User Guide: How to model biodiesel using GHGenius 5.02b or 5.02c

Issued: May 2025

Revised: November 2026

Executive Summary

This guide assists fuel producers and suppliers in determining the carbon intensity of biodiesel supplied in British Columbia (BC) using GHGenius 5.02b as the approved model of GHGenius, and GHGenius 5.02c as an alternative method.

The guide covers the steps that GHGenius users must follow to model a specific biodiesel pathway. This includes ensuring that Excel can properly run the model, setting up the model with correct region, year and using the Global Warming Potentials (GWPs) specified in the BC regulations, and inputting the facility specific data.

This guide also details how to run the model multiple times for activities that occur in multiple regions and describes where to find the results in GHGenius.

Table of Contents

1 Introduction 9
1.1 Approved Version of GHGenius 9
1.2 Process Overview 10
2 Initializing the Model 14
2.1 Excel Macro Settings 14
2.2 Reset Model 15
2.3 Production Region 15
2.4 Year 17
2.5 GWP 17
3 Feedstock 18
3.1 Feedstock Production 18
3.2 Feedstock Transportation 19
3.3 Oil Extraction from Feedstocks 20
4 Biodiesel Production and Transportation 21
4.1 Year 21
4.2 Mass and Energy 21
4.2.1 Electricity 22
4.2.2 Diesel Fuel 22
4.2.3 Natural Gas 22
4.2.4 Feedstock 22
4.2.5 Chemicals 22
4.3 Co-products 24
4.3.1 GHGenius 5.02b Allocation by Energy Method 25

4.3.1.1 Energy Allocation Out-of-Model Calculation 27
4.3.2 GHGenius 5.02c Allocation by Displacement Method..... 28
4.4 Carbon Capture and Sequestration 29
4.5 Biodiesel Transportation 29
4.5.1 Transloading 29
5 BC Distribution, Dispensing and Use 31
6 Material Balance Calculation 32
6.1 Biodiesel Material Balance Example 32
7 Soybean Oil Biodiesel Example 34
7.1 Soybean Oil Example – Material Balance..... 39
8 Tallow Biodiesel Example 41
8.1 GHGenius 5.02b out-of-model calculation 44
8.2 Tallow Example – Material Balance 48
9 Canola Biodiesel Example..... 50
9.1 GHGenius 5.02b Energy Allocation Calculation 54
9.2 Canola Example – Material Balance 57

List of Tables

Table 1-1 Biodiesel Pathways in GHGenius 10
Table 2-1 GHGenius Regions 16
Table 4-1 Feedstock Classification 21
Table 4-2 Chemical Inputs 23
Table 4-3 Biodiesel Co-products 24
Table 4-4 Required Allocation by Energy Changes 26
Table 4-5 Biodiesel co-products amounts 26
Table 4-6 Glycerine (fuel) Correction 27
Table 4-7 GHGenius 5.02c Co-products 28
Table 4-8 Finished Biodiesel Transport Inputs 29
Table 5-1 BC Distribution, Dispensing, and Use Model Inputs 31
Table 6-1 Soybean Oil Pathway: Material Balance Inputs 32
Table 6-2 Soybean Oil Pathway: Material Balance Outputs 33
Table 7-1 Model Inputs for US Central Emissions Run 34
Table 7-2 US Central Emissions 2024 36
Table 7-3 Model Inputs for BC Emissions Run 36
Table 7-4 BC Emissions 2024 37
Table 7-5 Total Emissions 2024 (5.02b) 37
Table 7-6 Total Emissions 2024 (5.02c) 38

Table 7-7 Soybean Oil Pathway: Material Balance Inputs 39
Table 7-8 Soybean Oil Pathway: Material Balance Outputs 39
Table 8-1 Model Inputs for Brazil Emissions Run 41
Table 8-2 Brazil Emissions 2024 42
Table 8-3 Model Inputs for US Central Emissions Run 43
Table 8-4 US Central Emissions 2024 44
Table 8-5 Model Inputs for BC Emissions Run 45
Table 8-6 BC Emissions 2024 46
Table 8-7 Total Emissions 2024 (5.02b) 46
Table 8-8 Total Emissions 2024 (5.02c) 47
Table 8-9 Tallow Pathway: Material Balance Inputs 48
Table 8-10 Tallow Pathway: Material Balance Outputs 49
Table 9-1 Model Inputs for Alberta Emissions Run 50
Table 9-2 Alberta Emissions 2024 51
Table 9-3 Model Inputs for US Central Emissions Run 51
Table 9-4 US Central Emissions 2024 53
Table 9-5 Model Inputs for BC Emissions Run 54
Table 9-6 BC Emissions 2024 55
Table 9-7 Total Emissions 2024 (5.02b) 55
Table 9-8 Total Emissions 2024 (5.02c) 57

Table 9-9 Canola Pathway: Material Balance Inputs 58

Table 9-10 Tallow Pathway: Material Balance Outputs 58

List of Figures

Figure 1-1 Soybean Biodiesel System Boundary 11

Figure 1-2 Animal Fat Biodiesel 12

Figure 1-3 Basic Biodiesel Process Diagram 13

Figure 2-1 US Regions 16

Figure 3-1 Feedstock Production Region 19

Figure 3-2 Transportation Inputs 20

Figure 3-3 Oil Extraction Inputs 20

Glossary

BC	British Columbia
CCS	Carbon Capture and Storage
CO_2	Carbon Dioxide
EPA	Environmental Protection Agency (United States)
GJ	Giga Joule (10^9 Joules)
GWP	Global Warming Potential
IPCC	Intergovernmental Panel on Climate Change
Kg	Kilogram
kWh	Kilowatt-hour
LCA	Lifecycle Analysis
LCFS	Low Carbon Fuel Standard
LNG	Liquified Natural Gas
LPG	Liquid Petroleum Gas
MJ	Mega Joule
MSW	Municipal Solid Waste
PADD	Petroleum Administration for Defense Districts (United States)
RNG	Renewable Natural Gas
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

This guide assists fuel producers and suppliers in determining the carbon intensity of biodiesel supplied in British Columbia (BC) using GHGenius 5.02b as the approved model of GHGenius, and GHGenius 5.02c as an alternative method for quantifying the carbon intensity of biodiesel.

GHGenius is an Excel-based lifecycle-assessment (LCA) model developed over the past twenty years. It is available for download at www.ghgenius.ca.

The model offers several unique features compared to some other models. In many instances it uses time series of data rather than single data points. The time series of data combined with the use of some government forecasts allows the model to show how emissions have changed and could change in the future. As Users change the year, the model updates automatically, ensuring it always delivers temporally relevant lifecycle emissions.

Additionally, the model includes data from several countries and regions worldwide. This allows users to apply the same process across different regions to determine the impact of local conditions. It also supports the modelling of fuels that are produced in one region of the world and used in another region.

1.1 Approved Version of GHGenius

Under the Low Carbon Fuels (Technical) Regulation, GHGenius version 5.02b is the currently approved lifecycle analysis model.

In 2024, the Ministry published an Intentions Paper on proposed changes to the allocation of biodiesel co-product emissions in fuel lifecycle assessment. Following public consultation, the Ministry worked with the developer of the GHGenius model to incorporate the feedback into a new version of the model, 5.02c. This update addresses previously unaccounted-for co-products, revises the displacement emissions of certain co-products, and reassigns methanol combustion emissions from co-products to the biodiesel

production pathway. The updated model, GHGenius 5.02c, is now available for download at www.ghgenius.ca.

The Ministry is in the process of updating the regulation to adopt version 5.02c as the official model for calculating the carbon intensity (CI) of low carbon fuels. In the interim, applicants have two options for modeling biodiesel pathways under the LCFS:

1. **GHGenius 5.02b with co-product allocation by energy:**

This version of the model is less accurate in allocating co-product emissions. If applicants choose to use this version, the allocation method for emissions of co-products should be set to Energy instead of displacement.

Or

2. **GHGenius 5.02c with co-product allocation by displacement:**

This version of the model is more accurate and includes the updated displacement credits for biodiesel co-products. If applicants choose to use this version, there is no need to change the allocation method for emissions of co-products. Since this version is still not the official version, applicants should submit an alternative method application. See RLCF-025: Use of Alternative Methods for Determining Carbon Intensities for more details.

1.2 Process Overview

Refer to the following table for the list of biodiesel pathways included in GHGenius:

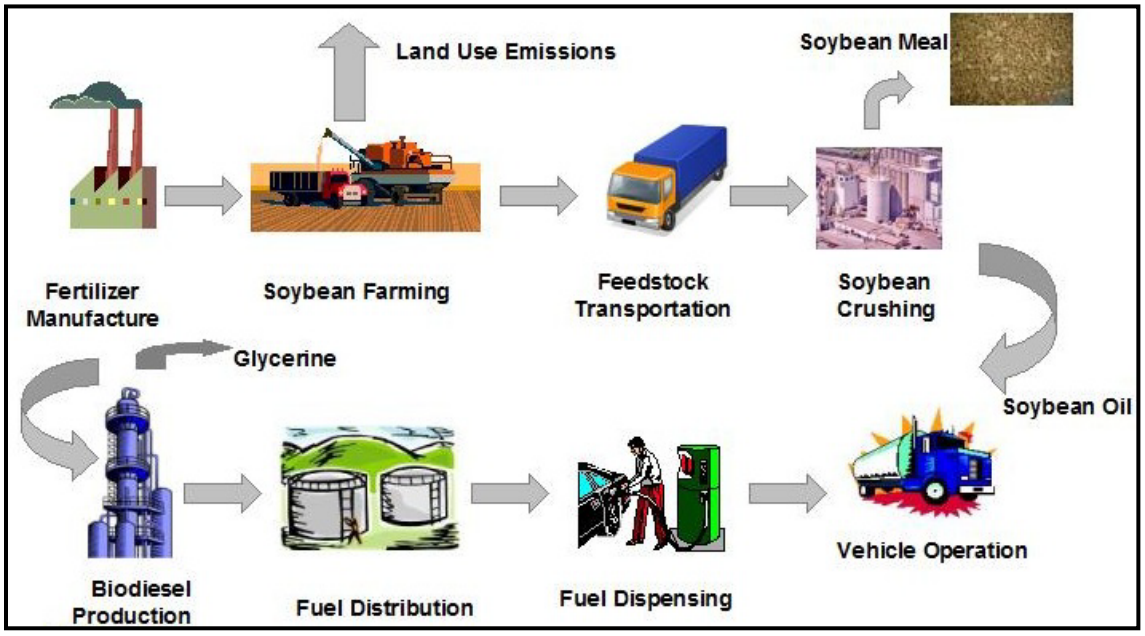
Table 1-1 Biodiesel Pathways in GHGenius

Vegetable Oils	Waste Based	Co-products
Canola	Used Cooking Oil / Yellow Grease	Distillers Corn Oil
Soybean	Tallow	
Jatropha	Tall Oil	
Palm	Palm Sludge Oil	
Camelina	Spent Bleaching Earth	

Vegetable Oils	Waste Based	Co-products
Algae		
Fish Oil		

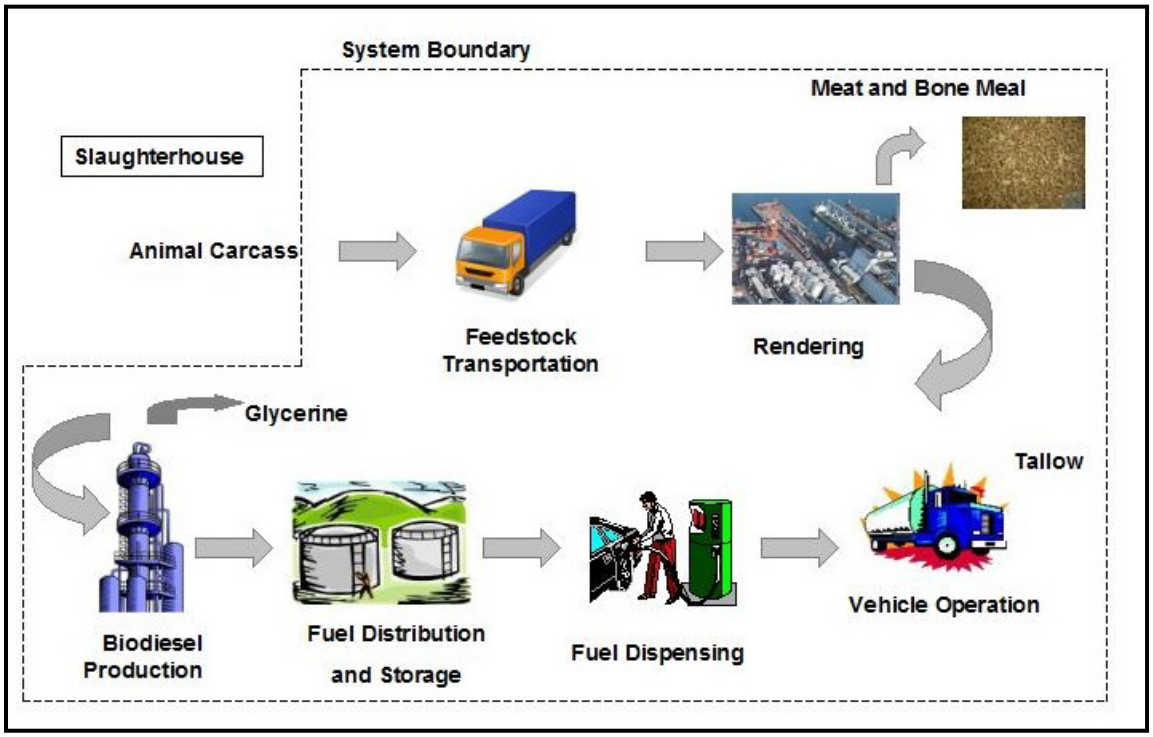
The following figure shows the lifecycle system boundary for soybean biodiesel. Other crops have similar system boundaries.

Figure 1-1 Soybean Biodiesel System Boundary



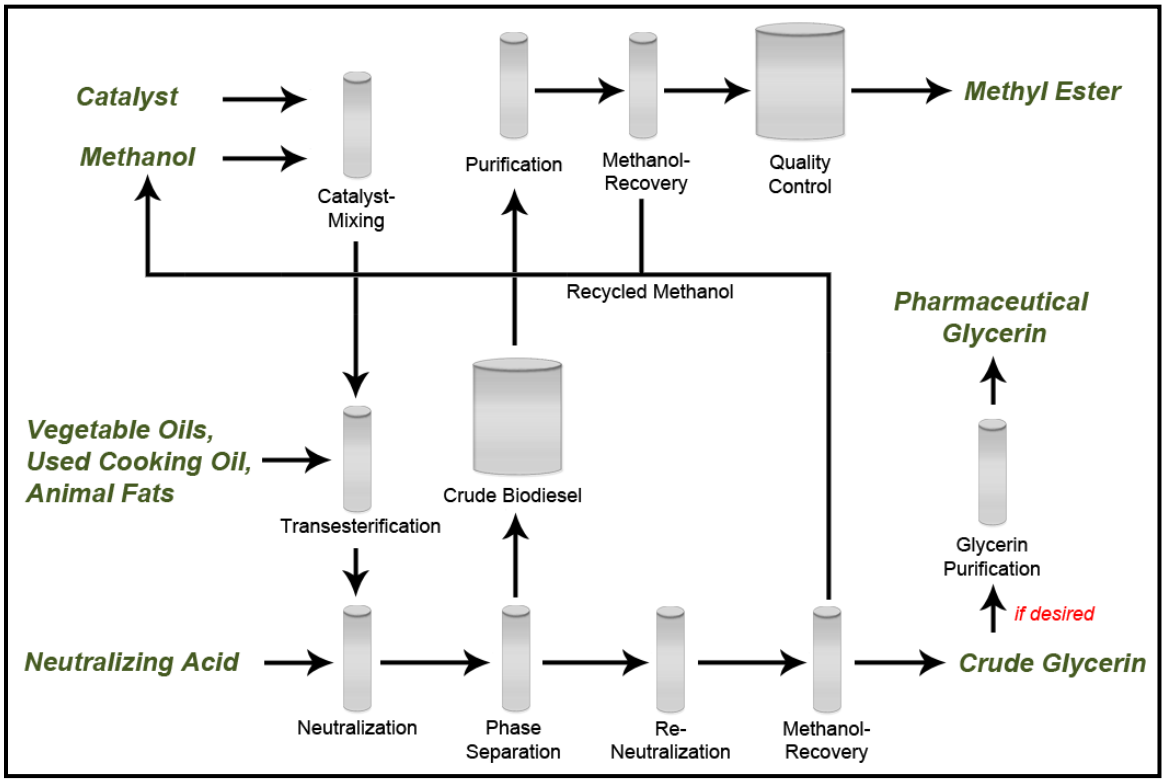
Waste based biodiesel can have different system boundaries. The following figure shows the animal fat (tallow) to biodiesel system.

Figure 1-2 Animal Fat Biodiesel



Biodiesel plant designs in North America vary more widely than those of ethanol plants. Some plants process only vegetable oils, while others use multiple feedstocks, operate as continuous processes, or run in batches. The following figure shows the basic process similar across all plants.

Figure 1-3 Basic Biodiesel Process Diagram



2 Initializing the Model

Download GHGenius 5.02b and 5.02c at https://ghgenius.ca/index.php/downloads. There is no cost to download the model, but GHGenius users must register at the website to be able to access the model.

After downloading and unzipping the file, users will receive a .xls file. This format ensures maximum compatibility with older versions of Excel. While this .xls file is larger than if saved as a .xlsm file, it runs faster and compresses to a smaller file size more efficiently. Users must not save the file as a .xlsx as this format disables macros required for full functionality. If the file is converted to a .xlsm file, it cannot be converted back to an .xls file or .xlsx file and some of the macro buttons will lose their functionality unless manually reassigned. For functionality and performance, users should run the model as a .xls file.

Before entering any facility specific data, users must first complete the required selections within the model.

2.1 Excel Macro Settings

GHGenius relies on macros to set up appropriate Excel settings, calculate many output values, and provide additional tools for GHGenius users. The model will not function properly without macros enabled.

To improve security, Microsoft Office has made it more difficult to enable macros when a file is downloaded from the internet. To unblock macros after downloading the model, locate the file in File Explorer, right-click the file, select Properties, and check unblock under the General tab.

For more information about this change and alternative ways to unblock macros visit https://learn.microsoft.com/en-us/deployoffice/security/internet-macros-blocked.

2.2 Reset Model

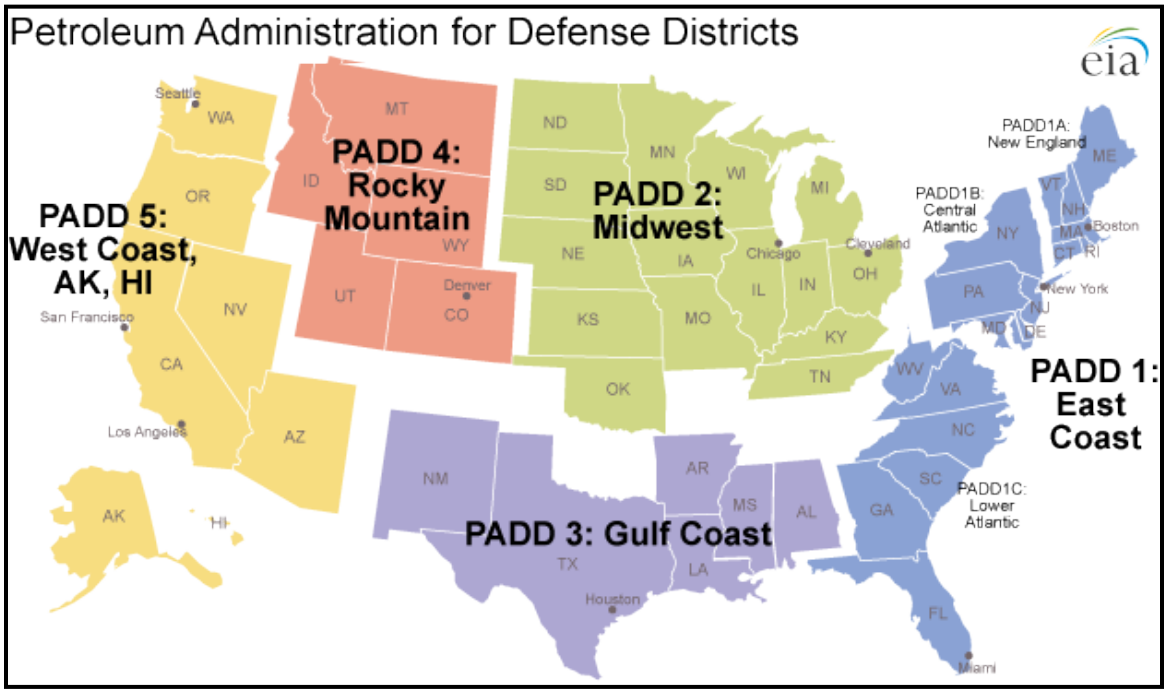
The Reset Model macro restores GhGenius to its original downloaded state. Specifically, it applies the Canada regional default, sets the GWP settings to the 2013 100-year values and configures the short-lived gases to be carbon weighted. It also runs most of the default buttons on the Input sheet and the Chemical Defaults button on the Alt Fuel Prod sheet. However, the macro does not set the year for the model, repair broken formulas, or reverse any changes made outside of the specified functions. The Reset Model macro does not make any changes to the Coprods sheet, nor does it change any of the values on the Alt Fuel Prod sheet related to the emission intensity of the chemicals included on the sheet.

If the file is closed without saving, the next time it opens it will open to the last saved version of the file.

2.3 Production Region

Users must select the region where the plant is located. For plants located in Canada, choose the appropriate Province. For plants located in the United States, select the corresponding region based on the U.S. Energy Information Administration's Petroleum Administration for Defense Districts (PADDs), as shown in the following figure and table.

Figure 2-1 US Regions



Source: US Energy Information Administration

The following table lists the GHGenius Regions.

Table 2-1 GHGenius Regions

GHGenius Region	**Province or PADD**
US East	1
US Central	2 and 3
US West	4 and 5
Canada West	BC, Alberta, Saskatchewan, Manitoba
Canada Central	Ontario, Quebec
Canada East	New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland

Most biodiesel plants draw their feedstock from the same PADD where the plant is located. However, some plants transport the feedstock over long distances with the feedstock production occurring in one region and processing occurring in another. Guidance on modelling these scenarios is provided later in this guide.

To set the desired region, select it from the drop-down menu in cell B4, then click the "Install Regional Defaults" button. Check to ensure the correct region has a 1.00 in row 9.

2.4 Year

The model year must be set to match the year the input data was collected or which the data represents. If the supporting data was collected over multiple years, set the model for the latest year in the dataset. For example, if data is from 2023 and 2024, set the year to 2024. If design data is used set the year to match the application year.

- Set the Target year in cell B7 of the Input sheet.
- Set the fuel production year in row 241 of the Input sheet under the column that corresponds to the feedstock type (see Table 4-1)

2.5 GWP

The model defaults to use the GWP values from the IPCC 5th Assessment Report (cell B11 (2013 (100 Years)) and D11 "Carbon Weighted" on the Input sheet). Clicking the "Reset Model" button also applies these settings.

To change the GWP values used in the model, select alternative values in the drop-down menus in cells B11 and D11 (GWP Selector & Short-Lived Gases).

3 Feedstock

If the plant processes multiple feedstocks, users must run the model for each feedstock separately. If plant-specific data on energy use, biodiesel yield and chemical requirements are not available for each feedstock, use the same values across all runs.

Enter feedstock weights on an as-received basis. There is no requirement to adjust them to dry weight.

3.1 Feedstock Production

If feedstock production data is not available, use the model defaults for feedstock production. The only exception to this is when a biodiesel plant is integrated with an oilseed extraction plant and the primary data (data measured at the facility) for the plant is available.

When selecting a region, the model will automatically assign feedstock producing regions for some feedstocks, such as canola and soybeans. However, it does not do this for all feedstocks. For example, camelina, jatropha and palm oil are not set automatically. Users must manually select the appropriate feedstock region for accurate modelling. Locate and enter these values on the input sheet in rows 153 to 236 and in columns B to Q. An example is shown in the following figure.

Figure 3-1 Feedstock Production Region

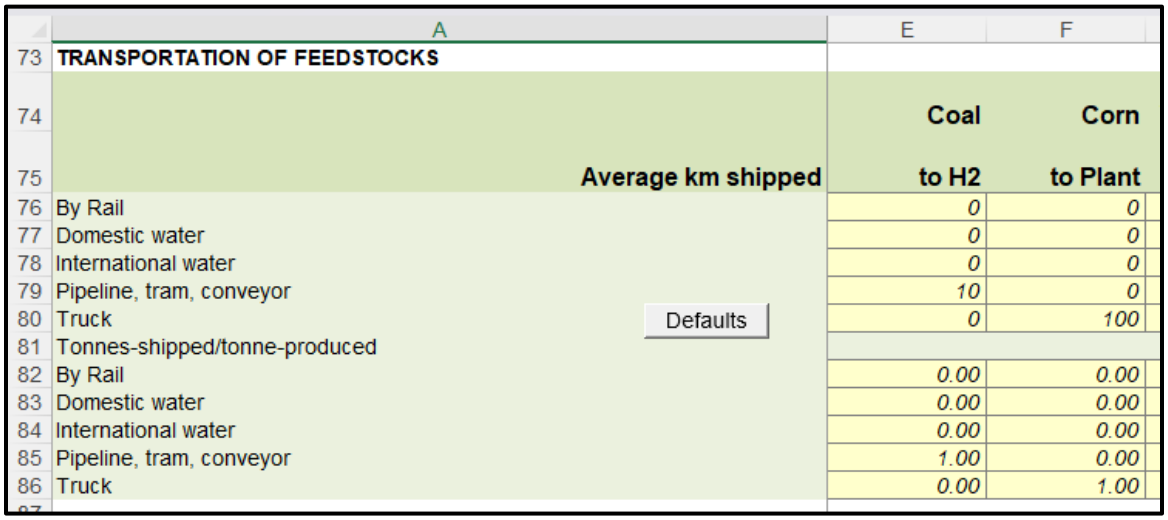
	A	B	C	D	E	F	G
153	FERTILIZER MANUFACTURE, APPLICATION; NUTRIENT LOSS; LAND USE ($heet: Fertilizers)						
154	Country data on yields and fertilizer use for:	Canada East	Canada Central	Canada West	US East	US Central	US West
155	Corn harvest yield, 1994 (tonne/hectare)	7.20	7.20	4.70	7.60	7.60	7.60
156	Change in corn harvest yield (Exp)	1.50	1.50	2.10	1.60	1.60	1.60
157	N rate, corn (kg/tonne)	13.00	13.00	13.00	19.20	19.20	19.20
158	Corn Producing Region	0.00	0.00	0.00	0.00	1.00	0.00
159	Wheat harvest yield, 2000 (tonne/hectare)	2.40	2.40	2.40	2.40	2.40	2.40
160	Change in wheat harvest yield (Exp)	1.40	1.40	1.40	1.40	1.40	1.40
161	N rate, wheat (kg/tonne)	20.00	20.00	20.00	20.00	20.00	20.00
162	Wheat Producing Region	0.00	0.00	0.00	0.00	1.00	0.00
163	Barley harvest yield, 1994 (tonne/hectare)	2.80	2.80	2.80	2.80	2.80	2.80
164	Change in barley harvest yield (Exp)	1.10	1.10	1.10	1.10	1.10	1.10
165	N rate, barley (kg/tonne)	23.00	23.00	23.00	23.00	23.00	23.00
166	Barley Producing Region	0.00	0.00	0.00	0.00	0.00	1.00
167	Peas harvest yield, 1994 (tonne/hectare)	2.00	2.00	2.00	2.00	2.00	2.00
168	Change in peas harvest yield (Exp)	1.10	1.10	1.10	1.10	1.10	1.10
169	N rate, peas (kg/tonne)	4.00	4.00	4.00	4.00	4.00	4.00
170	Peas Producing Region	0.00	0.00	1.00	0.00	0.00	0.00
171	Soy harvest yield, 1994 (tonne/hectare)	2.50	2.50	2.50	2.40	2.40	2.40
172	Change in soy harvest yield (Exp)	0.90	0.90	0.90	1.30	1.30	1.30
173	N rate, Soybean (kg/tonne)	1.80	1.80	1.80	1.80	1.80	1.80
174	Soybean Producing Region	0.00	0.00	0.00	0.00	1.00	0.00
175	Canola harvest yield, 1994 (tonne/hectare)	1.40	1.40	1.40	1.40	1.40	1.40
176	Change in Canola harvest yield (Exp)	1.60	1.60	1.60	1.60	1.60	1.60
177	N rate, Canola (kg/tonne)	51.00	51.00	51.00	51.00	51.00	51.00
178	Canola Producing Region	0.00	0.00	0.00	0.00	0.00	1.00
179	Palm harvest yield, 2000 (tonne/hectare)	18.30	18.30	18.30	18.30	18.30	18.30

3.2 Feedstock Transportation

Set feedstock transportation on the Input sheet in rows 76 through 86. Enter the one-way distance in kilometres in rows 76 to 80. Specify the tonnes-shipped/tonnes-produced in rows 82 to 86. This total should add up to 1.00 or higher, but it should not be less than one, except in cases where some of the feedstock is produced on site and some is imported. A sum greater than one indicates a multi modal transportation route. For example, when the feedstock is shipped by truck to a rail loading facility and then shipped by rail to the biodiesel plant.

This area of the Input sheet is shown in the following figure.

Figure 3-2 Transportation Inputs



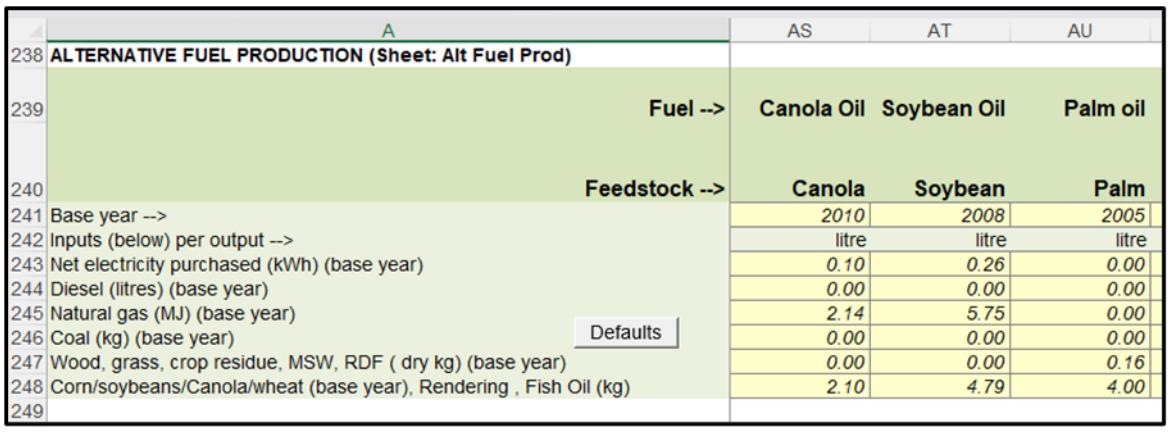
	A	E	F
73	**TRANSPORTATION OF FEEDSTOCKS**		
74		**Coal**	**Corn**
75	**Average km shipped**	**to H2**	**to Plant**
76	By Rail	*0*	*0*
77	Domestic water	*0*	*0*
78	International water	*0*	*0*
79	Pipeline, tram, conveyor	*10*	*0*
80	Truck [Defaults]	*0*	*100*
81	Tonnes-shipped/tonne-produced		
82	By Rail	*0.00*	*0.00*
83	Domestic water	*0.00*	*0.00*
84	International water	*0.00*	*0.00*
85	Pipeline, tram, conveyor	*1.00*	*0.00*
86	Truck	*0.00*	*1.00*

3.3 Oil Extraction from Feedstocks

If primary data (data measured at the facility) is available for the extraction process, use it in place of the default values. Enter this information in rows 239 to 248 on the input sheet. For solvent extraction processes, enter the quantity of hexane used on the Alt Fuel production sheet in row 60 and the appropriate column for the feedstock (columns BB to CA).

This section of the Input sheet is shown in the following figure.

Figure 3-3 Oil Extraction Inputs



	A	AS	AT	AU
238	**ALTERNATIVE FUEL PRODUCTION (Sheet: Alt Fuel Prod)**			
239	**Fuel -->**	**Canola Oil**	**Soybean Oil**	**Palm oil**
240	**Feedstock -->**	**Canola**	**Soybean**	**Palm**
241	Base year -->	*2010*	*2008*	*2005*
242	Inputs (below) per output -->	litre	litre	litre
243	Net electricity purchased (kWh) (base year)	*0.10*	*0.26*	*0.00*
244	Diesel (litres) (base year)	*0.00*	*0.00*	*0.00*
245	Natural gas (MJ) (base year)	*2.14*	*5.75*	*0.00*
246	Coal (kg) (base year) [Defaults]	*0.00*	*0.00*	*0.00*
247	Wood, grass, crop residue, MSW, RDF (dry kg) (base year)	*0.00*	*0.00*	*0.16*
248	Corn/soybeans/Canola/wheat (base year), Rendering , Fish Oil (kg)	*2.10*	*4.79*	*4.00*
249				

4 Biodiesel Production and Transportation

Enter biodiesel pathway data into the model based on per litre of biodiesel produced. Use only the volume to calculate the inputs. Do not include any diesel fuel added to the biodiesel calculation to collect the US Blenders Tax Credit.

4.1 Year

The Target Year and the fuel production base year must reflect the year that data used to generate the modelling inputs was collected. If the supporting data was collected over multiple years, set the model for the latest year in the dataset. If the data is design data set the year to match the application year.

- Set the Target year in cell B7 of the Input sheet.
- Set the fuel production year in row 241 of the Input sheet under the column that corresponds to the feedstock type (see Table 4-1)

4.2 Mass and Energy

Enter the main mass and energy inputs on the Input sheet in rows 243 to 248. Use values that correspond to the fuel's base year, as defined in row 241. Enter data for low FFA (Free Fatty Acid) feedstocks in column AZ for high FFA feedstocks in column BG. The following table identifies which feedstocks are in each category.

Table 4-1 Feedstock Classification

Low FFA Feedstock – Column AZ	**High FFA Feedstock – Column BG**
Canola Oil	Palm Sludge Oil
Soybean Oil	Spent Bleaching Earth Oil
Palm Oil	Tallow
Jatropha Oil	Yellow Grease
Camelina Oil	Tall Oil

Low FFA Feedstock – Column AZ	High FFA Feedstock – Column BG
Algae Oil	Corn Oil
Fish Oil	

4.2.1 Electricity

Enter the net electricity purchased based on the generic power of the region where the model is run. For low FFA feedstocks, input the value in cell AZ243; for high FFA feedstocks, use BG243. Report electricity usage in kilowatt-hours (kWh) per litre of biodiesel.

4.2.2 Diesel Fuel

Some biodiesel plants use a small amount of diesel fuel for rail car shuttles, front end loaders, or other diesel fueled equipment. Enter this value, litres of diesel/litre of biodiesel in row 244: AZ244 (low FFA) and BG244 (high FFA).

4.2.3 Natural Gas

The natural gas carbon intensity is not strongly regional. Enter the value in cell AZ245 for low FFA feedstocks, and in cell BG245 for high FFA feedstocks. Enter natural gas use in megajoules per litre (MJ/litre) on a HHV (higher heating value) basis.

4.2.4 Feedstock

Enter the feedstock input in kilograms of feedstock oil per litre of biodiesel. Use cell AZ248 for low FFA feedstocks and BG248 for high FFA feedstocks.

4.2.5 Chemicals

Specify chemical inputs for the biodiesel pathway on the Alt Fuel Prod sheet. Most plants use methanol and sodium methylate, while some may also use acids, bases for pH control, or nitrogen for tank blanketing. Not all plants use every chemical listed.

Enter all chemical inputs based on 100% purity. If a chemical is less than 100% pure, adjust the input accordingly. For example, multiply a 93% pure sulphuric acid input by 0.93 before entering it into the model.

Table 4-2 Chemical Inputs

Chemical	**Row on Alt Fuel Prod**
Methanol	51
Sodium Methylate	67
Sodium hydroxide	53
Hydrochloric acid	43
Sulphuric acid	72
Citric acid	36
Phosphoric acid	62
Nitrogen	56

Biodiesel plants often use catalysts dissolved in methanol, typically as a 30% weight solution. Add the methanol used in the catalyst solution to the total methanol input for the process. Enter the catalyst quantity in the model as a 100% pure value. For example:

If the 30% catalyst use is 0.025 kg/litre, the actual catalyst rate is:

$$0.3 * 0.025 \frac{kg}{l} = 0.0075 \frac{kg}{l\ of\ fuel}$$

The methanol consumption must be increased by:

$$0.7 * 0.025 \frac{kg}{l} = 0.0175 \frac{kg}{l\ of\ fuel}$$

Methanol has a volumetric density of 0.79 kg/l.

$$\frac{0.0175\ kg/l_{Fuel}}{0.79\ \ kg/l_{Fuel}} = 0.022\ \ l_{Methanol}/l_{Biodiesel}$$

This results in 0.022 litres of additional methanol needed for the catalyst.

4.3 Co-products

The primary co-product from the process is glycerine which facilities can further process to propylene glycol. GhGenius version 5.02c now includes distillation bottoms and free fatty acids as two additional co-products.

Enter all co-products on a dry mass basis, unless otherwise specified. The table below outlines common biodiesel co-products, provides their technical specifications and defines the criteria used to classify them for LCA modeling purposes.

Report each glycerine quantity only once, using the category that best reflects its quality and documented use. Do not report the same glycerine in more than one category. For example if crude glycerin is further processed to make refined glycerin, don't report both crude and refined glycerin.

Table 4-3 Biodiesel Co-products

Co-product	**Definition**	
Distillation Bottoms (5.02c only)	Must be used for heavier methyl esters left after biodiesel distillation, which are used or sold as an energy source.	
	Methyl Ester Content	> 40%
	Free Fatty Acid Content	< 40%
	Energy Content (HHV)	> 38.4 MJ/kg
Free Fatty Acids (5.02c only)	Must be used for free fatty acids that are used or sold for feed and/or industrial process	
	Free Fatty Acid Content	> 75%
	Methanol Content	< 0.5%
	Glycerol Content	< 1%
	Methyl Ester Content	< 2%
	Energy Content (HHV)	> 42 MJ/kg
Glycerine (fuel)	Must be used if the glycerine is used or marketed as a fuel	
	Glycerol Content	> 50% and < 80%

Co-product	Definition	
	Methanol Content	< 10%
	Energy Content (HHV)	> 18 MJ/kg
Glycerine (feed)	Must be used if the glycerine is used or marketed as animal feed	
	Glycerol Content	> 65%
	Moisture Content	< 10%
	Methanol Content	< 200 ppm
	Salts	< 2%
Glycerine (crude)	Must be used if the glycerine is sold to an upgrader for further processing into refined glycerine or propylene glycol.	
	Glycerol Content	> 80%
	Moisture Content	< 10%
	Methanol Content	< 0.5%
Glycerine (refined)	Must be used if the glycerine meets technical or USP grade glycerine	
	Glycerol Content	> 98%
	Moisture Content	< 2%
	Free Fatty Acid Content	< 0.1%
	Methanol Content	< 100 ppm
Propylene glycol	Must be used when the facility processes glycerine into propylene glycol within the same biodiesel production plant.	
	Propylene Glycol Content	> 98.0%
	Moisture Content	< 0.2%

4.3.1 GHGenius 5.02b Allocation by Energy Method

In GHGenius 5.02b, distillation bottoms and free fatty acids are not available as separate co-products. Instead, classify them under the following categories:

- Distillation bottoms → glycerine (fuel)
- Free fatty acids → glycerine (feed)

If applicants model using GHGenius 5.02b with allocation by energy, the changes in the table below must be made.

Table 4-4 Required Allocation by Energy Changes

Co-product	**Sheet**	**Cell**	**Allocation by:**
Glycerine (feed)	Coprods	B178	Energy
Glycerine (fuel)	Coprods	B179	Energy
Glycerine (crude)	Coprods	B180	Energy
Glycerine (refined)	Coprods	B181	Energy
Propylene Glycol	Coprods	B194	Energy

The table below provides the cells that biodiesel co-products should be entered in GHGenius 5.02b, the units are kg per L of biodiesel.

Table 4-5 Biodiesel co-products amounts

Co-product	**Sheet**	**Cell**
Glycerine (feed)	Coprods	X123
Glycerine (fuel)	Coprods	X124
Glycerine (crude)	Coprods	X125
Glycerine (refined)	Coprods	X126
Propylene Glycol	Coprods	X139

Note: GHGenius 5.02b requires a correction for the glycerine (fuel) co-product, to accurately account for the displacement co-product. This correction does not impact this method, as glycerine (fuel) does not receive a displacement credit. This correction has been made in the new version of GHGenius.

Table 4-6 Glycerine (fuel) Correction

Sheet	Cell	Description	Old Value	New Value
Coprods	O179	Glycerine (fuel) emissions by displacement	3	=IF(B179="Displacement", K179,0)

4.3.1.1 Energy Allocation Out-of-Model Calculation

An out-of-model calculation is required if the following occurs:

- Feedstock production and fuel production occur in different regions, and
- Energy allocation is used for any co-products.

For all biodiesel pathways modelled in GHGenius 5.02b, the co-products are required to be modelled using energy allocation.

The out-of-model calculation is done as follows, full examples are shown in examples 8.1 and 9.1:

1. Run the model for feedstock production emissions in the appropriate region. Save the results from rows 8–13 on the BC LCFS sheet.
2. Run the model for fuel production emissions, setting all co-products allocated by energy to zero in the Coprods sheet. Save the results of the fuel production run found in rows 14-15 and the fuel distribution and storage results from row 16 of the BC LCFS sheet.
3. Re-enter the quantities of co-products in the Coprods sheet that were set to zero in the previous step. Save the fraction of mass/energy co-products from row 163 of the Coprods sheet.

4. Use the following formula to calculate the "Fuel coproducts production" emissions:

$$\text{Fuel coproducts production} = -\text{fraction of energy coproducts} \times \left(\sum \text{Run 1 emissions} + \sum \text{Run 2 emissions} - \text{Run 2 Fuel distribution and storage emissions}\right)$$

5. Add the co-product credit for all energy-allocated co-products to any other co-product credit found in row 15 of the BC LCFS sheet. Since GHGenius 5.02b allocates all biodiesel co-products by energy, there are no additional co-product credits, so step 5 produces the same result as step 4.

4.3.2 GHGenius 5.02c Allocation by Displacement Method

GHGenius 5.02c adds distillation bottoms and free fatty acid; do not substitute other co-products instead of them. The model automatically sets emissions allocations to displacement, so users do not need to change the setting to energy.

The table below provides the cells in GHGenius 5.02c where you should enter biodiesel co-products. All entries must be in kilograms per litre of biodiesel.

Table 4-7 GHGenius 5.02c Co-products

Co-product	Sheet	Cell
Glycerine (feed)	Coprods	X123
Glycerine (fuel)	Coprods	X124
Glycerine (crude)	Coprods	X125
Glycerine (refined)	Coprods	X126
Biodiesel Distillation Bottoms	Coprods	X127
Free Fatty Acids (feed)	Coprods	X128

Co-product	Sheet	Cell
Propylene Glycol	Coprods	X141

4.4 Carbon Capture and Sequestration

GHGenius does not have the capacity to account for captured CO_2 as part of the carbon intensity modelling of biodiesel.

4.5 Biodiesel Transportation

Enter the details of the transportation of the finished biodiesel to BC in the Input sheet rows 91-102 and the column that corresponds to the feedstock type (see Table 4-8)

Table 4-8 Finished Biodiesel Transport Inputs

Biodiesel Type (i.e. type of feedstock)	Biodiesel Transport Data Column
Canola	AM
Soybean	AN
Palm	AO
Jatropha	AP
Camelina	AQ
Algae	AR
Tallow	AS
Yellow Grease	AT
Tall Oil	AU
Palm Sludge	AV
Spent Bleaching Earth	AW
Corn Oil	AX
Fish Oil	AY

4.5.1 Transloading

Transloading refers to the transfer of product from one mode to another (e.g. from truck to rail or vice versa). GHGenius accounts for transloading related emissions and provides a Transloading Yes/No option in the row 91 of the Input sheet (column varies depending on the feedstock type – see

Table 4-8). This yes/no toggle accounts for emissions associated with the electricity for the transloading as well as those for any blending and/or fuel storage (e.g. transfer pumps etc.). It may not be required for all situations where transloading occurs, follow the scenarios outlined below.

Set Transloading to “Yes” in row 91 when:

- Any transloading, blending, or storage occurs between the fuel production facility and the delivery to a location in BC, even if only a single mode of transportation.

Set Transloading to “No” in row 91 when:

- Only a single mode of transportation is used between the production facility and delivery to a location in BC and no blending or storage occurs enroute to the final destination in BC.

5 BC Distribution, Dispensing and Use

All fuel pathways must include a modelling run to account for the distribution, dispensing and end use emissions within BC. To model these emissions use the inputs outlined in Table 5-1 below.

Table 5-1 BC Distribution, Dispensing, and Use Model Inputs

GHGenius Location			Value	Description
Sheet	**Column**	**Row**		
Input	B	4	BC	Region
	C-D	3-5	Push Button	Install Regional Defaults
	See Table Table 4-8	91	Yes	Fuel transloading Toggle
		92	0	Fuel Rail Distance, km
		93	0	Fuel domestic water distance, km
		94	0	Fuel international water distance, km
		95	0	Fuel pipeline, tram and/or conveyor distance, km
		96	80	Fuel truck distance, km
		98	0	Fuel rail fraction
		99	0	Fuel domestic water fraction
		100	0	Fuel international water fraction
		101	0	Fuel pipeline, tram and/or conveyor fraction
		102	1	Fuel truck fraction

6 Material Balance Calculation

The material balance requirements are detailed in RLCF-008: How to Complete a Carbon Intensity Application. All CI applications submitted to the BC LCFS must include a material balance calculation for the fuel production stage.

6.1 Biodiesel Material Balance Example

Table 6-1 details the material balance inputs for a Soybean Oil pathway example. Energy inputs (Natural Gas) and material inputs that contribute less than 1% of the total input mass and are excluded.

Table 6-1 Soybean Oil Pathway: Material Balance Inputs

Input Stream	GHGenius Location	GHGenius Input	Input ($g/L_{Biodiesel}$)	Function	Notes
Soybean Oil	Input AZ248	0.9 $kg/L_{Biodiesel}$	900	Feedstock	
Hydrochloric acid	Alt Fuel Prod BE43	0.01 $kg/L_{Biodiesel}$	10	Esterification Catalyst	
Methanol	Alt Fuel Prod BE51	0.12 $kg/L_{Biodiesel}$	120	Esterification Reactant	
Nitrogen	Alt Fuel Prod BE56	0.02 $kg/L_{Biodiesel}$	20	Purging & Stripping Agent	
Total Input			**1050**		

The output data for this Soybean Oil example are shown in Table 6-2. Glycerine coproducts are entered in the model in mass per litre of biodiesel produced, so density information is not required.

Table 6-2 Soybean Oil Pathway: Material Balance Outputs

Output Stream	GHGenius Location	GHGenius Input	Input ($g/L_{Biodiesel}$)	Function	Notes
Biodiesel	N/A	N/A	884	Main Product	Density (884 g/L) from cell E90 of Fuel Char Sheet
Crude Glycerine	Coprods X125	0.08 $kg/L_{Biodiesel}$	80	Coproduct	Glycerol: 81% Moisture: 7.1% Methanol: 0.4%
Waste water	N/A	N/A	86	Waste	Metered stream.
Waste products (mainly soap and salt residues)	N/A	N/A	78	Waste	Unmetered streams. Calculated using material balance.
Total Output			**1050**		

7 Soybean Oil Biodiesel Example

Users must run the model at least twice to accurately calculate results for any fuel produced outside of BC. In the case of biodiesel fuels, the most common scenario involves producing feedstock and fuel in the US Central region and transporting the fuel to BC by rail. The example below shows this case using assumed input values.

The first run is in the US Central region. To begin, applicants must set cell B4 to the US Central region and hit the Apply Regional Defaults button to load the appropriate baseline data. The following table shows the values used for this modelling exercise. Users must replace these values with their actual facility-specific values.

Typically, a biodiesel plant operator buys soybean oil from a crusher. Transportation distances should reflect the movement of the oil only, while the crushed feedstock must retain the model's default values.

Refer to Table 4-1 to determine the correct feedstock classification (Low or High Free Fatty Acid Esterification).

Table 7-1 Model Inputs for US Central Emissions Run

Sheet	Cell	Description	Value
Input	B4	Region	US Central
Input	B7	Year	2024
Input	B11	GWP	2013 (100 years)
Input	N76	Feedstock Rail distance	300
Input	N80	Truck Distance	0
Input	N82	Rail mode	1
Input	AN91	Transloading	No
Input	AN92	BD Rail Distance	3000
Input	AN96	BD Truck Distance	0
Input	AN98	Rail mode	1

Sheet	Cell	Description	Value
Input	AZ241	Year	2024
Input	AZ243	Electricity	0.03
Input	AZ245	Natural gas	0.7
Input	AZ248	Feedstock	0.9
Alt Fuel Prod	BE36	Citric acid	0
Alt Fuel Prod	BE43	Hydrochloric acid	0.01
Alt Fuel Prod	BE51	Methanol	0.12
Alt Fuel Prod	BE53	NaOH	0.0005
Alt Fuel Prod	BE56	Nitrogen	0.02
Alt Fuel Prod	BE62	Phosphoric acid	0.0005
Alt Fuel Prod	BE67	Sodium methylate	0.01
Coprods	X123	Glycerine for feed	0
Coprods	X125	Crude Glycerine	0.08
Coprods (5.02b)	B180	Allocation by	Energy
Coprods (5.02c)	B182	Allocation by	Displacement

The following table shows the results for the year 2024. Locate these values in the BC LCFS sheet, Column Y, rows 8 to 16.

GHGenius 5.02c results in a larger “Fuel coproducts production” credit than GHGenius 5.02b for the following reasons:

- 5.02c allocates by displacement, while 5.02b uses energy allocation.
- 5.02b accounts for the fossil methanol combustion emissions in the “fuel coproducts production”, while 5.02c accounts for it under “Vehicle or Vessel operation”.

Table 7-2 US Central Emissions 2024

Stage	Emissions, g CO_2eq/GJ (5.02b)	Emissions, g CO_2eq/GJ (5.02c)
Direct land use change	0	0
Feedstock production or cultivation	34,343	34,343
Feedstock upgrading	14,926	14,926
Feedstock transport	1,928	1,928
Feedstock coproducts production	-41,137	-41,137
Avoided emissions	0	0
Fuel production	3,914	3,914
Fuel coproducts production	-549	-6,102
Fuel distribution and storage	1,484	1,484
Total	**14,908**	**9,355**

Run the model a second time using the BC region to calculate emissions from final distribution of 80 km, dispensing, and fuel use. Keep most of the inputs the same as in the initial US Central run. Only update the values outlined in the following table.

Table 7-3 Model Inputs for BC Emissions Run

Sheet	Cell	Description	Value
Input	B4	Region	BC
Input	AN91	Transloading	Yes
Input	AN92	Rail Distance	0
Input	AN96	Truck Distance	80
Input	AN102	Truck Mode	1

The results for the BC region are below. Locate these values in the BC LCFS sheet, column Y rows 16 to 18.

As mentioned above GHGenius 5.02b accounts for the combustion emissions of the fossil methanol under "Fuel coproducts production" emissions, while GHGenius 5.02c accounts for it in "Vehicle or Vessel operation" emissions. This results in larger "Vehicle or Vessel operation" emissions for pathways modelled in GHGenius 5.02c.

Table 7-4 BC Emissions 2024

Stage	**Emissions, g CO_2eq/GJ (5.02b)**	**Emissions, g CO_2eq/GJ (5.02c)**
Fuel distribution and storage	478	479
Fuel dispensing	100	100
Vehicle or Vessel operation	1,532	5,263
Total	**2,111**	**5,841**

Users must combine the results from the two regions, which produces a final CI of 17.02 g CO_2eq/MJ using GhGenius 5.02b and 15.20 g CO_2eq/MJ using GhGenius 5.02c in this scenario. Sum the values in the first two columns to produce the values in the right-hand column.

Note: Applicants must submit an alternative method request to use 5.02c.

Table 7-5 Total Emissions 2024 (5.02b)

Stage	**US Central Emissions**	**BC Emissions**	**Total Emissions**
	g CO_2eq/GJ (HHV)		
Direct land use change	0		0
Feedstock production or cultivation	34,343		34,343
Feedstock upgrading	14,926		14,926
Feedstock transport	1,928		1,928
Feedstock coproducts production	-41,137		-41,137

Stage	US Central Emissions	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)		
Avoided emissions	0		0
Fuel production	3,914		3,914
Fuel coproducts production	-549		-549
Fuel distribution and storage	1,484	479	1,963
Fuel dispensing		100	100
Vehicle or Vessel operation		1,532	1,532
Total			17,019
Total, g CO_2eq/MJ			17.02

Table 7-6 Total Emissions 2024 (5.02c)

Stage	US Central Emissions	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)		
Direct land use change	0		0
Feedstock production or cultivation	34,343		34,343
Feedstock upgrading	14,926		14,926
Feedstock transport	1,928		1,928
Feedstock coproducts production	-41,137		-41,137
Avoided emissions	0		0
Fuel production	3,914		3,914
Fuel coproducts production	-6,102		-6,102
Fuel distribution and storage	1,484	479	1,963
Fuel dispensing		100	100
Vehicle or Vessel operation		5,263	5,263

Stage	US Central Emissions	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)		
Total			15,196
Total, g CO_2eq/MJ			**15.20**

7.1 Soybean Oil Example – Material Balance

Table 7-7 details the material balance inputs for this Soybean Oil pathway example. Energy inputs (Natural Gas) and material inputs that contribute less than 1% of the total input mass and are not included.

Table 7-7 Soybean Oil Pathway: Material Balance Inputs

Input Stream	GHGenius Location	GHGenius Input	Input (g/$L_{Biodiesel}$)	Function	Notes
Soybean Oil	Input AZ248	0.9 kg/$L_{Biodiesel}$	900	Feedstock	
Hydrochloric acid	Alt Fuel Prod BE43	0.01 kg/$L_{Biodiesel}$	10	Esterification Catalyst	
Methanol	Alt Fuel Prod BE51	0.12 kg/$L_{Biodiesel}$	120	Esterification Reactant	
Nitrogen	Alt Fuel Prod BE56	0.02 kg/$L_{Biodiesel}$	20	Purging & Stripping Agent	
Total Input			**1050**		

The output data for this Soybean Oil example pathway are shown in

Table 7-8. Glycerine coproducts are entered in the model in mass per litre of biodiesel produced, so density information is not required.

Table 7-8 Soybean Oil Pathway: Material Balance Outputs

Output Stream	GHGenius Location	GHGenius Input	Input (g/$L_{Biodiesel}$)	Function	Notes

Biodiesel	N/A	N/A	884	Main Product	Density (884 g/L) from cell E90 of Fuel Char Sheet
Crude Glycerine	Coprods X125	0.08 $kg/L_{Biodiesel}$	80	Coproduct	Glycerol: 81% Moisture: 7.1% Methanol: 0.4%
Waste water	N/A	N/A	40	Waste	Metered stream.
Waste products (mainly soap and salt residues)	N/A	N/A	46	Waste	Unmetered streams. Calculated using material balance.
Total Output			**1050**		

8 Tallow Biodiesel Example

Users must run the model at least twice to accurately calculate results for any fuel produced outside of BC. More complicated examples may require three runs when producers source the feedstock in a different region from fuel production. The example below demonstrates this using assumed inputs. It is biodiesel from tallow produced in Brazil, with biodiesel production in the US Central region and use in BC.

The first run is in the Brazil region. To begin, users must set cell B4 to the appropriate region and hit the Apply Regional Defaults button to load the appropriate baseline data. Table 8-1 shows the values used for this modelling exercise. Users must replace these values with their actual values.

Typically, biodiesel plant operators buy oil from a renderer.

Transportation distances should reflect the movement of the oil only, while the rendered feedstock must retain the model's default values. If the supplier provides rendering data, use it in the model.

Process the tallow by the "High FFA Esterification" values.

Table 8-1 Model Inputs for Brazil Emissions Run

Sheet	Cell		Value
Input	B4	Region	Brazil
Input	B7	Year	2024
Input	B11	GWP	2013 (100 years)
Input	X78	Ocean shipping distance	10,000
Input	X80	Truck distance	100
Input	X84	Ocean shipping mode	1
Input	X86	Truck mode	1
Input	BG241	Year	2024
Input	BG248	Feedstock for BD	0.95

Table 8-2 shows the results for the year 2024. Locate these values in the BC LCFS sheet, Column AD, rows 8 to 13.

Table 8-2 Brazil Emissions 2024

Stage	**Emissions, g CO_2eq/GJ (5.02b)**	**Emissions, g CO_2eq/GJ (5.02c)**
Direct land use change	0	0
Feedstock production or cultivation	0	0
Feedstock upgrading	19,295	19,295
Feedstock transport	5,892	5,893
Feedstock coproducts production	-10,304	-10,304
Avoided emissions	0	0
Total	**14,884**	**14,884**

In this scenario, users must run the model a second time using the US Central region to account for fuel production from the tallow. Free Fatty Acids (FFA) is reported as a co-product in addition to crude glycerin. Users must report free fatty acids as glycerine feed in 5.02b or free fatty acids in 5.02c.

As this pathway has the feedstock and fuel production run in separate regions users must perform an out-of-model calculation (as detailed in section 4.3.1.1) to get the correct credit for the co-products allocated by energy. Users must set all co-products allocated by energy to zero for the fuel production run, then complete a second run to calculate the fraction of energy co-products which is used in the out-of-model calculation. Users do not need this out-of-model calculation for pathways modelled in 5.02c as the co-products are allocated by displacement and are not impacted by the separate feedstock and fuel production regions.

Table 8-3 Model Inputs for US Central Emissions Run

Sheet	Cell	Description	Value
Input	B4	Region	US Central
Input	B7	Year	2024
Input	AS91	Transloading	No
Input	AS92	BD Rail Distance	4,500
Input	AS96	BD Truck Distance	0
Input	AS98	Rail mode	1
Input	BG241	Year	2024
Input	BG243	Electricity	0.1
Input	BG245	Natural gas	3
Input	BG248	Feedstock	0.95
Alt Fuel Prod	BO36	Citric acid	0
Alt Fuel Prod	BO43	Hydrochloric acid	0.01
Alt Fuel Prod	BO51	Methanol	0.12
Alt Fuel Prod	BO53	NaOH	0.0005
Alt Fuel Prod	BO56	Nitrogen	0.02
Alt Fuel Prod	BO62	Phosphoric acid	0.0005
Alt Fuel Prod	BO67	Sodium methylate	0.01
Coprods	X123	Glycerine for feed	0.00 **(1)**
Coprods (5.02c)	X128	Free Fatty Acids	0.02
Coprods (5.02b)	X125	Crude Glycerine	0.00 **(2)**
Coprods (5.02c)	X125	Crude Glycerine	0.08
Coprods (5.02b)	B178	Allocation by	Energy
Coprods (5.02b)	B180	Allocation by	Energy
Coprods (5.02c)	B182	Allocation by	Displacement
Coprods (5.02c)	B185	Allocation by	Displacement

(1) Set to zero in GHGenius 5.02b and 5.02c. Accounted for in out-of-model calculation in 5.02b, and free fatty acids in 5.02c.

Set to zero in GHGenius 5.02b accounted for in out-of-model calculation.Table 8-4 shows the results for the year 2024. Locate these values in the BC LCFS sheet. Column AD, rows 14 to 16.

GHGenius 5.02c results in a larger "Fuel coproducts production" credit than GHGenius 5.02b for the following reasons:

- 5.02c allocates by displacement, while 5.02b uses energy allocation.
- 5.02b accounts for the fossil methanol combustion emissions in the "fuel coproducts production", while 5.02c accounts for it under "Vehicle or Vessel operation".

Table 8-4 US Central Emissions 2024

Stage	**Emissions, g CO_2eq/GJ (5.02b)**	**Emissions, g CO_2eq/GJ (5.02c)**
Fuel production	9,076	9,076
Fuel coproducts production	0	-6,626
Fuel distribution and storage	2,226	2,226
Total	**11,302**	**4,676**

8.1 GHGenius 5.02b out-of-model calculation

As noted above an out-of-model calculation is required for pathways with different feedstock and fuel production regions modelled in 5.02b. We will now model the free fatty acids (feed glycerine in GHGenius 5.02b) and crude glycerine, by setting Coprods cells X123 and X125 to 0.02 and 0.08 kg respectively. The fraction of energy co-products can be found in cell X163, the result is 0.0486 (unitless). To calculate the "Fuel coproducts production" emissions, use the following equation:

$$\text{Fuel coproducts production} = -\text{fraction of energy coproducts} * \left(\sum \text{Run 1 emissions} + \sum \text{Run 2 emissions} - \text{Run 2 Fuel distribution and storage emissions}\right)$$

This results in the following calculation:

$$\text{Fuel coproducts production} = -0.0486 * (14{,}884 + 11{,}302 - 2{,}226) = -1{,}165$$

Run the model a third time using the BC region to calculate final distribution of 80km, dispensing, and fuel use emissions. Keep most of the inputs the same as the US Central run. Apply only the changes that are outlined in Table 8-5.

Table 8-5 Model Inputs for BC Emissions Run

Sheet	Cell	Description	Value
Input	B4	Region	BC
Input	AS91	Transloading	Yes
Input	AS92	Rail Distance	0
Input	AS96	Truck Distance	80
Input	AS102	Truck Mode	1

Table 8-6 shows the results for the BC region. Locate these values in the BC LCFS sheet, column AD rows 16 to 18.

As mentioned above GHGenius 5.02b accounts for the combustion emissions of the fossil methanol under “Fuel coproducts production” emissions, while GHGenius 5.02c accounts for it in “Vehicle or Vessel operation” emissions. This results in larger “Vehicle or Vessel operation” emissions for pathways modelled in GHGenius 5.02c.

Table 8-6 BC Emissions 2024

Stage	Emissions, g CO_2eq/GJ (5.02b)	Emissions, g CO_2eq/GJ (5.02c)
Fuel distribution and storage	478	479
Fuel dispensing	100	100
Vehicle or Vessel operation	1,532	5,263
Total	**2,111**	**5,841**

Users must combine the results from the three regions along with the out of model calculation, which produces a final CI of 27.13 g CO_2eq/MJ in GhGenius 5.02b and 25.40 g CO_2eq/MJ in GhGenius 5.02c. Sum the values in the first four columns to produce the values in the right-hand column.

Note: Applicants must submit an alternative method request to use 5.02c.

Table 8-7 Total Emissions 2024 (5.02b)

Stage	Brazil Emissions	US Central Emissions	Out-Of-Model Calculation	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)				
Direct land use change	0				0
Feedstock production or cultivation	0				0
Feedstock upgrading	19,295				19,295
Feedstock transport	5,892				5,892
Feedstock coproducts production	-10,304				-10,304

Stage	Brazil Emissions	US Central Emissions	Out-Of-Model Calculation	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)				
Avoided emissions	0				0
Fuel production		9,076			9,076
Fuel coproducts production		0	-1,165		-1,165
Fuel distribution and storage		2,226		478	2,704
Fuel dispensing				100	100
Vehicle or Vessel operation				1,532	1,532
Total					27,130
Total, g CO_2eq/MJ					27.13

Table 8-8 Total Emissions 2024 (5.02c)

Stage	Brazil Emissions	US Central Emissions	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)			
Direct land use change	0			0
Feedstock production or cultivation	0			0
Feedstock upgrading	19,295			19,295
Feedstock transport	5,893			5,893
Feedstock coproducts production	-10,304			-10,304
Avoided emissions	0			0
Fuel production		9,076		9,076
Fuel coproducts production		-6,626		-6,626

Stage	Brazil Emissions	US Central Emissions	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)			
Fuel distribution and storage		2,226	479	2,704
Fuel dispensing			100	100
Vehicle or Vessel operation			5,263	5,263
Total				25,401
Total, g CO_2eq/MJ				**25.40**

8.2 Tallow Example – Material Balance

Table 8-9 details the material balance inputs for this Tallow pathway example. Energy inputs (Natural Gas) and material inputs that contribute less than 1% of the total input mass and are not included.

Table 8-9 Tallow Pathway: Material Balance Inputs

Input Stream	GHGenius Location	GHGenius Input	Input (g/$L_{Biodiesel}$)	Function	Notes
Tallow	Input BG248	0.95 kg/$L_{Biodiesel}$	950	Feedstock	
Hydrochloric acid	Alt Fuel ProdBE43	0.01 kg/$L_{Biodiesel}$	10	Esterification Catalyst	
Methanol	Alt Fuel Prod BE51	0.12 kg/$L_{Biodiesel}$	120	Esterification Reactant	
Nitrogen	Alt Fuel Prod BE56	0.02 kg/$L_{Biodiesel}$	20	Purging & Stripping Agent	
Total Input			**1100**		

The output data for this Tallow example pathway are shown in Table 8-10. Glycerine and Free Fatty Acid coproducts are entered in the model in mass per litre of biodiesel so density information is not required.

Table 8-10 Tallow Pathway: Material Balance Outputs

Output Stream	GHGenius Location	GHGenius Input	Input ($g/L_{Biodiesel}$)	Function	Notes
Biodiesel	N/A	N/A	884	Main Product	Density (884 g/L) from cell E90 of Fuel Char Sheet
Crude Glycerine	Coprods X125	0.08 $kg/L_{Biodiesel}$	80	Coproduct	Glycerol: 83% Moisture: 7.3% Methanol: 0.3%
Free Fatty Acids	Coprods X128	0.02	20	Coproduct	
Waste water	N/A	N/A	32	Waste	Metered stream.
Waste products (mainly soap and salt residues)	N/A	N/A	84	Waste	Unmetered streams. Calculated using material balance.
Total Output			**1100**		

9 Canola Biodiesel Example

Users must run the model at least twice to accurately calculate results for any fuel produced outside of BC. More complicated examples may require three runs when producers source the feedstock in a different region from fuel production. The example below demonstrates this using assumed inputs.

The first run is in the Alberta region. To begin, users must set cell B4 to the appropriate region and hit the Apply Regional Defaults button to load the appropriate baseline data. A user must replace these values with their actual values. Typically, biodiesel plant operators buy oil from a crusher. Transportation distances should reflect the movement of the oil only, while the crushed feedstock must retain the model's default values.

Process canola oil by the "Low FFA Esterification" values.

Table 9-1 Model Inputs for Alberta Emissions Run

Sheet	Cell	Description	Value
Input	B4	Region	Alberta
Input	B7	Year	2024
Input	B11	GWP	2013 (100 years)
Input	L76	Rail distance	2,000
Input	L80	Truck distance	0
Input	L82	Rail mode	1
Input	AZ241	Year	2024
Input	AZ248	BD Feedstock	0.9

Table 9-2 shows the results for the year 2024. Locate these values in the BC LCFS sheet, Column X, rows 8 to 13.

Table 9-2 Alberta Emissions 2024

Stage	**Emissions, g CO_2eq/GJ (5.02b)**	**Emissions, g CO_2eq/GJ (5.02c)**
Direct land use change	0	0
Feedstock production or cultivation	15,058	15,058
Feedstock upgrading	5,056	5,056
Feedstock transport	1,689	1,689
Feedstock coproducts production	-11,659	-11,659
Avoided emissions	0	0
Total	**10,143**	**10,143**

In this scenario the user must run the model a second time in the US Central region that accounts for fuel production from the canola oil.

As this pathway has the feedstock and fuel production run in separate regions users must perform an out-of-model calculation (as detailed in 4.3.1.1) to get the correct credit for the co-products allocated by energy. Users must set all co-products allocated by energy to zero for the fuel production run, then complete a second run to calculate the fraction of energy co-products used in the out-of-model calculation. Users do not need this out-of-model calculation for pathways modelled in 5.02c as the co-products are allocated by displacement and are not impacted by the separate feedstock and fuel production regions.

Table 9-3 Model Inputs for US Central Emissions Run

Sheet	**Cell**	**Description**	**Value**
Input	B4	Region	US Central
Input	B7	Year	2024
Input	AM91	Transloading	No
Input	AM92	BD Rail Distance	3,000
Input	AM96	BD Truck Distance	0

Sheet	Cell	Description	Value
Input	AM98	Rail mode	1
Input	AZ241	Year	2024
Input	AZ243	Electricity	0.05
Input	AZ245	Natural gas	0.7
Input	AZ248	Feedstock	0.9
Alt Fuel Prod	BC36	Citric acid	0
Alt Fuel Prod	BC43	Hydrochloric acid	0.01
Alt Fuel Prod	BC51	Methanol	0.12
Alt Fuel Prod	BC53	NaOH	0.0005
Alt Fuel Prod	BC56	Nitrogen	0.02
Alt Fuel Prod	BC62	Phosphoric acid	0.0005
Alt Fuel Prod	BC67	Sodium methylate	0.01
Coprods	X123	Glycerine (feed)	0
Coprods (5.02b)	X124	Glycerine (fuel)	0.00 **(1)**
Coprods (5.02b)	X125	Crude Glycerine	0.00 **(2)**
Coprods (5.02c)	X125	Crude Glycerine	0.08
Coprods (5.02c)	X127	Biodiesel Distillation Bottoms	0.01
Coprods (5.02b)	B179	Allocation by	Energy

Sheet	Cell	Description	Value
Coprods (5.02b)	B180	Allocation by	Energy
Coprods (5.02c)	B182	Allocation by	Displacement
Coprods (5.02c)	B184	Allocation by	Displacement
Coprods (5.02b)	O179	Glycerine (fuel) emissions	=IF(B179="Displacement",K179,0)

(1) Set to zero in GHGenius 5.02b and 5.02c. Accounted for in out-of-model calculation in 5.02b, and distillation bottoms in 5.02c.
(2) Set to zero in GHGenius 5.02b accounted for in out-of-model calculation.

Table 9-4 shows the results for the year 2024. Locate these values in the BC LCFS sheet, column AD, rows 14 to 16.

GHGenius 5.02c results in a larger "Fuel coproducts production" credit than GHGenius 5.02b for the following reasons:

- 5.02c allocates by displacement, while 5.02b uses energy allocation.
- 5.02b accounts for the fossil methanol combustion emissions in the "fuel coproducts production", while 5.02c accounts for it under "Vehicle or Vessel operation".

Table 9-4 US Central Emissions 2024

Stage	Emissions, g CO_2eq/GJ (5.02b)	Emissions, g CO_2eq/GJ (5.02c)
Fuel production	4,225	4,225
Fuel coproducts production	0	-7,076
Fuel distribution and storage	1,484	1,484
Total	**5,709**	**-1,367**

9.1 GHGenius 5.02b Energy Allocation Calculation

Pathways modeled in GHGenius 5.02b with feedstock and fuel production occurring in different regions require an out-of-model calculation. To model distillation bottoms (represented as fuel glycerine in 5.02b) and crude glycerine, enter 0.01 kg in cell X124 and 0.08 kg in cell X125 on the Coprods sheet. Find the resulting fraction of energy co-products in cell X163, which yields a value of 0.044 (unitless).

To calculate the "Fuel coproducts production" emissions, use the following equation:

$$\begin{aligned}&\text{Fuel coproducts production}\\&\quad = -\text{fraction of energy coproducts}\\&\quad \times \left(\sum \text{Run 1 emissions} + \sum \text{Run 2 emissions}\right.\\&\quad \left. - \text{Run 2 Fuel distribution and storage emissions}\right)\\&\\&\quad = -0.044 \times (10{,}143 + 5{,}709 - 1{,}484) = -632\end{aligned}$$

Run the model a third time in the BC region to calculate the final distribution of 80km, dispensing, and fuel use emissions. Keep most of the inputs the same as the US Central run. Apply only the changes outlined in Table 9-5.

Table 9-5 Model Inputs for BC Emissions Run

Sheet	Cell	Description	Value
Input	B4	Region	BC
Input	AM91	Transloading	Yes
Input	AM92	Rail Distance	0
Input	AM96	Truck Distance	80
Input	AM102	Truck Mode	1

Table 9-6 below shows the BC region results. Locate these values in the BC LCFS sheet, column X rows 16 to 18.

As mentioned above GHGenius 5.02b accounts for the combustion emissions of the fossil methanol under "Fuel coproducts production" emissions, while GHGenius 5.02c accounts for it in "Vehicle or Vessel operation" emissions. This results in larger "Vehicle or Vessel operation" emissions for pathways modelled in GHGenius 5.02c.

Table 9-6 BC Emissions 2024

Stage	**Emissions, g CO_2eq/GJ (5.02b)**	**Emissions, g CO_2eq/GJ (5.02c)**
Fuel distribution and storage	478	479
Fuel dispensing	100	100
Vehicle or Vessel operation	1,532	5,263
Total	**2,111**	**5,841**

Users must combine the results from the three regions along with the out of model calculation, which produces a final CI of 17.33 g CO_2eq/MJ in GhGenius 5.02b and 14.62 g CO_2eq/MJ in GhGenius 5.02c. Sum the values in the first four columns to produce the values in the right-hand column.

Note: Applicants must submit an alternative method request to use 5.02c.

Table 9-7 Total Emissions 2024 (5.02b)

Stage	**Alberta Emissions**	**US Central Emissions**	**Out-of-Model Calculation**	**BC Emissions**	**Total Emissions**
	g CO_2eq/GJ (HHV)				
Direct land use change	0				0

Stage	Alberta Emissions	US Central Emissions	Out-of-Model Calculation	BC Emissions	Total Emissions
	g CO_2eq/GJ (HHV)				
Feedstock production or cultivation	15,058				15,058
Feedstock upgrading	5,056				5,056
Feedstock transport	1,689				1,689
Feedstock coproducts production	-11,659				-11,659
Avoided emissions	0				0
Fuel production		4,225			4,225
Fuel coproducts production		0	-632		-632
Fuel distribution and storage		1,484		478	1,962
Fuel dispensing				100	100
Vehicle or Vessel operation				1,532	1,532
Total					17,331
Total, g CO_2eq/MJ					**17.33**

Table 9-8 Total Emissions 2024 (5.02c)

Stage	Alberta Emissions	US Central Emissions		BC Emissions	Total Emissions
		g CO_2eq/GJ (HHV)			
Direct land use change	0				0
Feedstock production or cultivation	15,058				15,058
Feedstock upgrading	5,056				5,056
Feedstock transport	1,689				1,689
Feedstock coproducts production	-11,659				-11,659
Avoided emissions	0				0
Fuel production		4,225			4,225
Fuel coproducts production		-7,076			-7,076
Fuel distribution and storage		1,484		479	1,962
Fuel dispensing				100	100
Vehicle or Vessel operation				5,263	5,263
	Total				14,618
	Total, g CO_2eq/MJ				**14.62**

9.2 Canola Example – Material Balance

Table 9-9 details the material balance inputs for this Canola Oil pathway example. Energy inputs (Natural Gas) and material inputs that contribute less than 1% of the total input mass and are not included.

Table 9-9 Canola Pathway: Material Balance Inputs

Input Stream	GHGenius Location	GHGenius Input	Input (g/$L_{Biodiesel}$)	Function	Notes
Canola Oil	Input AZ248	0.9 kg/$L_{Biodiesel}$	900	Feedstock	
Hydrochloric acid	Alt Fuel Prod BE43	0.01 kg/$L_{Biodiesel}$	10	Esterification Catalyst	
Methanol	Alt Fuel Prod BE51	0.12 kg/$L_{Biodiesel}$	120	Esterification Reactant	
Nitrogen	Alt Fuel Prod BE56	0.02 kg/$L_{Biodiesel}$	20	Purging & Stripping Agent	
Total Input			**1050**		

The output data for this Canola Oil example pathway are shown in Table 9-10. Glycerine coproducts are entered in the model in mass per litre of biodiesel, so density information is not required.

Table 9-10 Tallow Pathway: Material Balance Outputs

Output Stream	GHGenius Location	GHGenius Input	Input (g/$L_{Biodiesel}$)	Function	Notes
Biodiesel	N/A	N/A	884	Main Product	Density (884 g/L) from cell E90 of Fuel Char Sheet
Crude Glycerine	Coprods X125	0.08 kg/$L_{Biodiesel}$	80	Coproduct	Glycerol: 83% Moisture: 7.3% Methanol: 0.3%
Waste water	N/A	N/A	43	Waste	Metered stream.
Waste products (mainly soap and salt residues)	N/A	N/A	37	Waste	Unmetered streams. Calculated using material balance.
Total Output			**1050**		