California LCFS fuel pathway modification: Used cooking oil to biodiesel by Consolidated Biofuels Ltd.- A company in Delta, British Columbia, Canada

GREET modeling technical support document

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I. Introduction

We are applying to add a new pathway to the California LCFS fuel carbon-intensity lookup table. This pathway is for the biodiesel production from used cooking oil (UCO) by the Consolidated Biofuels Ltd. (Referred to as "Consolidated" hereafter), a company in Delta, British Columbia, Canada. It is a modification to the published Midwest UCO pathway GREET model [1]. Although the UCO providers claimed they used "non-cooking" methods to refine the UCO, because no detailed energy consumption information is available from them, the pathway under consideration instead assumes "cooking" is used to refine the UCO for the purpose of being conservative.

Except for the points of deviation summarized below, our pathway is identical to the Midwest UCO pathway GREET model. The pathway differs only in the following:

1) The feedstock and fuel are both produced in Delta, British Columbia, Canada, and the fuel is transported to California by truck for distribution and consumption,
2) Electricity consumed at the plant is generated almost exclusively from hydropower, and
3) Values specific to the Consolidated facility, including the use of electricity and natural gas, are used in the calculation of fuel production energy use.

This application is for low-FFA or "yellow grease" UCO. Feedstock was verified by submitting a feedstock sample to Iowa Central Fuel Testing Laboratory for a forensic feedstock analysis. The sample was found to be consistent with low-FFA UCO feedstock.

Based on our modeling in CA-GREET, we find that the modified pathway has a carbon intensity of **21.34** $gCO_2e\ MJ^{-1}$.

II. Company Details:

The Consolidated Biofuels Ltd. biodiesel facility is located at 7651 Vantage Way, Delta, British Columbia V4G1A6, Canada. The Consolidated Biofuels Ltd. is a coatings manufacturing company with biodiesel production capabilities at the Delta, BC facility. The facility is designed for an annual production of *[Confidential Business Information]* per year of biodiesel and produces glycerin as a co-product for non-fuel markets. The facility has registered with the Central Data Exchange (CDX) with an actual peak capacity of *[Confidential Business Information]* of biodiesel production per year *[Confidential Business Information]*. An assessment was completed by the local air authority which determined that no air permit is required for the facility to operate.

The facility is capable of producing biodiesel under a D code of 4 utilizing any of the following feed stocks whose pathways have been modeled by the EPA including: waste

oils/fats/greases (160); soybean oil (210); canola oil (360), non-food grade corn oil(200); Algal oil (230); and, oil from annual cover crops (240).

The facility is currently operational and produced the following biodiesel production quantities:

[Confidential Business Information]

The Consolidated biodiesel facility produces biodiesel using a batch-continuous system. UCO is first heated to a processing temperature of 55 degree C and the free fatty acids that may be present in the feedstock are esterified in the storage tank. Then the pretreated UCO is converted using a two stage process where the bulk trans-esterification takes place in reactor stage 1 and finishing trans-esterification takes place in reactor stage 2. The quantity of reactant is governed by the chemical stoichiometry of which methanol is added in excess. At the end of reactor stage 1, crude biodiesel and glycerin are separated and the glycerin continues on to the glycerin storage while the crude biodiesel is pumped to reactor stage 2. Reactions stages before reactor stage 2 are in batch mode. After reactor stage 2, methanol is recovered and recycled. A continuous two-stage ion exchange resin system then is used to remove impurities and water from the biodiesel effluent from reactor stage 2. In the end, the qualified biodiesel is transferred to storage tanks.

EcoEngineers conducted an on-site 3rd party engineering review of the Consolidated biodiesel facility on November 16th, 2012, as required under 40CFR Part 80, section 1450 to register under the EPA's Renewable Fuels Standard. EcoEngineers met with Dan Treleaven, President and Barb Lervold, Controller of Consolidated Biofuels Ltd. The on-site review included a review of information provided by the facility prior to the visit and a tour of the quality control laboratory and biodiesel plant.

III. Table of changes to baseline CA-GREET model inputs for the Consolidated pathway

The modified input values to CA-GREET spreadsheet are in Table 1.

Table 1: Changes from CA_GREET spreadsheet for Midwest UCO biodiesel pathway to Consolidated UCO biodiesel pathway

Parameter	Cell location	Midwest UCO value	BC Canada UCO value	Units	Explanation
Region for Analysis	Regional LT!C2	Midwest	CBI		
Region for Analysis	Regional LT!J6	Southeast Asia	CBI		
Res. oil electric generation	Regional LT!J83	0.0%	CBI	%	CBI
Natural gas electric generation	Regional LT!J84	33.5%	CBI	%	CBI
Coal electric generation	Regional LT!J85	51.6%	CBI	%	CBI
Nuclear electric generation	Regional LT!J86	0.0%	CBI	%	CBI
Biomass electric generation	Regional LT!J87	5.8%	CBI	%	CBI
Other (renewables) electric generation	Regional LT!J88	9.1%	CBI	%	CBI
UCO transesterification NG use	UCO BD!F189	889	CBI	btu/lb BD	CBI
UCO transesterification electricity use	UCO BD!F192	47	CBI	btu/lb BD	CBI
UCO transport distance	T&D!IH93	50	CBI	miles	CBI
Biodiesel truck transport distance	T&D!GB93	50	CBI	miles	CBI
Fraction of biodiesel transported by truck	T&D!CL142	80	CBI	%	
Fraction of biodiesel transported by rail	T&D!CL141	100	CBI	%	

IV. Basis for the Input Values

This pathway is similar to the published CA GREET model for UCO biodiesel from Midwest, with changes in the following areas as further detailed below:

1. electricity generation mix
2. fuel production energy use
3. transport modes and distances

The modified CA-GREET spreadsheet is included in the application package.

The Consolidated Biofuels Ltd. produces biodiesel using electricity provided by BC Hydro and natural gas provided by Fortis BC. Total electricity and natural gas consumption from January 2012 to November 2013 is provided in Section XII of this application. BC Hydro's 2012 (the latest found on their website) electric generation mix is 0.5% natural gas, 0.1% diesel, and 99.4% hydropower [2]. However, we reallocated the 99.4% hydropower to natural gas because it is expected that the marginal electricity demand of this facility will be fulfilled by increased natural gas capacity. We assumed the same shares of different natural gas power plant in BC, Canada as in Midwest US, which is 36%, 44% and 20% for Simple-cycle (SCGT) turbine, Combined-cycle (CCGT) turbine, and Utility boiler, respectively. The produced biodiesel is transported by truck from Delta, British Columbia, Canada to the state of California, and then distributed using trucks.

The Auditor's Report to the Department of Natural Resources Canada dated March 2013 and prepared by Samson & Associates was used to estimate energy usage dedicated to biodiesel production. The estimates are described as follows:

Natural gas dedicated to biodiesel production is estimated at 79.98% of the total gas usage measured at the single meter location which feeds both biodiesel and coatings. This estimate is based on the following:

- Total Gas Usage is taken from April 2011 through March 2012 meter readings when biodiesel was being produced
- Gas Usage for the existing coatings business is taken from January 2009 through February 2010 meter readings which is prior to biodiesel production
- From these two data sets tabulated in the report, 79.98% of the combined meter reading is a best estimate of natural gas dedicated to biodiesel production (using figures from Page 22 of the Audit Report: 30,185 m3 / 37,742 m3 = 79.98%)

Electricity dedicated to biodiesel production is estimated at 67.06% of the total electricity usage measured at the single meter location which feeds both biodiesel and coatings. This estimate is based on the following:

- Total Electricity Usage is taken from April 2011 through March 2012 meter readings when biodiesel was being produced
- Electricity Usage for the existing coatings business is taken from January 2009 through February 2010 meter readings which is prior to biodiesel production
- From these two data sets, EcoEngineers proposes that 67.06% of the total combined meter reading is a best estimate of electricity dedicated to biodiesel

production (using figures from Page 23 of the Audit Report: 99,528 kWH / 148,420 kWH = 67.06%)

Energy use values in the submitted pathway are based on facility data from January 2012 to November 2013 during which time low-FFA UCO was used for feedstock. Since Consolidated Biofuels Ltd. also has a coatings manufacturing facility on site, only a fraction of the electricity and natural gas was consumed for biodiesel generation. Engineering audit shows that separate meters are available to monitor the fraction used for biodiesel production. Overall, 79.98% of the natural gas and 67.07% of the electricity was consumed for biodiesel production.

In order to attribute the amount of energy being consumed by the FFA process and transesterification process separately, we took the total amount of energy and subtracted the default value from the total amount consumed to estimate the energy used by the transesterification process. This should not influence the final results as long as the total energy usage is correct that is based on the natural gas and electric meters feeding into each process.

Consolidated Biofuels has continuously used UCO at its facility to produce biodiesel. Consolidated is configured to handle UCO with FFA's up to 10% of the total volume. Low-FFA feedstock here refers to the UCO with less than 10% FFA's, as opposed to higher FFA feedstocks that are available in the market which Consolidated cannot utilize directly. High FFA feedstocks would need to undergo a different pre-treatment process that would have a different energy consumption than the proposed pathway and would therefore not be applicable for CI credit generation.

Consolidated will only utilize UCO feedstock with that contains a maximum of 10% FFA content for all future production that will be used with the proposed pathway. This will ensure that their production process matches their pathway and that their facility will be able to process the materials using the same amount of energy.

This application is only for a new pathway for a low-FFA yellow grease biodiesel at Consolidated, which has a carbon intensity of **21.34 $gCO_2e\ MJ^{-1}$**.

V. CA-GREET Model Output

Table 2: Energy use and emissions from UCO biodiesel produced in the Midwestern U.S. and in BC Canada, separated by life cycle stage. Figures are rounded.

	UCOME Cooking Required, Fuel produced in the Midwest		**UCOME Cooking Required, Fuel produced in BC, Canada**		**% difference**	
	Energy (BTU/MMBTU BD)	**Emissions (gCO2e/MJ)**	**Energy (BTU/MMBTU BD)**	**Emissions (gCO2e/MJ)**	**Energy (BTU/MMBTU BD)**	**Emissions (gCO2e/MJ)**
UCO Transport to Rendering Plant	0.00	0.00	0.00	0.00	0	0
Rendering of UCO	88,681	5.69	88,743	5.26	0%	-8%
UCO Transport (after rendering)	3,912	0.30	9,787	0.75	150%	151%
Biodiesel Production	174,956	6.06	135,614	3.51	-22%	-42%
Biodiesel Transport	28,384	2.19	95,757	7.34	237%	235%
Total (Well To Tank)	**295,933**	**14.24**	**329,901**	**16.86**	**11%**	**18%**
Total (Tank To Wheel)	**1,000,000**	**4.48**	**1,000,000**	**4.48**	**0%**	**0%**
Total (Well To Wheel)	**1,295,933**	**18.72**	**1,329,901**	**21.34**	**3%**	**14%**

VI. Discussion of Results

Table 2 compares energy use and emissions from the proposed pathway to those from reference [1] for UCO biodiesel produced in the Midwestern U.S. with cooking. The UCO is rendered before being transported to the Consolidated biodiesel facility; energy use data for rendering is not available from the facility. We assume the same energy consumption for this rendering in Consolidated pathway as in the Midwest pathway. As a result, emissions from UCO rendering are slightly lower for production in Consolidated compared to production in the Midwestern U.S due to the cleaner electricity mix in BC Canada. Also due to the cleaner electricity generation, the emissions during biodiesel production for Consolidated are lower than that from Midwest. Shipping the biodiesel from British Columbia, Canada by truck creates more emissions than shipping biodiesel from the Midwest by rail. Actually, the transportation of biodiesel from BC Canada to CA is the most carbon-intensive life cycle stage for Consolidated biodiesel. Overall, the Consolidated pathway has 14% higher GHG emissions than the Midwest US pathway.

VII. Production Range of the Consolidated Pathway

The new pathway should be applicable to the Consolidated Biofuels Ltd. biodiesel facility for the actual peak capacity of *[Confidential Business Information]* registered on CDX.

VIII. Sustainability of the Consolidated Pathway

The Consolidated Biofuels Ltd. biodiesel facility was designed and constructed using well-established modern designs and equipment and is managed by professional staff well-qualified to assure that over time the energy efficiency of and emissions from the facility do not deteriorate. Any deterioration would result in a less profitable business. Thus the sustainability of the plant is well aligned with the business objectives of the owners.

IX. Impact on Land Use

Since the raw material discussed is Used Cooking Oil, there is no land use impact.

X. Conclusion

Based on our modeling in CA-GREET and the available data, we find that biodiesel produced from low-FFA or "yellow grease" UCO at the Consolidated biofuels Ltd. biodiesel facility has a carbon intensity of 21.34 $gCO_2e\ MJ^{-1}$.

XI. References:

1. *Detailed California-Modified GREET Pathway for Biodiesel Produced in the Midwest from Used Cooking Oil and Used in California*. Version 2.0. California Environmental Protection Agency Air Resources Board, 2011.
2. *Sustainable electricity indicators BC Hydro performance results 2011 and 2012.* http://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/accountability-reports/global-reporting-initiative/sustainable-electricity-reporting-2011-2012.pdf
3. *Detailed California-Modified GREET Pathway for Biodiesel Produced in California from Used Cooking Oil.* Version 2.0. California Environmental Protection Agency Air Resources Board, 2009.

XII. Documents supporting Annual Quantities of electricity and natural gas use and biodiesel production

The 2012 and 2013 monthly utility bills and natural gas bills authenticating the amounts of electricity and natural gas shown in the table above are on the following pages.

Table 3: Summary of Electrical Power and Natural Gas Monthly Invoices 2012 and 2013

2012

Month	**Electricity purchased (kWh)**	**Natural gas (GJ)**	**Biodiesel production (L)**
Jan	15,300	149.8	CBI
Feb	15,300	150.4	CBI
Mar	19,440	174.4	CBI
Apr	19,620	159.7	CBI
May	17,640	151.8	CBI
Jun	15,300	113.5	CBI
Jul	19,980	130.3	CBI
Aug	20,520	124.2	CBI
Sep	19,620	8.5	CBI
Oct	16,020	83.4	CBI
Nov	18,900	123.2	CBI
Dec	14,940	105.3	CBI

2013

Month	**Electricity purchased (kWh)**	**Natural gas (GJ)**	**Biodiesel production (L)**
Jan	13,320	94.2	CBI
Feb	15,300	100	CBI
Mar	9,540	54.7	CBI
Apr	15,300	123	CBI
May	13,500	99	CBI
Jun	12,780	73.3	CBI
Jul	17,100	105	CBI
Aug	16,740	105	CBI
Sep	16,920	84	CBI
Oct	18,900	172	CBI
Nov	16,740	140	CBI
Dec			