# California LCFS fuel pathway modification: Used cooking oil to biodiesel in Shanghai with electricity and diesel fuel as sources for processing energy

**GREET modeling technical support document**

**Table of Contents**


I. Introduction

II. Shanghai Luming Biodiesel Facility Details

III. Changes to Baseline CA-GREET Model Inputs for Shanghai Luming Facility

IV. Basis for the Input Values

V. CA-GREET Model Output

VI. Discussion of Results

VII. Production Range of Shanghai Luming Biodiesel Facility

VIII. Sustainability of Shanghai Luming Facility

IX. Impact on Land Use

X. Conclusion

XI. References

XII. Data Supporting Annual Quantities of Electricity, Diesel Fuel Use and Biodiesel Production

## I. Introduction

We are applying to add a new pathway to the California LCFS fuel carbon-intensity lookup table. This pathway is a modification to the published Midwest used cooking oil (UCO) pathway GREET model [1]. The pathway under consideration does not use "cooking" to refine the UCO.

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 Shanghai and the fuel is shipped to California via ocean tanker for distribution and consumption,
2) Electricity mix is specific to China, and
3) Values specific to the Shanghai Luming facility, including the use of electricity and diesel fuel, are used in the calculation of fuel production energy use.

This application is for low-FFA or "yellow grease" UCO. Based on our modeling in CA-GREET, we find that the modified pathway has a carbon intensity of **16.86** $gCO_2e\ MJ^{-1}$.

## II. Company Details

Shanghai Luming Environmental Protection Technology Co., Ltd. is a biodiesel production facility located at 99 Diantai Road, Huacao County, Minhang District, Shanghai, China. It was constructed between December 2009 and January 2011. It is owned by China Authority Company which also owns another biodiesel plant in Hong Kong, China.

The facility operates under a permit issued by the Shanghai City Minhang District Environmental Protection Agency. This license limits production to 3 million gallons of biodiesel per year or 10,000 metric tons per year (10,000 metric tons per year X 1,000 kg per metric ton X 2.205 lbs per kg X 1 gal per 7.35 pounds biodiesel).

The Shanghai Luming biodiesel facility accepts only waste oils/fats/greases including UCO and brown grease as part of an overall Shanghai program to prevent black market introduction of used gutter oil into the human food chain. Under this program, UCO and brown grease is collected by 10 registered collectors and processed at two biodiesel facilities. The Shanghai Luming facility is one of two biodiesel producers for Shanghai. Only waste oils/fats/greases may be processed into biodiesel within China. Use of food grade oils is not allowed. So while the Shanghai Luming facility is capable of using a variety of feed stocks, registration is sought for waste oils/fats/greases only.

Shanghai Luming facility utilizes a typical transesterification process to convert triglycerides present in UCO into methyl esters. The raw UCO or brown grease is

separated from wastewater and solid impurities through a centrifugal process. The treated lipids are converted to crude fatty acid methyl esters (FAMEs) in reactors by esterification and trans-esterification processes. After centrifugal separation of the crude FAMEs and the glycerol phase, the crude FAME is further purified from traces of free glycerol by an absorption process. The crude FAMEs will be further refined into high quality biodiesel by a distillation process. The Shanghai Luming facility uses diesel fuel fired boilers for process heat.

EcoEngineers conducted an on-site 3rd party Engineering Review of Shanghai Luming's biodiesel facility on June 12, 2013, as required under 40 CFR Part 80, section 1450 to register under the EPA's Renewable Fuels Standard. EcoEngineers met with Mr. Wong Yiu Kwong, Operations Director; Ji Weilong, Plant Manager and Jiang Shi Jie, Project Coordinator. 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 renewable fuel production facility.

## III. Changes to baseline CA-GREET model inputs for Shanghai Luming facility

The modified input values to CA-GREET spreadsheet are all listed in a separate spreadsheet. CI calculation results can be found in the "UCO Results" tab of the modified CA-GREET spreadsheet. A spreadsheet listing of all GREET model changes is available in the Shanghai Original Data File under the "1.0 Change made to CA GREET" tab.

## 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 (2.0 Electricity Mix)
2. Fuel production energy use (3.0 Electricity, 4.0 Diesel Fuel)
3. Transport modes and distances (5.0 Transportation)

Next to each item in parentheses is the supporting documentation reference in the Shanghai Original Data File reference.

The modified CA-GREET spreadsheet is included in the application package; results can be found in the "UCO Results" tabs.

The Shanghai Luming biodiesel uses electricity from the Shanghai Municipal Electric Power Co., Ltd. and diesel fuel for its process energy requirements. Total electricity and diesel fuel consumption from January 2013 to December 2013 is provided in the same spreadsheet in which modifications to CA-GREET were documented. China's current electric generation mix is 75.8% coal, 1.6% natural gas, 3.8% nuclear, 0.3% residual oil,

0% biomass, and 18.5% others [2]. The produced biodiesel is transported using ocean tankers from Shanghai port to CA port, and then distributed using trucks.

Energy use values in the submitted pathway are based on facility data from January 2013 to December 2013 when low-FFA UCO feedstock was used. This application is only for a new pathway for a low-FFA yellow grease biodiesel at Shanghai Luming, which has a carbon intensity of **16.86 $gCO_2e\ MJ^{-1}$**.

It is worth noting that in 2013, the facility experienced a re-engineering process. Therefore although the facility provided the 2012 electricity and fuel oil usage, the 2013 data are more representative for the current facility and are adopted here.

Supporting Methanol calculations can be viewed in the Shanghai Original Data File under the tab labelled "6.0 Methanol."

Table 1: Input Values used in the GREET model to calculate the CI number for the Shanghai Ming Green Pathway.

| Parameter | Cell location | Default Midwest value | Shanghai UCO value | Units |
|---|---|---|---|---|
| **Res. oil electric generation** | Regional LT!J83 | 0% | 0.3% | % |
| **Natural gas electric generation** | Regional LT!J84 | 33% | 1.6% | % |
| **Coal electric generation** | Regional LT!J85 | 52% | 75.8% | % |
| **Nuclear electric generation** | Regional LT!J86 | 0% | 3.8% | % |
| **Biomass electric generation** | Regional LT!J87 | 6% | 0.0% | % |
| **Other (renewables) electric generation** | Regional LT!J88 | 9% | 18.5% | % |
| **FFA transesterification NG use** | UCO BD!E189 | 155 | 0 | btu/lb BD |
| **FFA transesterification diesel fuel use** | UCO BD!E187 | 0 | 155 | btu/lb BD |
| **FFA transesterification electricity use** | UCO BD!E192 | 16 | 16 | btu/lb BD |
| **UCO transesterification NG use** | UCO BD!F189 | 889 | 0 | btu/lb BD |
| **UCO transesterification diesel use** | UCO BD!F187 | 0 | 445 | btu/lb BD |
| **UCO transesterification electricity use** | UCO BD!F192 | 47 | 161 | btu/lb BD |
| **UCO transesterification methanol use** | UCO BD!F194 | 865 | 1,159 | btu/lb BD |
| **FFA Transesterification % diesel fuel boiler** | UCO BD!C151 | 0 | 100% | % |

| | | | | |
|---|---|---|---|---|
| **UCO Transesterification % diesel fuel boiler** | UCO BD!D151 | 0 | 100% | % |
| **Ocean tanker transport distance (miles)** | T&D!GB93 | NA | 6,585 | miles |
| **Biodiesel truck transport distance (miles)** | T&D!GC93 | 50 | 67 | miles |
| **Biodiesel ocean tanker payload (tons)** | T&D!V5 | -- | 35664 | tons |
| **Biodiesel ocean tanker horsepower requirement** | T&D!T12 | -- | 12672 | hp |
| **Column for biodiesel ocean tanker** | T&D!GB90:132 | Move right (insert new transport column) | | |
| **Title** | T&D!GB91 | -- | Ocean Tanker | |
| **Ocean tanker fraction diesel power** | T&D!GB95 | -- | 0% | % |
| **Ocean tanker fraction residual oil power** | T&D!GB96 | -- | 100% | % |
| **Ocean tanker outbound energy intensity** | T&D!GB108 | -- | 71 | btu/ton-mile |
| **Fraction of biodiesel transported by ocean tanker** | T&D!CL138 | 0 | 100 | % |
| **Fraction of biodiesel transported by truck** | T&D!CL142 | 80 | 100 | % |

## V. CA-GREET Model Output

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

| | **UCOME Cooking Not Required, Fuel produced in the Midwest** | | **UCOME Cooking Not Required, Fuel produced in Shanghai** | | **% 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 | Confidential | Confidential | Confidential | Confidential |
| *Rendering of UCO* | NA | 0.80 | Confidential | Confidential | Confidential | Confidential |
| *UCO Transport (after rendering)* | 3,912 | 0.30 | Confidential | Confidential | Confidential | Confidential |
| *Biodiesel Production* | 174,956 | 6.06 | Confidential | Confidential | Confidential | Confidential |
| *Biodiesel Transport* | 28,384 | 2.19 | Confidential | Confidential | Confidential | Confidential |
| *Total (Well To Tank)* | | **9.35** | Confidential | Confidential | Confidential | Confidential |
| *Total (Tank To Wheel)* | **1,000,000** | **4.48** | Confidential | Confidential | Confidential | Confidential |
| *Total (Well To Wheel)* | **NA** | **13.83** | **1,254,737** | **16.86** | Confidential | Confidential |

* NA indicate values that could not be found in references [1] or [4].

## 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. without cooking. The UCO is rendered before being transported to the Shanghai Luming biodiesel plant; energy use data for rendering is not available from the plant. We assume the same energy consumption for this rendering in Shanghai pathway as in the Midwest pathway. As a result, emissions from UCO rendering are similar for production in Shanghai compared to production in the Midwestern U.S. The majority of the emissions for both pathways come from the biodiesel production, in which production in Shanghai consumes more

electricity, more diesel fuel, but no natural gas compared to the production in the Midwestern U.S. Overall, the Shanghai process consumes slightly higher total fossil fuel than that of Midwestern U.S. Shipping the UCO BD from Shanghai by ocean tanker creates more emissions than shipping UCO BD from the Midwest by rail.

## VII. Production Range of the Shanghai Luming Facility

The new pathway should be applicable to the Shanghai Luming biodiesel facility for 100% (3,000,000 gallons/year) of Permitted Capacity.

## VIII. Sustainability of the Shanghai Luming Facility

The Shanghai Luming 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 Shanghai Luming biodiesel plant has a carbon intensity of **16.86 $gCO_2e\ MJ^{-1}$**.

## 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. *International Energy Outlook 2013.* US Energy Information Administration, 2013. *Available at:* http://www.eia.gov/forecasts/ieo/ (Accessed April 4th, 2014).

3. *Farnel Capital Incorporated. Port to port distances, 2013. Available at: http://www.searates.com/reference/portdistance/ (Accessed April 4th, 2014).*

4. *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. Data supporting Annual Quantities of electricity, diesel fuel use and biodiesel production

The data supporting the annual quantities of electricity, diesel fuel use and biodiesel production, as well as the modifications to the CA-GREET model and methanol calculations are documented in a separate spreadsheet named “Shanghai Original Data File”.