensity (CI), associated with New Leaf Biodiesel biodiesel. This biodiesel production process also results in the co-production of glycerin.

The fuel pathway includes UCO collection, rendering, transport, biodiesel production, co-product production, biodiesel transport and distribution and fuel combustion.
The pathway examined here is:

- Feedstock production
- Feedstock Transport
- Biodiesel Production
- Biodiesel Transport

The system boundary diagram in Figure 1 shows the components that form the biodiesel pathway for UCO feedstocks. The feedstock phase includes UCO collection. NLB receives UCO that is rendered off site as well as collecting UCO directly from restaurants. In the case of self-collected UCO, the material is separated/rendered at the NLB facility. Energy inputs and emissions are allocation based on biodiesel and glycerin energy.

New Leaf Biodiesel provided historical data for transesterification. CA_GREET2.0 defaults values are assumed for UCO rendering

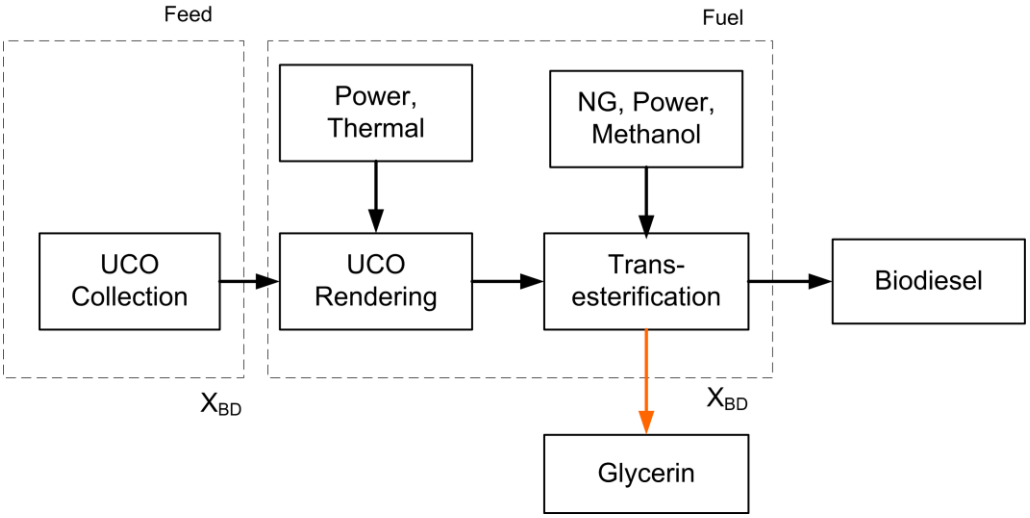

Figure 1. System Boundary Diagram for UCO Biodiesel

Feedstocks

Separate pathways are calculated for each feedstock.

- UCO biodiesel, rendered off-site
- Self Rendered UCO biodiesel

Renewable Fuel Types

The facility produces UCO biodiesel.

Baseline Volume

The biodiesel production occurs at the EPA certified New Leaf Biofuel biodiesel facility in San Diego, California. This facility has the capacity to produce up to 6 million gallons of biodiesel per year, and has been in operation since 2009.

Regional Electricity and Crude Oil Mix

In order to accurately reflect the emissions associated with the facility, the California electricity mix was selected for the feedstock and fuel phase.

3. Result Summary

The WTT results for New Leaf Biofuel biodiesel are shown in Table 3.

Table 3. Carbon Intensity for New Leaf Biofuel Biodiesel (g CO_2e/MJ)

Life Cycle Step	Off -site Rendering	NLB Self Rendering
Feed Phase Allocated	**5.43**	**0.30**
- Raw UCO transport	0.30	0.30
- Rendering energy	4.83	0.00
- Rendered oil transport	1.83	0.00
Fuel Phase	**8.43**	**8.45**
Transesterification	6.97	6.97
BD T&D	0.61	0.61
Diesel Blending Adder	0.0941	0.0998
TTW	0.76	0.76
Total	15.39	8.74

4. Feedstock Phase

Feedstock Production and Transport

The calculations are performed using the California electricity mix. All production inputs for rendered UCO production assume GREET 2.0 defaults.

New Leaf and its partner [redacted] also collect UCO directly from restaurants in the San Diego area. UCO is normally collected in small trucks and hauled to rendering facilities. Since biodiesel production does not change the hauling requirement for collection, these emissions are zero in the default CA_GREET2.0. For self-rendered UCO, these hauling emissions also do not contribute to the CI. For the self-rendered pathway, UCO is simply collected by New Leaf; so, UCO transport and rendered UCO transport do not occur and these emissions are zero. The emissions in the T1Calculator cells C381 and C404 were set to zero.

5. Fuel Phase

Rendering

Data are based on CA_GREET2.0 defaults for delivered rendered UCO. For self-rendered UCO, New Leaf performs the dewatering/rendering at its biodiesel production facility. The energy inputs correspond to the operating of pumps and mechanical equipment. The power is a very small part of New Leaf's overall energy use and is included in the biodiesel fuel phase. Therefore, the rendering emissions in cell C393 were set to zero. The self-rendering analysis was submitted as a Tier 2 application since these cells are not intended to be changed in Tier 1.

Counting the small amount of power for rendering in biodiesel production is the most accurate approach for the following reasons. New Leaf monitors its total natural gas and electric power usage but they do not have separate utility meters on the relatively small electrical load associated with self-rendering. New Leaf sells all of its biodiesel in California, thus all of the emissions associated with self-rendering are included in New Leaf's aggregate CI. Estimating the energy associated with separating and assigning this energy to self-rendered UCO is another option. The self-rendered pathway would include energy for separation and the biodiesel production energy would be slightly lower for delivered rendered UCO. However, the aggregate CI is identical to the results presented here.

Biodiesel Production

UCO biodiesel production requires process heat and electricity inputs. Oils are reacted with methanol and glycerin is a co-product. New Leaf does not use a free fatty acid (FFA) removal step, so these inputs in CA_GREET are zero. Some FFA's in the feedstock are converted through treatment with sulfuric acid. The life cycle emissions from biodiesel production are calculated using CA_GREET2.0. The analysis is based on monthly product yields, and monthly natural gas and electricity consumption data.

Glycerin is sold as a raw glycerin product which contains unconverted oil (MONG) as well as glycerin and methanol. Raw glycerin is processed off site to recover the glycerin and methanol. Since the CA_GREET2 model is based on the energy content of glycerin, only the glycerin fraction of crude glycerin is claimed as a co-product. The GREET default of 0.105 lb glycerin per lb biodiesel is assumed because this value is slightly below New Leaf's data. Note that the co-product credit is calculated for the pure glycerin component, which is consistent with the CA_GREET approach. New Leaf recovers methanol for re-use and the methanol consumed input is slightly higher than the GREET default.

Process Flow Diagram

The process flow diagram for the production process is shown in EPA engineering review.

Biodiesel Facility Process Energy

The facility burns natural gas for process heat. The facility also draws on grid power for electrical needs. Electricity and natural gas usages are calculated from the utility bills.

Energy Inputs and Yields

The inputs and outputs from the plant are provided in spreadsheet format in the Energy Consumption Template (supplied as a separate file).

Chemical and Enzyme Use Rates

The use rate for process chemicals and enzymes are based on historical data. The use rates are based on actual grams per gallon consumption and are detailed in the Energy Consumption Template (supplied as a separate file).

Allocation to Products

Co-product allocation is based on the CA_GREET method for biodiesel

Table 2. CA_GREET Inputs for Biodiesel Production

Yield	GREET Inputs New Leaf	GREET default for UCO	Unit
Biodiesel Yield	[redacted]	0.9615	lb BD/ lb feedstock
Energy Inputs			
Thermal	[redacted]	1,044	Btu/ lb BD
Electricity	[redacted]	0.018	kWh/ lb BD
Glycerin Yield		0.105	lb glycerin / lb BD
Chemicals			
Methanol	[redacted]	865	Btu/ lb BD
Sodium hydroxide	[redacted]	0.44	g/ lb BD
Sodium methoxide	[redacted]	10.48	g/ lb BD
Hydrochloric acid	[redacted]	19.68	g/ lb BD
Phosphoric acid	[redacted]	0.45	g/ lb BD
Citric acid	[redacted]	0.00	g/ lb BD
Sulfuric acid	[redacted]	0.00	g/ lb BD
Diesel Blending	[redacted]	0.000	Blending Fraction

6. Transport and Distribution

Feedstock

Feedstocks are collected from local San Diego county restaurants and renderers. The maps and distances are shown in a separate document. Feedstock is assumed to be transported [redacted] miles by truck from the collection center in both pathways. For the UCO biodiesel pathway, it is also assumed to travel an additional [redacted] miles by rail and [redacted] miles by truck.

Biodiesel Distribution

Biodiesel is transported local customers in the San Diego area. New Leaf distributes directly to customers. The weighted average transport distance is [redacted] miles. This distance is less than the GREET default of [redacted] miles transport plug [redacted] miles distribution. In 2016 New Leaf will distribute to a local San Diego terminal that is [redacted] miles away. Distribution to San Diego will be less than the 50 mile GREET default. Transportation inputs of [redacted] miles and distribution of [redacted] miles are used as the inputs as a conservative value, which is consistent with the historical data.

Blending Component

New Leaf uses a diesel blending component at [redacted] level. The impact on the CI is calculated as a blending adder in Table 4, which is comparable to the ethanol denaturant calculation. The energy weighted biodiesel fraction is added to the energy weighted diesel fraction and the net CI is subtracted from the pure biodiesel CI from CA_GREET to determine the denaturant adder.

7. Pathway Inputs

Process heat and electricity inputs and chemical inputs for biodiesel production based on inputs from 2-year average values of monthly data.

8. Acronyms

Btu:	British thermal units
CO_2e:	Carbon dioxide-equivalent
HHV:	Higher heating value
kWh:	kilowatt-hour
LHV	Lower heating Value
MC:	Moisture content
MGY:	Million gallons per year
mmBtu:	Million British thermal units
scf:	Standard cubic feet (natural gas)

Disclaimer

This report was prepared by Life Cycle Associates, LLC for New Leaf Biofuel of San Diego, California. Life Cycle Associates is not liable to any third parties who might make use of this work. No warranty or representation, express or implied, is made with respect to the accuracy, completeness, and/or usefulness of information contained in this report. Finally, no liability is assumed with respect to the use of, or for damages resulting from the use of, any information, method or process disclosed in this report. In accepting this report, the reader agrees to these terms.

