California LCFS fuel pathway modification: South Korean used cooking oil to biodiesel

GREET modeling technical support document

Summary:

We are applying to add a new pathway to the California LCFS fuel carbon-intensity lookup table. Our pathway is a modification to the existing pathway for biodiesel produced in California from used cooking oil[1]. The modified pathway is identical to the version of the existing pathway which uses mechanical separation instead of "cooking" to refine the used cooking oil, with the exception that the feedstock and fuel are both produced in South Korea and shipped to California via ocean tanker for distribution and consumption. Based on our modeling in CA-GREET, we find that the modified pathway has a carbon intensity of **15.01** $gCO_2e\ MJ^{-1}$. The carbon intensity for the modified pathway is similar to the carbon intensity from UCO-biodiesel produced in the U.S. Midwest[3].

Company Details:

Dansuk Industrial Co. Ltd. operates a biodiesel plant in the Republic of Korea registered with the USEPA under the registration requirements of Part 80.1450 to produce biodiesel using Used Cooking Oil (UCO) as feedstock. The plant has a registered capacity of 21.13 million gallons per year. The Dansuk biodiesel facility is located at #1239-5 Jeongwang-Dong, Shiheung-City, Kyonggi-Do, Korea. The facility uses liquified natural gas and electricity for process energy. The facility is capable of producing Biodiesel utilizing a variety of feedstock.

The Dansuk biodiesel facility is owned by Dansuk Industrial Co., a diversified S. Korean chemicals company that supplies processed metals and fine chemicals to a variety of industries. Dansuk Industrial Co. was established in 1965 and has been operating continuously since then. More information can be found at http://www.dansuk.co.kr/ENG/main/main.php.

The Dansuk Industrial Co. Biodiesel Plant processes incoming UCO and produces UCO Methyl Esters (UCOME). It also processes other oils to make biodiesel. Only the UCOME is sold into the export market. Some of the UCOME and all the biodiesel from other oils are sold into the domestic market. The incoming UCO and the manufactured UCOME are stored in dedicated tanks at the plant. The UCOME is then transferred from the plant to the port approximately 60 kilometers away s via tanker trucks and stored in dedicated shore tanks.

On May 25, 2012, EcoEngineers performed an-site 3rd party engineering review of the Dansuk Industrial Co. Biodiesel Plant, where EcoEngineers staff met with Seung-Uk Han, Vice President; Chul-Seung Lee, General Manager; Jin-Won Jang, Manager; Jong-Woan Kim, Senior Research Engineer; and, Soo Min Kang, Assistant Manager. The on-site review included the following activities:

- Review of information provided by Dansuk on plant operations
- Tour of the quality control laboratory and biodiesel plant
- Performance of a mass balance audit with review of feedstock and biodiesel production for a 46 hour test run

Pathway description and itemized GREET changes:

Below is a description of the pathway (numbered items), as well as the modifications that were made to CA-GREET (as downloaded from LCFS website; file name: ca_greet1.8b_dec09.xls) to model the pathway (bulleted items). The modified CA-GREET spreadsheet is included in the application packet; results can be found in the "UCO Results" tab.

1. The Korean biodiesel producer receives shipments of unrefined UCO by tanker truck from an average distance of 66 miles away.

    - Leave distance from UCO supplier (T&D!IG93) as 0 miles, assuming the UCO would have to travel a comparable distance to a landfill if not converted to biodiesel

2. In a South Korean facility, the UCO is dewatered by heating it to liquefy it and break the oil-water emulsion, then the liquefied grease is filtered and the water and sediment is allowed to settle from the oil.

    - Change electrical generation mix (Regional LT!J83:88) to the South Korean electrical generation mix[2], modified to represent marginal generation by substituting natural gas for nuclear and "other renewable", as in the following table:

Fuel	Generation fraction
Residual oil	4.4%
Natural gas	49.5%
Coal	46.0%
Nuclear	0.0%
Biomass	0.1%
Other (renewable)	0.0%

- Change UCO processing energy intensity (UCO_BD!B11) to 152 btu/lb UCO (from CARB UCO report[1] for processes not using cooking; formula = (7224/7.5+0.241*3412/7.5)*0+(938/7.5+0.06*3412/7.5)*1)

- Change UCO processing shares of process fuels (UCO_BD!C174&C177) to 82% NG, 18% electricity to match the relative contributions of natural gas and electricity in the above formula.

3. In the same facility, FFA esterification and transesterification is performed to convert the UCO into biodiesel, using electricity, natural gas, and methanol as the only significant inputs, and getting biodiesel and glycerin as the only outputs. A chemical catalyst is also used as an input, but we follow the GREET1.8b assumption that catalysts are not an important contributor to life cycle emissions.

    - Change distance from UCO refiner to biodiesel producer (T&D!IH93) to 0 miles (was 50 miles)

4. The finished biodiesel is shipped 37 miles to a port by tanker truck, then shipped to California by ocean tanker, where it is blended with diesel and distributed to refilling stations.

    - Add pathway for biodiesel transportation by ocean tanker in T&D sheet (column GB).

    - Change biodiesel distance traveled by truck (T&D!GC93) to the distance from the biodiesel production facility to the port (37 miles) plus the distance traveled in California from the port to the bulk terminal (80% * 50 miles + 20% * 0 miles) for a total of 77 miles.

    - Set the biodiesel distance traveled by ocean tanker (T&D!GB93) to the shipping distance from Seoul to Long Beach (6594 miles[4]).

    - Change biodiesel cargo transported by ocean tanker (cell T&D!V5) to 35,664 short tons (from information on actual vessel to be used).

Comparison of results to UCO biodiesel from the Midwest where cooking is not required:

Table 1: Energy use and emissions from UCO biodiesel produced in the Midwestern U.S. and in South Korea, separated by life cycle stage

	UCOME Cooking Not Required, Fuel produced in the Midwest	**UCOME Cooking Not Required, Fuel produced in S. Korea**	

	Energy (BTU/MMBTU BD)	Emissions (gCO2e/MJ)	Energy (BTU/MMBTU BD)	Emissions (gCO2e/MJ)	% difference	
UCO Transport to Rendering Plant	0.00E+00	0.00	0.00E+00	0.00	-	-
Rendering of UCO	NA	0.80	1.39E+04	0.95	NA	19%
UCO Transport (after rendering)	3.91E+03	0.30	0.00E+00	0.00	-100%	-100%
Biodiesel Production	1.75E+05	6.06	1.75E+05	6.09	0%	0%
Biodiesel Transport	2.84E+04	2.19	4.29E+04	3.49	51%	60%
Total (Well To Tank)	**NA**	**9.35**	**2.31E+05**	**10.53**	**NA**	**13%**
Total (Tank To Wheel)	**1.00E+06**	**4.48**	**1.00E+06**	**4.48**	**-**	**-**
Total (Well To Wheel)	**NA**	**13.83**	**1.23E+06**	**15.01**	**NA**	**9%**

NA means ARB pathway report does not include values for low-energy rendering.

Table 1 compares energy use and emissions from the proposed pathway to those from reference [3] for UCO biodiesel produced in the Midwestern U.S. without cooking. Emissions from UCO rendering and biodiesel production are slightly higher for production in South Korea compared to production in the Midwestern U.S. owing to a dirtier electrical grid. Because the Korean UCO rendering and biodiesel facilities are co-located, the Korean biodiesel does not include emissions from transportation between the facilities. Shipping the UCO from Korea by ocean tanker creates slightly more emissions than shipping UCO from the Midwest by rail.

Table detailing changes from baseline CA_GREET

See included file “Dansuk_changes.xlsx”

References:

1. *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.

2. International Energy Agency, *IEA Energy Statistics -- Electricity for Korea, Republic of, 2009*. Available from: http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=KR (Accessed March 14, 2013).

3. *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.

4. Farnel Capital Incorporated. *Port to port distances*, 2013. Available from: http://www.searates.com/reference/portdistance/ (Accessed March 14, 2013).