Methes Energies Canada Inc.

Life Cycle analysis of the Methes Biodiesel Fuel Pathway

Introduction:

The Methes Energies Canada Inc. (Methes), Sombra facility is located at 224 Holt Line West, Sombra, Ontario, Canada, N0P 2H0 and is owned by Methes. This Sombra facility has been designed to produce 13.5 million gallons of biodiesel per year with a maximum flow rate of 1585 gallons per hour.

The property is a 22 acre facility which was previously utilized as a chemical processing facility providing many advantages compared to a green field construction project. Infrastructure in place included, storage tanks with spill containment, storm water management systems, onsite rail service, roads for traffic, administration, maintenance and process buildings and employee comfort requirements including a kitchen / lunch room, washrooms, showers and emergency first aid infrastructure. Potable water, natural gas and sewage service are utilized from local supply which is delivered via buried road side piping.

The geographical region where the plant is located has a long history of petrochemical processing making available extensive local resources including but not limited to skilled journey men / contractors, health and safety resources for enhanced training and compliance, local government understanding of process based industry and human resource advantages.

Process Overview

The biodiesel production process includes two (2) Denami 3000 process modules.
The Denami 3000 is a closed looped continuous biodiesel modular process systems that connects above ground storage tanks (ASTs) to the processor. This is achieved via above ground piping for inputs of feedstock and methanol and outputs of glycerine and biodiesel. Each Denami 3000 unit is expected to produce 3,000 litres (792.5 gallons) of biodiesel per hour or approximately twenty five million litres of biodiesel per year. The two units are expected to produce 50,000,000 litres (13,208,602.55 gallons) net per annum.

The conversion process is a standard transesterification process of mixing natural oils with methanol and a catalyst to convert to biodiesel and is technically described as the base-catalyzed transesterification of oils with methanol for the production of biodiesel. The conversion process is more generally described as follows:

Feedstock or raw products consisting of animal or vegetable based fatty acids (triglycerides) are received by rail and stored in ATSs identified as 'Feedstock Storage Tanks'. Process chemicals consisting of methanol and a catalyst (high pH base) are also received by rail or transport truck and stored in ASTs. The feedstock, methanol and catalyst are pumped directly from their storage units into the two Denami 3000 processors. The approximate ratio of material transfer to the processors is 90 percent feedstock, 9 to 10 percent methanol and 0 to 1 percent of catalyst. Within the Processor, low heat (generally 71 to 82 degrees Celsius), and pressure (15 to 30 psi), are applied to force the chemical conversion of the feedstock/methanol/catalyst mixture to methylated fatty acids (biodiesel) and glycerine. The final stage of processing is to remove the glycerine from the biodiesel (referred to as polishing). Glycerine is then pumped from the processor into an AST identified as 'Glycerine Storage' and then shipped via rail as commodities to consumers of this product. Biodiesel will be stored in ASTs and tested internally every day to ensure fuel quality. Three samples will be taken from each tank from the top, middle and bottom and submitted for analysis to an accredited laboratory for testing in accordance with American Society for Testing and Materials (ASTM) Method D6751 Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels. Provided that the fuel passes testing with respect to the ASTM analysis, the biodiesel will be sold as a commodity.

Feedstock, Acquisition, and Storage

Methes currently uses UCO and non-food grade corn oil for its feedstock where one gallon of feedstock produces roughly one gallon of biodiesel at current throughputs and yields. UCO is delivered by rail and non-food grade corn oil is delivered by truck.

Property	Test Method	Limits	Units
Calcium and Magnesium	EN14538	5 MAX	ppm (ug/g)
Sulphur	D5453 0.0015	max (15%)	% mass (ppm)
Phosphorus content	D4951	0.001 max	% Mass
Sodium and Potassium	EN14538	5 max	ppm (ug/g)
FFA	D5555	4 max	% Mass
Water	EN ISO 12937	0.3 max	% Mass
Insoluble		0.2 Max	% Mass

Methes processes from UCO and corn oil extracted from distillers grains prior to drying for its production of biodiesel, however Methes does not collect or process raw product. All feedstock is purchased at or above the above specification which does not require additional purification.

UCO feedstock is delivered to our plant by rail tanker and corn oil feedstock is delivered to our plant by truck and is pumped via above ground piping into above ground storage tanks until it is required in the process.

Corn oil has been purchased from **confidential business information redacted**. This address is an accounting office and not the ship from address. Within the supplied invoices from **confidential business information redacted** there is a ship to address of Methes Energies, **confidential business information redacted**. The corn oil was shipped from **confidential business information redacted** by truck and transloaded to our rail cars for forwarding to our plant in Sombra. The total mileage including truck and rail from the **confidential business information redacted**.

In consultation with **confidential business information redacted**, corn oil is shipped to Methes Energies from ethanol plants is well within a 400 mile radius of our plant and their accounting address is for administration only.

Feedstock is purchased from the following companies:

confidential business information redacted

Process Units

Specific process units include:

- feedstock pre-treatment to remove excess water, impurities
- acid esterification for the conversion of free fatty acids
- metered inputs: feedstock oil, methanol and catalyst (100:10:1)
- mixing and reaction of the inputs

- methanol recovery through primary evaporation (recovered methanol is then returned to the methanol storage tank for reuse in the process)
- settling for the natural separation of biodiesel and glycerin
- biodiesel polishing via ionic resin (waterless wash)
- final methanol evaporation from the finished biodiesel (recovered methanol is then returned to the methanol storage tank for reuse in the process)

Scenario:

The Methes Sombra facility is located in Sombra, Ontario, Canada and is applying for a Method 2B pathway to produce biodiesel from UCO. Although there is currently a pathway utilizing UCO a new pathway is required to encompass our foreign geographical location.

Energy Requirement

Methes Sombra Facility utilizes process steam generated by a 150 HP natural gas steam boiler, hot water for internal tank heating to maintain fluid oil generated by a 400 HP hot water boiler and electrical power to pump motors and process electronics.

Natural gas usage for the plant using the Denami 3000 processors is (0.0015817 m3 per 1 kg of biodiesel or 0.0015817 m3 per 1 gallon) 0.055857 ft3 per 1 gallon of biodiesel processed. 1kg x 3.33= 1 gallon and 1m3= 35.315 ft3

The electrical energy consumption of the Sombra Plant is calculated as 0.1012 kWh per gallon of biodiesel produced. This number is from data measured over a three day continuous production run, and is calculated as follows:
Plant Average Base Load (Biodiesel Process not Running) = 47.4 kW
Plant Average Total Load (Biodiesel Plant Running) = 131.6 kW
Process Load = 84.2 kW
Total Continuous Run Time = 4,690 minutes (3.26 days)
Total Energy Consumed by Process = 6,582 kWh
Total Biodiesel Produced = 65,050 gallons
Electrical Energy per Gallon Produced = 0.1012 kWh/gallon

Feedstock Accounting

Methes Energies utilizes the **confidential business information redacted** accounting system which also monitors Purchase orders, work orders, deliveries, shipments and inventory.

To present how we can accurately demonstrate which specific feedstock is part of an outgoing load (batch#) of biodiesel we look back via queries **confidential business information redacted**. I have

provided the documents/reports we generate to track back to inputs from a biodiesel sales invoice and have attached them to this report as Appendix 1.

The first item to look at is the Sales invoice (attached Sales Invoice 81274), within the Additional Information box at the bottom of the invoice you will see a Lot #, BD08330. Each railcar is assigned its own lot number upon sealing of that load.

From this lot number, BD08330, we perform a query to find out what entries are there assigned to that lot #, In this case as shown on Detailed Inventory History by Lot Serial Number 1.pdf we find three input entries coded with RL (relocate) from location 000005 (Sombra) for batch BD08330 and that those relocates were performed on 27 September 2013.

We then run a query on location Sombra on the date specified (27 September 2013) to find the batch numbers and volumes that were combined to form the outgoing batch number BD08330. The results of that query are seen in Detailed Inventory History by Lot Serial Number 2.pdf

We then look for the source of one of the inputs to BD08330 discovered and find one of them to be (indicated by the number 3 in a circle) and see the input was from BD07652.

We run a query on Lot # BD07652 to produce Detailed Inventory History by Lot Serial Number 3.pdf and look for the time stamp and volume we found in Detailed Inventory History by Lot Serial Number 2.pdf to identify the ReLocate (RL) and in that report we also see the Work Order of origin.

We run a query on the Work Order 20115. This report (Detailed Inventory History by Lot Serial Number 4.pdf) shows all of the inputs to Work Order 20115 and we could search each of the inputs but for this description we chose OIL07626 for demonstration.

We run a query on OIL07626 (Detailed Inventory History by Lot Serial Number 5.pdf)and see it originated from Work Order WO-20120.

We run a query on W0-20120 In this report (Detailed Inventory History by Lot Serial Number 6.pdf) we see the inputs to OIL07626, being OIL07437 and OIL07594. We could trace both but chose OIL07437 for demonstration.

We run a query on OIL07437 (Detailed Inventory History by Lot Serial Number 7.pdf)and see it came from PO-23712-1 and PO-23712-3, indicating the PO number-number-line item.

We then look to PO-23712 lines 1 and 3 and see this input was Corn Oil from **confidential business information redacted**.

In conclusion, Methes can accurately track back from any outgoing biodiesel load back to the type, source, date and volume or ratio of any inputs to that shipment.

Assumptions from the ARB Pathways:

Methes is using the following ARB default CI values for generic pathways and adjusting the electricity mix, feedstock distance and mode and distance of transport of the finished biodiesel fuel to market:

- Conversion of UCO to biodiesel (fatty acid methyl esters - FAME) where "cooking" is required (BIOD003)
- Conversion of corn oil, extracted from distillers grains prior to the drying process, to biodiesel (BIOD007)

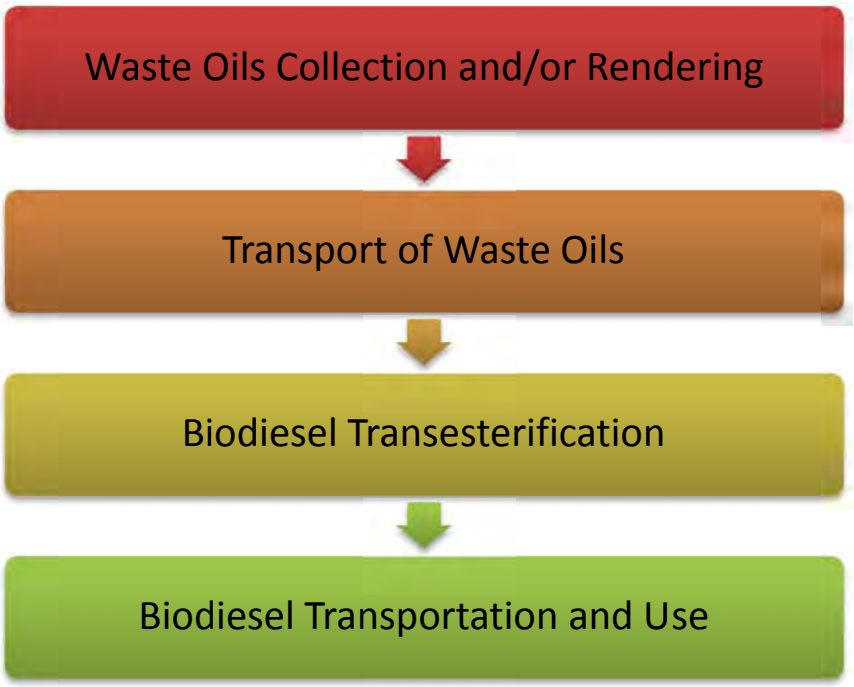
The electricity mix for Canada:

Average Power Mix	Marginal Mix
Residual Oil – 0%	Residual Oil – 0%
Natural Gas – 27.9	Natural Gas – 95.4%
Coal – 9.2%	Coal – 0%
Nuclear – 36.2%	Nuclear – 0%
Biomass – 0.3%	Biomass – 0.3%
Other (renewables) – 26.4% (hydro – 22.1%, wind – 4.3%)	Other (renewables) – 4.2%

New coal fired electricity production has been effectively banned in Canada as plants will only be approved if the emission intensity is less than 420 kg/MWh, about the same level as an advanced natural gas fired plant (http://laws-lois.justice.gc.ca/eng/regulations/sor-2012-167/index.html). Therefore, the marginal mix is derived by adding the proportion from coal, nuclear, and hydro generation to natural gas generation.

The distance traveled for feedstock delivered by rail from our major suppliers to our production facility is from 75 - 400 miles. The distance traveled for finished biodiesel product by rail from our production facility to California is 2,353 miles.

Figure 1: Process Flow Diagram of Waste Feedstocks to Biodiesel



Summary:

Based on the above assumptions, CA-GREET calculates the CI values by process shown in Table 1 and Table 2 for two feedstock pathways: Cooked UCO and Corn Oil.

Table 1: Summary of Carbon Intensity Associated with Biodiesel Production from UCO by Process:

Components	Carbon Intensity – gCO2e/MJ
UCO Rendering	5.78
UCO Transportation and Distribution (T&D)	0.49
Biodiesel Production	5.80
Biodiesel T&D	3.20
Tail pipe emissions	4.48
Total Well to Wheels	**19.75**

Table 2: Summary of Carbon Intensity Associated with Biodiesel Production from Corn oil by Process:

Components	Carbon Intensity – gCO2e/MJ
Corn Oil Extraction	12.94
Corn Oil T&D	9.01
Biodiesel Production	5.07
Biodiesel T&D	3.21
DGS credit	10.6
Energy Saving credit	-28.69
Tail pipe emissions	4.48
Total Well to Wheels	**16.62**

Conclusion:

As shown in Table 1 and Table 2 above the CA-GREET calculation of CI value for Biodiesel produced from Cooked UCO at the Methes Energies plant in Canada and transported to California by rail will be 19.75 gCO2e/MJ; and for Biodiesel produced from corn oil at the Methes Energies plant in Canada and transported to California by rail will be 16.62 gCO2e/MJ.

Appendix 1