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|  | <p>Ministry of Energy<br/>and Climate<br/>Solutions</p> <p>Issued: June 2024<br/>Revised: Sept. 2026</p> | <p>Low Carbon Fuels Act</p> <p>GHGenius 5.02b User Guide:<br/>Carbon Intensity of Renewable Hydrocarbon Fuels</p> <p>Replacing: Hydrogenation-derived Renewable Diesel<br/>(HDRD) User Guide</p> |
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**GHGenius 5.02b User Guide:  
Carbon Intensity of Renewable Hydrocarbon Fuels**

Issued: June 2024  
Revised: September 2026

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# Executive Summary

This guide assists Renewable Hydrocarbon Fuel (RHF) producers and suppliers in determining the carbon intensity (CI) of fuel delivered to British Columbia (BC) using GHGenius 5.02b. RHF includes hydrogenation-derived renewable fuel (HDRF), co-processed renewable fuel (CPRF), and biomass-to-liquid fuels (BtLF). This user guide does not cover other types of RHF such as electro fuels.

Earlier versions of this user guide were focused on determining the CI of hydrogenation-derived renewable diesel (HDRD). HDRD is still covered in this user guide, but the scope has been expanded to cover other RHF pathways including CPRF and BtLF.

The guide covers the steps that a GHGenius user must follow to model a specific RHF plant. This includes ensuring that Excel can properly run the model, setting up the model with the correct region, year and Global Warming Potentials (GWPs) specified in the BC regulations, and inputting the plant-specific data. This guide covers running the model multiple times for activities that occur in multiple regions and describes where the results are found.

CPRF CI applications must also meet the co-processing requirements detailed in [RLCF-019 Co-processing Methodology](#).

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## Glossary

|                                       |                                                                               |
|---------------------------------------|-------------------------------------------------------------------------------|
| AJF                                   | Alternative jet fuel                                                          |
| AB                                    | Alberta                                                                       |
| BC                                    | British Columbia                                                              |
| BtL                                   | Biomass-to-liquid                                                             |
| BtLD                                  | Biomass-to-liquid diesel                                                      |
| BtLF                                  | Biomass-to-liquid fuels                                                       |
| BtLG                                  | Biomass-to-liquid gasoline                                                    |
| CCS                                   | Carbon capture and sequestration                                              |
| CCS <sub>fraction</sub>               | Fraction of the maximum CCS rate represented by the actual sequestration rate |
| CCS <sub>max rate</sub>               | Maximum CCS rate calculated by GHGenius                                       |
| CCS <sub>rate, GJ</sub>               | Permanent CCS rate per GJ of fuel                                             |
| CCS <sub>rate, L</sub>                | Permanent CCS rate per L of fuel                                              |
| CH <sub>4</sub>                       | Methane                                                                       |
| CHP                                   | Combined heat and power                                                       |
| CI                                    | Carbon intensity                                                              |
| CO                                    | Carbon monoxide                                                               |
| CO <sub>2</sub>                       | Carbon dioxide                                                                |
| CO <sub>2</sub> captured              | Captured CO <sub>2</sub>                                                      |
| CO <sub>2</sub> injection, fugitives  | Fugitive CO <sub>2</sub> emissions at injection site                          |
| CO <sub>2</sub> injection, subsurface | CO <sub>2</sub> emissions from subsurface to atmosphere                       |
| CO <sub>2</sub> injection, venting    | CO <sub>2</sub> venting at injection site                                     |
| CO <sub>2</sub> e                     | CO <sub>2</sub> equivalent                                                    |
| CPRD                                  | Co-processed renewable diesel                                                 |
| CPRF                                  | Co-processed renewable fuels                                                  |
| CPRG                                  | Co-processed renewable gasoline                                               |
| CPRJ                                  | Co-processed renewable jet fuel                                               |
| CPRN                                  | Co-processed renewable naphtha                                                |
| CPRP                                  | Co-processed renewable propane                                                |
| DHT                                   | Diesel hydrotreating unit                                                     |
| DME                                   | Dimethyl ether                                                                |
| EPA                                   | Environmental Protection Agency                                               |
| FCC                                   | Fluid catalytic cracking unit                                                 |
| FCC RD                                | FCC renewable diesel                                                          |
| FT                                    | Fischer-Tropsch process                                                       |
| GHG                                   | Greenhouse gas                                                                |



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|                |                                                             |
|----------------|-------------------------------------------------------------|
| GJ             | Giga Joule                                                  |
| GWP            | Global warming potential                                    |
| H <sub>2</sub> | Hydrogen                                                    |
| HCO            | Heavy cycle oil                                             |
| HDRD           | Hydrogenation-derived renewable diesel                      |
| HDRF           | Hydrogenation-derived renewable fuel                        |
| HDRJ           | Hydrogenation-derived renewable jet fuel                    |
| HDRN           | Hydrogenation-derived renewable naphtha                     |
| HDRP           | Hydrogenation-derived renewable propane                     |
| HHV            | Higher heating value                                        |
| HRD            | GHGenius label for hydrogenation-derived renewable diesel   |
| HRG            | GHGenius label for renewable gasoline                       |
| HRJ            | GHGenius label for hydrogenation-derived renewable jet fuel |
| HRP            | GHGenius label for hydrogenation-derived renewable propane  |
| HVO            | Hydrogenated vegetable oil                                  |
| IPCC           | Intergovernmental Panel on Climate Change                   |
| Kg             | Kilogram                                                    |
| kWh            | Kilowatt-hour                                               |
| LCA            | Lifecycle analysis                                          |
| LCFS           | Low Carbon Fuel Standard                                    |
| LFO            | Light fuel oil                                              |
| LNG            | Liquified natural gas                                       |
| LPG            | Liquid petroleum gas                                        |
| MJ             | Megajoule                                                   |
| NaOH           | Sodium hydroxide, also known as caustic soda                |
| NG             | Natural gas                                                 |
| NMOC           | Non-methane organic compounds                               |
| PADD           | Petroleum Administration for Defense Districts              |
| RD             | Renewable diesel                                            |
| RF             | Renewable fuel                                              |
| RG             | Renewable gasoline                                          |
| RHF            | Renewable hydrocarbon fuels                                 |
| RJF            | Renewable jet fuel                                          |
| RLCF           | Renewable and Low Carbon Fuels                              |
| RN             | Renewable naphtha                                           |
| RP             | Renewable propane                                           |
| RNG            | Renewable natural gas                                       |
| SAF            | Sustainable aviation fuel                                   |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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|        |                                                       |
|--------|-------------------------------------------------------|
| SBE0   | Spent bleaching earth oil                             |
| SBO    | Soybean oil                                           |
| SK     | Saskatchewan                                          |
| SMR    | Steam methane reforming                               |
| SRF    | Short rotation forestry                               |
| UCO    | Used cooking oil                                      |
| UNFCCC | United Nations Framework Convention on Climate Change |
| US     | United States                                         |
| USA    | United States of America                              |
| USC    | US Central                                            |
| USE    | US East                                               |
| USW    | US West                                               |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## Introduction

This guide is intended to assist renewable hydrocarbon fuel (RHF) producers and suppliers in determining the carbon intensity (CI) of fuel delivered to British Columbia (BC) using GHGenius 5.02b. RHF includes hydrogenation-derived renewable fuel (HDRF), co-processed renewable fuel (CPRF), and biomass-to-liquid fuels (BtLF).

HDRF pathways include:

- Hydrogenation-derived renewable diesel (HDRD)
- Alternative jet fuel (AJF)
- Renewable naphtha (RN)
- Renewable propane (RP)

CPRF is the renewable component of fuel produced by co-processing a renewable feedstock with a fossil feedstock in a co-processing unit such as a diesel hydrotreating (DHT) unit or a fluid catalytic cracking (FCC) unit.

The co-processing unit is the unit that the renewable feedstock is first processed in. For example, if canola oil is first co-processed in an FCC unit before being sent to a DHT unit, the co-processing unit is the FCC.

CPRF includes but is not limited to the following pathways:

- DHT unit co-processed renewable diesel (RD)
- DHT unit co-processed AJF
- DHT unit co-processed RN
- DHT unit co-processed RP
- FCC unit co-processed renewable gasoline (RG)
- FCC unit co-processed RD
- FCC unit co-processed RP

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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- Other co-processing unit renewable fuels (RF)

BtLF covers pathways where biomass feedstocks are converted through a thermochemical process to produce a synthetic RHF. An example is Fischer-Tropsch (FT) renewable diesel from wood.

## 1 RHF Overview and GHGenius Pathways

The RHF covered are shown in **Table 1-1** along with where the CI results can be found on the BC LCFS sheet.

**Table 1-1 RHF pathways and CI results location**

| RHF Type | Fuel         | Other names                  | BC LCFS Sheet cells             | Note                        |
|----------|--------------|------------------------------|---------------------------------|-----------------------------|
| HDRF     | HDRD         | HRD<br>HVO<br>RD             | AK8-18                          | Main product                |
|          | AJF          | HDRJ<br>RJF<br>SAF           | Coproduct:<br>AK8-16<br>AL16-18 | Coproduct only <sup>1</sup> |
|          | RN           | HDRN                         | Coproduct:<br>AK8-16<br>AM16-18 | Coproduct only              |
|          | RP           | HRP<br>Renewable LPG<br>HDRP | Coproduct:<br>AK8-16<br>AN16-18 | Coproduct only              |
| CPRF     | DHT unit RD  | CPRD<br>HDRD<br>RD           | AK8-18                          | Main product                |
|          | DHT unit AJF | CPRJ<br>RJF<br>SAF           | Coproduct:<br>AK8-16<br>AL16-18 | Coproduct only <sup>1</sup> |
|          | DHT unit RN  | DHT<br>CPRN                  | Coproduct:<br>AK8-16<br>AM16-18 | Coproduct only              |
|          | DHT unit RP  | CPRP<br>RP                   | Coproduct:<br>AK8-16<br>AN16-18 | Coproduct only              |

<sup>1</sup> When AJF is the main product (section 1.2) see: Alternative Jet Fuel User Guide

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| RHF Type | Fuel                              | Other names                 | BC LCFS Sheet cells             | Note           |
|----------|-----------------------------------|-----------------------------|---------------------------------|----------------|
|          | FCC unit RG                       | CPRG<br>RG                  | AM8-18                          | Main product   |
|          | FCC unit AJF                      | CPRJ<br>RJF                 | Coproduct:<br>AM8-16<br>AL16-18 | Coproduct only |
|          | FCC unit RD                       | CPRD<br>RD                  | Coproduct:<br>AM8-16<br>AK16-18 | Coproduct only |
|          | FCC unit RP                       | CPRP<br>RP                  | Coproduct:<br>AM8-16<br>AN16-18 | Coproduct only |
| BtLF     | Biomass-to-liquid diesel (BtLD)   | FT RD<br>Synthetic diesel   | BF8-18                          |                |
|          | Biomass-to-liquid gasoline (BtLG) | FT RG<br>Synthetic gasoline | BK8-18                          |                |

## 1.1 RHF Pathway Exclusions:

This user guide does not cover the following:

- RHF pathways where alternative jet fuel (AJF) is the main product (see section 1.2),
  - See: [Alternative Jet Fuel User Guide](#)
- RHF pathways where renewable propane (RP) is the main product (see section 1.2), and
- Synthetic renewable hydrocarbon fuels other than BtLF from wood.

## 1.2 Main Product Determination

RHF fuel production can produce multiple fuels at the same time. Whatever fuel product is produced in the largest quantity should be considered the main product, with the other fuels considered coproducts. The coproducts' CI should use the same lifecycle results as the main product except for the following lifecycle stages:

1. Fuel distribution and storage
2. Fuel dispensing

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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### 3. Vehicle or vessel operation

#### **Example:**

A HDRF facility produces the following fuel products:

- 3 million L of HDRD
- 1 million L of AJF
- 0.2 million L of RN

The main product is HDRD, with AJF and RN coproducts.

If AJF is the main product, see the [AJF User Guide](#) for further guidance. Pathways where AJF is the main product are not covered in this user guide.

AJF and RN must use the lifecycle results from the HDRD pathway for the following lifecycle stages:

1. Direct land use change
2. Feedstock production or cultivation
3. Feedstock upgrading
4. Feedstock transport
5. Feedstock coproducts production
6. Avoided emissions
7. Fuel production
8. Fuel coproducts production

The following lifecycle stage results should come from their respective pathways to account for the different densities and combustion emissions associated with the coproduct fuels.

9. Fuel distribution and storage

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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10. Fuel dispensing

11. Vehicle or vessel operation

### 1.3 RHF Feedstocks and System Boundaries

HDRF and CPRF pathways are produced from fat and oil feedstocks, with the available GHGenius feedstocks detailed in **Table 1-2**.

**Table 1-2 HDRF and CPRF Feedstocks in GHGenius**

| Vegetable Oils | Waste Based                          | Coproduct |
|----------------|--------------------------------------|-----------|
| Canola Oil     | Used Cooking Oil (UCO)/Yellow Grease | Corn Oil  |
| Soybean Oil    | Tallow                               |           |
| Jatropha Oil   | Tall Oil                             |           |
| Palm Oil       | Palm Sludge Oil                      |           |
| Camelina Oil   | Spent Bleaching Earth Oil (SBE0)     |           |
| Algae Oil      | Fish Oil                             |           |

The BtLF feedstocks are limited to wood feedstocks in GHGenius as shown in **Table 1-3**.

**Table 1-3 BtLF Feedstocks in GHGenius**

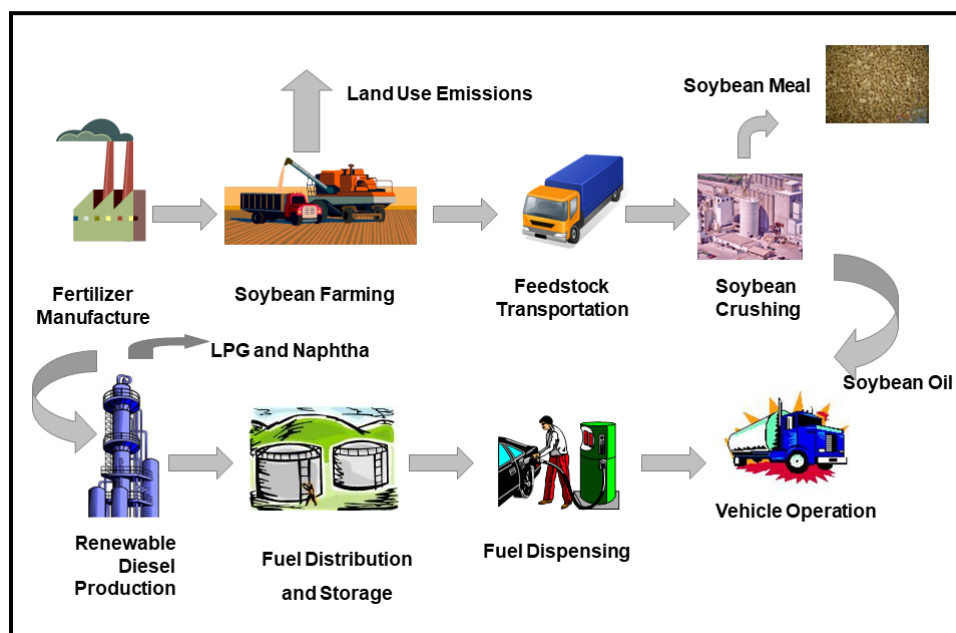
| Feedstock                     | Description                                                                                                                                                                                                                                                                    |
|-------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Short rotation forestry (SRF) | Trees grown and harvested over a brief period (10-20 years), primarily for the purpose of producing biomass.                                                                                                                                                                   |
| Standing timber               | The fibre left behind on a site after primary harvesting operations have been completed. Includes smaller or poor-quality logs and pieces of logs, branches, and other woody biomasses. This waste is often left in a cut block and piled into large slash piles by machinery. |
| Wood residue                  | Wood waste including sawdust, bark, and shavings. Does not include forest residues.                                                                                                                                                                                            |

RHF pathways have different system boundaries depending on whether the feedstock is categorized as a vegetable oil, waste based or a coproduct. The system boundaries of each feedstock category are described in the sections below.

#### 1.3.1 Vegetable Oil Derived RHF System Boundary

The lifecycle system boundary for soybean HARD is shown in the following figure. Other vegetable oil derived RHF pathways have similar system boundaries.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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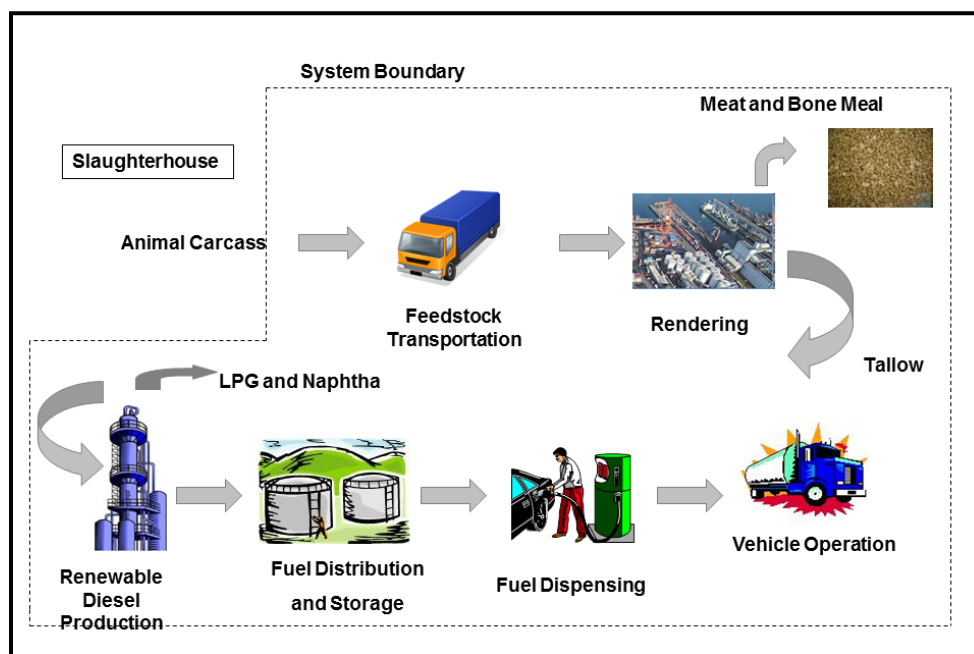


**Figure 1-1 Soybean HDRD System Boundary**

### 1.3.2 Waste Derived HDRF and CPRF

Waste derived HDRF and CPRF can have different system boundaries, depending on the feedstock. The animal fat (tallow) to HDRD system is shown in the following figure. Waste derived feedstocks are characterized by having little to no feedstock production emissions. An example of feedstock production emissions that could be included is the emissions associated with rendering animal fat to produce tallow.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Figure 1-2 Animal Fat HDRD System Boundary**

### 1.3.3 Coproduct Derived RHF

Corn oil is a coproduct of corn ethanol production, which can be used as a feedstock for RHF or biodiesel production. The feedstock production emissions for the corn oil are taken from the displacement coproduct credit for animal feed in the corn ethanol pathway.

### 1.3.4 BtLF Feedstocks

GHGenius 5.02b includes three types of wood-derived feedstocks for BtLF production that have different system boundaries. The three feedstocks are discussed below.

#### 1.3.4.1 Short Rotation Forestry

Wood from short rotation forestry (SRF) includes the lifecycle emissions associated with feedstock recovery, land management emissions, pesticide use and feedstock transportation to produce SRF. SRF typically has the highest upstream emissions of the wood BtLF feedstocks, as it is not considered a waste.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**1.3.4.2 Standing Timber**

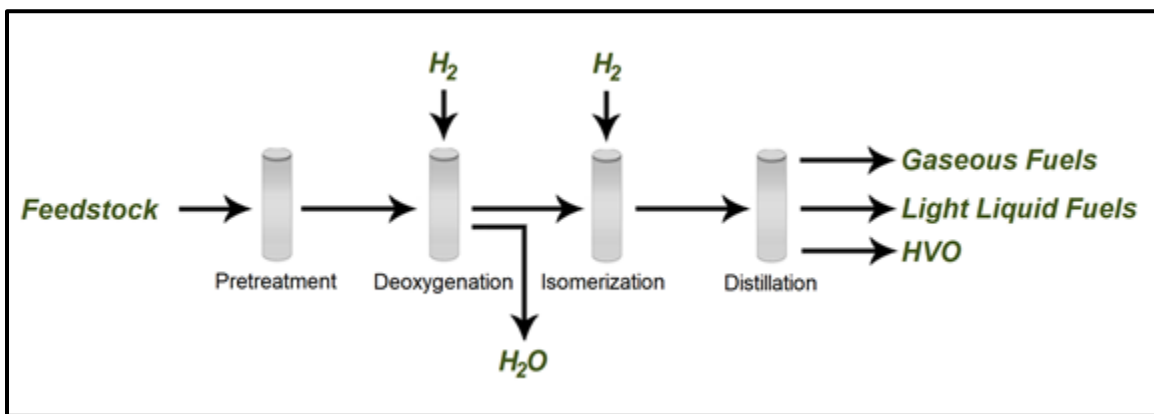
Wood from standing timber is considered a waste that includes lifecycle emissions associated with feedstock recovery and transportation. Standing timber also can include avoided emissions from slash burning (see Section 3.4), which can lead to negative feedstock production emissions if eligible.

**1.3.4.3 Wood Residue**

Wood from wood residue is considered a waste and includes no upstream emissions other than feedstock transportation. The wood residue feedstock can be used for waste that comes from mills.

**1.4 HDRF Process**

There are several process developers that offer HDRF technology including Topsoe, Honeywell UOP, Axens, Shell, and others. Currently, Topsoe has more plants in North America than the other HDRF technology providers. There are plants that only process vegetable oils and plants that process multiple feedstocks. There are quality requirements for the feedstock, particularly the phosphorus content, and some plants include pre-treatment units to lower the contaminants and prolong catalyst life. The basic process is similar for all technology options and is shown in the following figure.



**Figure 1-3 Basic HDRF Process Diagram**

## 1.5 CPRF Process

CPRF pathways represent the renewable component of fuel produced through processing both biogenic and fossil-derived feedstocks at the same time in a co-processing unit. Examples of co-processing units include but are not limited to:

- Fluid catalytic cracking unit (FCC)
- Diesel hydrotreating unit (DHT)

CPRF pathways have similar system boundaries to HDRF pathways, with fuels co-processed in a DHT modelled using either the HDRD or HDRJ pathway in GHGenius 5.02b. These pathways are labelled HRD and HRJ in the model. Renewable gasoline (RG) has a separate pathway in GHGenius 5.02b which is representative of renewable gasoline produced in an FCC. This pathway is labelled HRG in the model.

CPRF producers must review the [RLCF-019: Co-processing Methodology](#).

## 1.6 BtLF Process

BtLF pathways are produced through the gasification of biomass to produce syngas, with the syngas then converted to hydrocarbon fuels through processes such as the Fischer-Tropsch process.

GHGenius only includes the capability to model BtLF from wood feedstocks but BtLF can be produced from other biomass feedstocks including agricultural waste (straw, stover and husks) and grasses.

|                                                                                   |                                                                                                          |                                                                                                                                                                                                  |
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Only BtLD and BtLG pathways can be modelled in GHGenius. Other BtLF pathways such as BtL jet fuel, BtL dimethyl ether and BtL methanol do not have a dedicated pathway in GHGenius.

If an applicant would like to apply for a fuel code for a BtLF pathway not included in GHGenius please contact the BC Low Carbon Fuels Branch at [lcfs@gov.bc.ca](mailto:lcfs@gov.bc.ca).

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 2 GHGenius Model Overview

This section outlines how to obtain GHGenius 5.02b and the steps needed to initialize GHGenius 5.02b prior to inputting values for LCA modelling.

GHGenius 5.02b is an Excel-based LCA model. Features of GHGenius 5.02b that users should be aware of include:

- The use of time-based data series rather than static data:
  - This means the selection of the Target year will alter the CI value of fuels modelled in GHGenius. Users must ensure that they select the appropriate Target year for their modelling (see sections 2.2.2 and 4.1)
- The inclusion of region and country specific datasets:
  - This means that the selection of the region will alter the CI value of fuel modelled in GHGenius. Users must ensure that they select the appropriate region for their modelling. If different lifecycle stages occur in different regions, multiple runs of the model may be required (see section 2.2.1)

### 2.1 Downloading the Model

GHGenius 5.02b is available to download on the [GHGenius 5.02b webpage](#). Though there is no cost to users, registration is required before downloading the model.

The downloaded file is provided as a zipped [.xls] Excel file. After unzipping the file, do not save it as a [.xlsx] file as this will deactivate the macros that the model needs to operate correctly.

Although the file can be saved as a macro enabled [.xlsm] format, this may result in loss of functionality. More specifically, some macro buttons may stop working unless manually reassigned. To ensure full functionality it is strongly recommended to save and run the model in its original [.xls] format.

#### 2.1.1 Unblocking Macros

GHGenius relies on macros to set up appropriate Excel settings, calculate output values, and provide additional tools for users. The model will only function properly with macros enabled.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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To make Microsoft Office more secure, macros are now blocked by default on files downloaded from the internet. To unblock macros:

1. Navigate to the file in File Explorer
2. Right-click on the file's icon and select [Properties]
3. Select [Unblock] at the bottom of the General tab in the Properties window

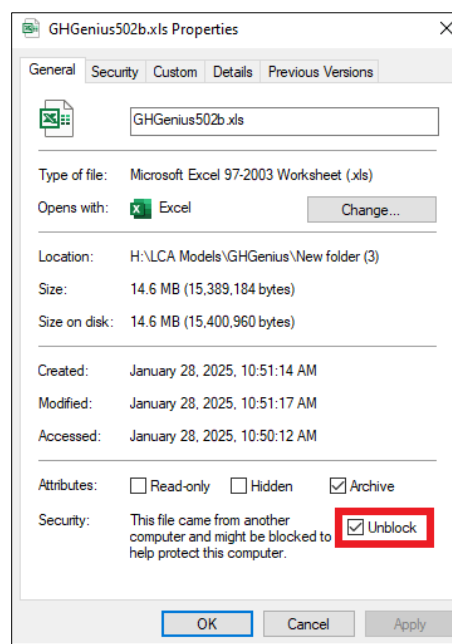


Figure 2-1 Unblocking Macros

For more information about this change and alternative ways to unblock macros please visit the [Macros from the internet are blocked by default in Office webpage](#).

## 2.2 Initializing the Model

Before entering any facility specific data to model a fuel pathway, users must first initialize the model as outlined in the sections below.

### 2.2.1 Model Region

To install the correct model region users must:

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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1. Select the appropriate modelling region from the drop-down list in cell B4 on the Input sheet.
2. Press the “Install Regional Defaults” button found to the right of the drop-down list (cells C3-D5). This action will run macros to populate region-specific data for the current modelling run.
3. Verify that the correct region has been applied in the model by checking that cell B10 on the Input sheet, which displays the currently active region, shows the correct region.

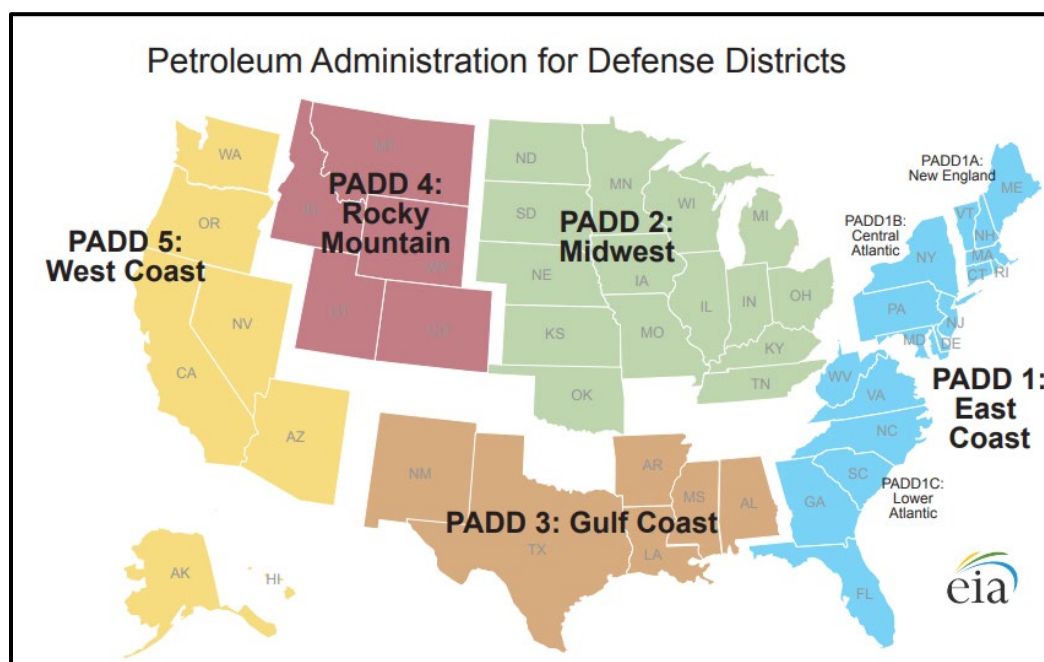
The selected region must correspond to where the fuel lifecycle stage(s) occurred. Because fuel pathways often span multiple regions, most CI applications will require two or three model runs to reflect the geographic locations of each lifecycle stage. For example, if the feedstock originates from one region and the fuel is produced in another (outside British Columbia), the user must complete the following three modelling runs to determine the CI of the fuel:

1. Feedstock production and transportation – use the region where the feedstock originates.
2. Fuel production, transportation, storage, and distribution – use the region where the production facility is located.
3. Fuel distribution, storage, dispensing, and end use – use the region where the fuel is used (British Columbia).

For processes occurring within Canada, although the model allows selection of broader regions (i.e. Canada West/Central/East), users must select the specific province to accurately determine the fuel’s carbon intensity. For cases where the feedstock comes from multiple provinces in one region, but the producer cannot determine the split from each province, users may select the broader Canadian region that the feedstock comes from (e.g. Canada West, if the wheat comes from Manitoba and Saskatchewan).

The United States regions in GHGenius align with the US Energy Information Administration’s Petroleum Administration for Defense Districts ([PADDs](#)) as shown in **Figure 2-2** and **Table 2-1**.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Figure 2-2 US Model Regions - PADDs**

**Table 2-1 PADD and corresponding GHGenius region**

| PADD  | GHGenius Region |
|-------|-----------------|
| 4 & 5 | US West         |
| 2 & 3 | US Central      |
| 1     | US East         |

If a process occurs outside of Canada or the USA, users must select the appropriate country/region from the drop-down list. If the country is not available in the model, users must select the most appropriate proximate region within the model and provide a clear rationale for their selection. If unsure on which region to select please contact the BC Low Carbon Fuels Branch at [lcfs@gov.bc.ca](mailto:lcfs@gov.bc.ca) to determine which region to use, before submitting a CI application.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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### 2.2.2 Model 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 the data is design data set it to match the application year.

Users must enter the modelling year in two locations in the model, both on the Input sheet:

- Target Year: cell B7
- Base year for Alt Fuel Production: row 241
  - Column will vary depending on RHF type (see **Table 4-1**).

### 2.2.3 Global Warming Potentials (GWPs)

By default, the model uses GWP values from the International Panel on Climate Change (IPCC) 5<sup>th</sup> Assessment Report (2013 (100 years)) and sets the treatment of short-lived gases as “Carbon Weighted”.

The carbon weights for short-lived gases are shown in **Table 2-2**.

**Table 2-2 Carbon Weights of Short-Lived Gases**

| Short-Lived Gas                      | Carbon Weight |
|--------------------------------------|---------------|
| Non-Methane Organic Compounds (NMOC) | 2.99          |
| Methane (CH <sub>4</sub> )           | 2.00          |
| Carbon monoxide (CO)                 | 1.57          |

To change the GWP settings, users can select different values in cells B11 and D11 on the Input sheet. However, for the purposes of fuel CI modelling under the BC LCFS, the selected GWP settings must align with those provided in Information Bulletin [RLCF-011: Approved Version of GHGenius and Global Warming Potentials](#).

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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### 3 Feedstock Production and Transportation

Since the model incorporates region-specific data, users must model each feedstock type and its correlating region separately to calculate an accurate fuel CI.

For example, an HARD plant in US Central that uses soybean oil from US Central and US East and canola oil from Saskatchewan would need to complete three separate feedstock transportation and production modelling runs which will then produce three separate fuel CI values when combined with the modelling results for fuel production, distribution and use.

**Table 3-1** details the RHF feedstocks available in GHGenius and the RHF fuels that include a pathway for the feedstock. Unlike other fuels such as ethanol and biodiesel, GHGenius uses the same column of the BC LCFS sheet for each RHF regardless of the feedstock that is modelled. The column of the BC LCFS for each RHF pathway is shown in **Table 1-1** in Section 1.

**Table 3-1 RHF Feedstocks**

| RHF Feedstock           | Eligible Fuels |
|-------------------------|----------------|
| Algae Oil               | HARD and CPRF  |
| Camelina Oil            |                |
| Canola Oil              |                |
| Corn Oil                |                |
| Fish Oil                |                |
| Jatropha Oil            |                |
| Palm Oil                |                |
| Palm Sludge Oil         |                |
| SBEO                    |                |
| Soybean Oil             |                |
| Tall Oil                |                |
| Tallow                  |                |
| UCO/ Yellow Grease      |                |
| Short Rotation Forestry | BtLF           |
| Standing Timber         |                |
| Wood Residue            |                |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 3.1 Feedstock Selection

GHGenius requires the user to select the feedstock being modelled for RHF pathways. The feedstocks for HDRF and CPRF pathways are selected in the same location, while BtLF pathway feedstocks are selected in a separate location in GHGenius.

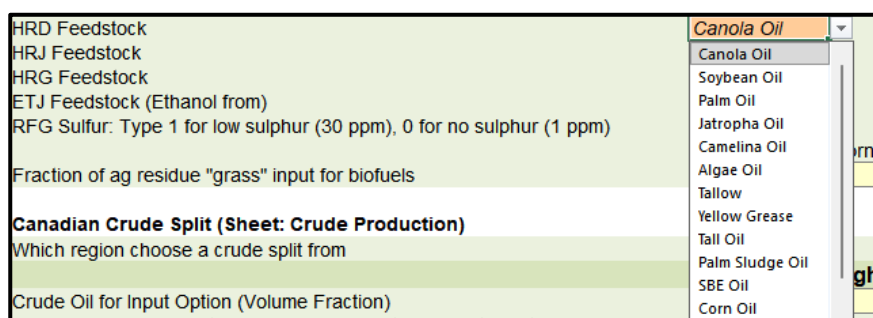
### 3.1.1 HDRF and CPRF Feedstock Selection

While all the lipid feedstocks can be used for HDRF and CPRF production there is only one fuel production column on the Input sheet and only one output column on the BC LCFS sheet (see **Table 1-1**). The selection of the feedstock is made using the drop-down for the corresponding main product (see Section 1.2) as shown in **Table 3-2**. There is a separate drop-down for AJF, but this is to be used when AJF is the main product which is not covered in this user guide.

**Table 3-2 HDRF and CPRF feedstock drop-down location**

| Main Product | Drop-down Input sheet cell |
|--------------|----------------------------|
| HARD (HRD)   | B53                        |
| RG (HRG)     | B55                        |

The feedstock drop-down for HARD is shown in **Figure 3-1**. By selecting the feedstock in the drop-down GHGenius will connect the upstream feedstock production emissions from the selected feedstock and change the feedstock type for the HDRF or CPRF pathway on the BC LCFS sheet.



**Figure 3-1 HDRF Feedstock Drop-down**

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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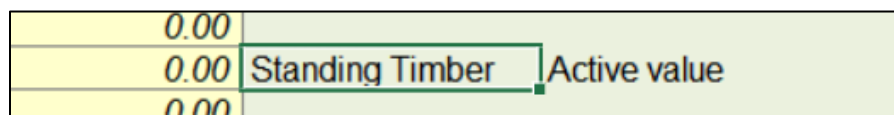
### 3.1.2 BtLF Feedstock Selection

The BtLF feedstock is selected by pressing one of 3 buttons found in cells A114-A122 of the Input sheet as shown in **Figure 3-2**. Selecting the BtLF feedstock will change the upstream feedstock production emissions and the feedstock label for the BtLF pathway on the BC LCFS sheet to match the selected feedstock.



**Figure 3-2 BtLF Feedstock Selection Buttons**

To verify the correct BtLF feedstock is selected cell J114 of the Input sheet can be checked. **Figure 3-3** shows that Standing Timber is the BtLF feedstock active value.



**Figure 3-3 BtLF Feedstock Active Value**

## 3.2 Feedstock Transportation

GHGenius can account for the following feedstock transportation emissions:

- Feedstock transportation to upgrader (e.g. soybean transport to the crusher), and
- Feedstock transportation to RHF plant (e.g. soybean oil transport to the HDRF plant).

Feedstock transportation is entered in the Input sheet, with the one-way distances entered in rows 76 to 80 and the tonnes-shipped/tonnes-produced entered in rows 82 to 86. See Appendices 1-6 for examples.

|                                                                                   |                                                                                      |                                                                                                                                                                              |
|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
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If the fuel producer knows the transportation distances and fractions of the raw (non-upgraded) feedstock to the upgrader the default inputs for the raw feedstock transportation values must be modified. These are located on the Input sheet in the column detailed in **Table 3-3**. If the raw feedstock transportation values are not known, the defaults in GHGenius should be used.

**Table 3-3 Feedstock Transportation to Upgrader Column**

| RHF Feedstock     | Upgrader Feedstock    | Column |
|-------------------|-----------------------|--------|
| Algae Oil         | Algae                 | U      |
| Camelina Oil      | Camelina              | S      |
| Canola Oil        | Canola                | K      |
| Corn Oil          | N/A                   | N/A    |
| Fish Oil          | N/A                   | N/A    |
| Jatropha Oil      | Jatropha              | Q      |
| Palm Oil          | Palm Fruit            | O      |
| Palm Sludge Oil   | Palm Sludge           | AC     |
| Soybean Oil       | Soybean               | M      |
| SBEO              | Spent Bleaching Earth | AE     |
| Tall Oil          | Tall Soap             | AA     |
| Tallow            | Animal Carcasses      | W      |
| UCO/Yellow Grease | Waste cooking oil     | Y      |
| SRF               | N/A                   | N/A    |
| Standing Timber   | N/A                   | N/A    |
| Wood Residue      | N/A                   | N/A    |

The feedstock transportation distances and fractions from the upgrader to the RHF plant are set on the Input sheet in rows 76 though 86 in the column shown in **Table 3-4**.

**Table 3-4 Feedstock Transportation to RHF Plant Column**

| RHF Feedstock   | Column |
|-----------------|--------|
| Algae Oil       | V      |
| Camelina Oil    | T      |
| Canola Oil      | L      |
| Corn Oil        | AG     |
| Fish Oil        | AH     |
| Jatropha Oil    | R      |
| Palm Oil        | P      |
| Palm Sludge Oil | AD     |
| Soybean Oil     | N      |
| SBEO            | AF     |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| RHF Feedstock   | Column |
|-----------------|--------|
| Tall Oil        | AB     |
| Tallow          | X      |
| UCO             | Z      |
| SRF             | J      |
| Standing Timber | J      |
| Wood Residue    | J      |

### 3.3 Feedstock Production

If feedstock production data is not available, the GHGenius defaults for feedstock production should be used. If a RHF plant has data related to feedstock upgrading the GHGenius defaults must be updated as per Section 3.3.1.

Some feedstock producing regions are selected by the model when the region is selected but this is not the case for every feedstock. GHGenius users should ensure that the appropriate feedstock region is selected for modelling the specific feedstock, this can be verified by looking at columns B to Q of the Input sheet in the rows detailed in **Table 3-5**.

**Table 3-5 Feedstock Production Region Verification Input Sheet Row**

| RHF Feedstock   | Feedstock Production Region Row |
|-----------------|---------------------------------|
| Algae           | 194                             |
| Camelina        | 190                             |
| Canola          | 178                             |
| Corn Oil        | N/A                             |
| Fish Oil        | N/A                             |
| Jatropha        | 186                             |
| Palm            | 182                             |
| Palm Sludge     | N/A                             |
| Soybean         | 174                             |
| SBEO            | N/A                             |
| Tall Oil        | N/A                             |
| Tallow          | N/A                             |
| UCO             | N/A                             |
| SRF             | 220                             |
| Standing Timber | 220                             |
| Wood Residue    | 220                             |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Figure 3-4** shows an example where the soybean production region has been set to the US Central, as the corresponding cell has a 1 in it. If another region is selected there will be a 1 in its corresponding cell.

| Country data on yields and fertilizer use for: | Canada<br>East | Canada<br>Central | Canada<br>West | US East | US Central | US West | Mexico |
|------------------------------------------------|----------------|-------------------|----------------|---------|------------|---------|--------|
| 154                                            |                |                   |                |         |            |         |        |
| 155                                            | 7.20           | 7.20              | 4.70           | 7.60    | 7.60       | 7.60    | 2.20   |
| 156                                            | 1.50           | 1.50              | 2.10           | 1.60    | 1.60       | 1.60    | 2.40   |
| 157                                            | 13.00          | 13.00             | 20.66          | 19.20   | 19.20      | 19.20   | 20.00  |
| 158                                            | 0.00           | 0.00              | 0.00           | 0.00    | 1.00       | 0.00    | 0.00   |
| 159                                            | 2.40           | 2.40              | 2.40           | 2.40    | 2.40       | 2.40    | 4.20   |
| 160                                            | 1.40           | 1.40              | 1.40           | 1.40    | 1.40       | 1.40    | 1.50   |
| 161                                            | 20.00          | 20.00             | 20.00          | 20.00   | 20.00      | 20.00   | 20.00  |
| 162                                            | 0.00           | 0.00              | 0.00           | 0.00    | 1.00       | 0.00    | 0.00   |
| 163                                            | 2.80           | 2.80              | 2.80           | 2.80    | 2.80       | 2.80    | 3.00   |
| 164                                            | 1.10           | 1.10              | 1.10           | 1.10    | 1.10       | 1.10    | 1.00   |
| 165                                            | 23.00          | 23.00             | 23.00          | 23.00   | 23.00      | 23.00   | 23.00  |
| 166                                            | 0.00           | 0.00              | 0.00           | 0.00    | 1.00       | 0.00    | 0.00   |
| 167                                            | 2.00           | 2.00              | 2.00           | 2.00    | 2.00       | 2.00    | 2.30   |
| 168                                            | 1.10           | 1.10              | 1.10           | 1.10    | 1.10       | 1.10    | 1.00   |
| 169                                            | 4.00           | 4.00              | 4.00           | 4.00    | 4.00       | 4.00    | 4.00   |
| 170                                            | 0.00           | 0.00              | 1.00           | 0.00    | 0.00       | 0.00    | 0.00   |
| 171                                            | 2.50           | 2.50              | 2.50           | 2.40    | 2.40       | 2.40    | 1.70   |
| 172                                            | 0.90           | 0.90              | 0.90           | 1.30    | 1.30       | 1.30    | 0.00   |
| 173                                            | 1.80           | 1.80              | 1.84           | 1.80    | 1.80       | 1.80    | 2.00   |
| 174                                            | 0.00           | 0.00              | 0.00           | 0.00    | 1.00       | 0.00    | 0.00   |
| 175                                            | 1.40           | 1.40              | 1.40           | 1.40    | 1.40       | 1.40    | 1.30   |

**Figure 3-4 US Central Soybean Feedstock Production Region**

### 3.3.1 Feedstock Upgrading

If primary data (data measured at the facility) is available for the feedstock upgrading process, then this can be used in the modelling in place of using the default GHGenius values.

Feedstock upgrading energy and feedstock consumption data is entered in rows 239 to 248 of the Input sheet. Material inputs used in feedstock upgrading are entered in the Alt Fuel Prod sheet. The columns for feedstock upgrading on the Input and Alt Fuel Prod sheets are shown in **Table 3-6**.

**Table 3-6 Feedstock Upgrading Data Locations**

| Feedstock       | Feedstock Upgrading<br>Input Column | Feedstock Upgrading<br>Alt Fuel Prod Column |
|-----------------|-------------------------------------|---------------------------------------------|
| Algae Oil       | AX                                  | BL                                          |
| Camelina Oil    | AW                                  | BJ                                          |
| Canola Oil      | AS                                  | BB                                          |
| Corn Oil        | BF                                  | BX                                          |
| Fish Oil        | AY                                  | BC                                          |
| Jatropha Oil    | AV                                  | BH                                          |
| Palm Oil        | AU                                  | BF                                          |
| Palm Sludge Oil | BA                                  | BT                                          |
| SBE0            | BB                                  | BV                                          |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Feedstock       | Feedstock Upgrading<br>Input Column | Feedstock Upgrading<br>Alt Fuel Prod Column |
|-----------------|-------------------------------------|---------------------------------------------|
| Soybean Oil     | AT                                  | BD                                          |
| Tall Oil        | BE                                  | BR                                          |
| Tallow          | BC                                  | BN                                          |
| UCO             | BD                                  | BP                                          |
| SRF             | N/A                                 | N/A                                         |
| Standing Timber | N/A                                 | N/A                                         |
| Wood Residue    | N/A                                 | N/A                                         |

GHGenius does not have a separate location to enter feedstock upgrading emissions associated with wood feedstocks used in BtLF pathways. Energy and material inputs associated with upgrading wood for use in BtLF pathways should be included in the fuel production inputs (see Section 4).

### 3.4 Avoided Emissions

The disposal of waste materials often produces GHG emissions. By repurposing these materials for other uses, such as producing RHF, emissions from conventional disposal methods can be avoided. GHGenius calculates these avoided emissions and applies an emissions credit to the waste materials used in RHF production. The avoided emissions credit can result in negative CIs for RHF.

The only RHF pathways that may be eligible for avoided emissions are the standing timber BtLF pathways. Standing timber that is sourced from forestry residues, which would otherwise be burnt in a slash pile are eligible for an avoided emission credit.

#### 3.4.1 Slash Burning Avoided Emissions

The standing timber (forest residues) BtLF pathways may be eligible for an avoided emission credit in GHGenius for avoiding slash burning.

Forestry residues are burned in slash piles in some regions to reduce forest fire risk. Burning slash piles leads to suboptimal combustion conditions that produce methane and nitrous oxide emissions.

By using forestry residues from these slash piles as a feedstock for BtLF pathways the emissions associated with burning slash piles are avoided.

To select the avoided emission factor for the standing timber BtLF pathway set cell E50 of the Input sheet to a value between 0 and 1:

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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- 0: 0% of feedstock does not avoid slash burning emissions.
- 0-1: Part of feedstock avoids slash burning emissions
- 1: 100% of feedstock avoids slash burning emissions

If the BtLF plant processes a combination of wood feedstock with only a portion of the feedstock avoiding slash burning cell E50 of the Input sheet should be set to a value between 0 and 1 to reflect the fraction of feedstock on a dry mass basis that avoids slash burning.

CI applications that include an avoided emission credit from slash burning must include documentation justifying the avoided emission credit in their Technical Report, which is subject to approval by the Director. Note that Technical Reports are submitted with CI applications to support the application.

### 3.4.1.1 Example: Slash Burning Avoided Emissions Modelling

A BtLF plant uses standing timber to produce BtLD, the standing timber has the following characteristics:

- 2 kg<sub>wet mass</sub>/L BtLD of standing timber (50% moisture content) avoids slash burning.
  - 1 kg<sub>dry mass</sub>/L BtLD
- 7 kg<sub>wet</sub>/L of BtLD of standing timber (40% moisture content) does not avoid slash burning.
  - 4.2 kg<sub>dry mass</sub>/L BtLD

The total dry mass standing timber feedstock input is 5.2 kg<sub>dry mass</sub>/L<sub>BtLD</sub> with 1 kg<sub>dry mass</sub>/L<sub>BtLD</sub> avoiding slash burning. Therefore 19% of the feedstock is avoiding slash burning and 0.19 should be entered in cell E50 of the Input sheet.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 4 RHF Production

Each feedstock pathway must be assigned a unique fuel code. However, mixed-feedstock production facility operating data may be used to model the fuel production stage. For example, if an HDRF plant processes both tallow and UCO and does not have separate operating data for each feedstock, the same plant operating data may be used for both pathways.

The energy, material and feedstock consumption data is entered in the column associated with the main product (see Section 1.2). **Table 4-1** details the columns of the Input and Alt Fuel Prod sheets that energy, material, and feedstock consumption data are entered.

**Table 4-1 RHF Pathway Input and Alt Fuel Prod Sheet Locations**

| RHF Type | Input Sheet Column | Alt Fuel Prod Sheet Column |
|----------|--------------------|----------------------------|
| BtLD     | D                  | D                          |
| BtLG     | I                  | I                          |
| HDRD     | CD                 | CM                         |
| RG       | CF                 | CO                         |

### 4.1 Year

When modelling a specific plant, put the model year in B7 and the base year in row 241 of the column defined in **Table 4-1**. Both are entered on the Input sheet. The model year and base year must match the date that the data was collected (see section 2.2.2). If the data spans multiple years set the model to the latest year in the dataset. If the data is design data set the year to match the application year.

### 4.2 Feedstock Consumption Rate

Feedstock consumption rate is entered in rows 247 and 248 of the Input sheet under the column that corresponds to the feedstock type (see **Table 4-1**).

Feedstock consumption rate is entered either on a dry mass basis or as-received (wet) mass basis. The row corresponding with the feedstock category and its mass basis is detailed in **Table 4-2**.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 4-2 RHF Feedstock Consumption**

| RHF Feedstock   | Feedstock Consumption Rate Row | Mass Basis             |
|-----------------|--------------------------------|------------------------|
| Algae Oil       | 248                            | As-received (wet) mass |
| Camelina Oil    | 248                            | As-received (wet) mass |
| Canola Oil      | 248                            | As-received (wet) mass |
| Corn Oil        | 248                            | As-received (wet) mass |
| Fish Oil        | 248                            | As-received (wet) mass |
| Jatropha Oil    | 248                            | As-received (wet) mass |
| Palm Oil        | 248                            | As-received (wet) mass |
| Palm Sludge Oil | 248                            | As-received (wet) mass |
| SBEO            | 248                            | As-received (wet) mass |
| Soybean Oil     | 248                            | As-received (wet) mass |
| SRF             | 247                            | Dry mass               |
| Standing Timber | 247                            | Dry mass               |
| Tall Oil        | 248                            | As-received (wet) mass |
| Tallow          | 248                            | As-received (wet) mass |
| Yellow Grease   | 248                            | As-received (wet) mass |
| Wood Residue    | 247                            | Dry mass               |

### 4.3 Energy Consumption

Energy consumption is entered in rows 243 to 247 of the Input sheet under the column that corresponds to the RHF (see **Table 4-1**). **Table 4-3** details the units, location in GHGenius and the section of the user guide for each energy input in GHGenius.

**Table 4-3 RHF Energy inputs**

| Energy Input            | Unit                 | Input Sheet Row                                     | Section of User Guide |
|-------------------------|----------------------|-----------------------------------------------------|-----------------------|
| Electricity             | kWh/L <sub>RHF</sub> | 243                                                 | 4.3.1                 |
| Diesel (light fuel oil) | L/L <sub>RHF</sub>   | 244                                                 | 4.3.2                 |
| Natural gas             | MJ/L <sub>RHF</sub>  | 245                                                 | 4.3.3                 |
| Coal                    | Kg/L <sub>RHF</sub>  | 246                                                 | 4.3.4                 |
| Biomass                 | Kg/L <sub>RHF</sub>  | 247                                                 | 4.3.5                 |
| Steam                   | Not included         | Not included.<br>Modelled using other energy inputs | 4.3.7                 |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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### 4.3.1 Electricity

The net electricity consumed is based on the generic power of the region in which the model is run. This value is entered in row 243 of the main product's corresponding column shown in **Table 4-1**. The input unit for electricity is kWh/L<sub>RHF</sub>.

If a RHF production facility generates electricity internally, such as from a steam pressure let-down turbine, do not include this electricity in the model input. The model only accounts for net electricity use, meaning only electricity that crosses the system boundary outlined in Section 1.3 should be included. Internally generated electricity that does not cross the system boundary should be excluded.

#### 4.3.1.1 Combined Heat and Power Systems

Some fuel production facilities include a combined heat and power (CHP) system that generates thermal energy and electricity. The thermal energy is used in the fuel production facility, and the electricity is either used in the fuel production facility or sold to the local grid.

In cases where electricity generated by the CHP system is exported to the local grid, while electricity used in the fuel production facility is purchased from the grid and the CHP system's thermal energy is used for fuel production, the electricity generated by the CHP system is considered within the system boundary. Any excess electricity exported to the grid may receive a coproduct credit.

Electricity consumption in GHGenius is looked at on a net basis using the equation below:

$$E_{Net} = E_{purchased} - E_{sold}$$

- If  $E_{Net} > 0$ 
  - $E_{Net}$  is entered as a fuel production input in row 243 of the Input sheet.
- If  $E_{Net} < 0$ :
  - Fuel production electricity in row 243 of the Input sheet is set to 0.
  - $E_{Net}$  is entered as a coproduct of the main product in the locations detailed in **Table 4-4**.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 4-4 Electricity coproduct location by product**

| Main Product | Sheet   | Cell  |
|--------------|---------|-------|
| HDRD         | Coprods | BC107 |
| RG           | Coprods | BE107 |
| BtLD         | Input   | Y274  |
| BtLG         | Input   | AC274 |

CHP systems can use fossil (e.g. natural gas) and/or biogenic feedstocks (e.g. sugarcane bagasse and agricultural residues). For instructions on how to model biogenic feedstocks used in a CHP system, see Section 4.3.5. Fossil feedstocks used in a CHP system are entered in the following rows of the Input sheet in the column detailed in **Table 4-1**:

- Diesel (light fuel oil),  $L_{\text{diesel}}/L_{\text{RHF}}$ : row 244
- Natural gas,  $MJ_{\text{natural gas}}/L_{\text{RHF}}$ : row 245
- Coal,  $Kg_{\text{coal}}/L_{\text{RHF}}$ : row 246

#### 4.3.1.2 Other On-Site Electricity Generation

Other on-site electricity generation (e.g. solar panels) is considered outside of the system boundary of the fuel production facility and excess electricity sold to the grid is ineligible for a coproduct credit.

Although it is not eligible for a co-product credit, other on-site electricity generation can be used to reduce the amount of electricity entered into the model if the fuel production facility consumes more electricity than it sells to the grid.

##### 4.3.1.2.1 Example: HDRD plant with CHP and Solar

An HDRD production facility has a CHP system and on-site solar panels with the following electricity generation and consumption:

- HDRD plant purchased electricity: 0.2 kWh/ $L_{\text{HDRD}}$
- CHP system electricity generation: 0.3 kWh/ $L_{\text{HDRD}}$
- Solar electricity generation: 0.06 kWh/ $L_{\text{HDRD}}$
- $E_{\text{net}} = E_{\text{purchased}} - E_{\text{sold}} = \frac{0.2 \text{ kWh}}{L_{\text{HDRD}}} - \frac{0.3 \text{ kWh}}{L_{\text{HDRD}}} = \frac{-0.1 \text{ kWh}}{L_{\text{HDRD}}}$

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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Since this facility produces more electricity through the CHP system than is consumed by the plant, the solar generation is excluded from the  $E_{net}$  calculation. As  $E_{net}$  is less than zero, 0.0 is entered into cell CD243 on the Input sheet and the excess 0.1 kWh/L of electricity is entered as a co-product in cell BC107 of the Coprods sheet.

If instead the HARD production facility had the following characteristics:

- HARD plant purchased electricity: 0.2 kWh/  $L_{HARD}$
- CHP system electricity generation: 0.12 kWh/  $L_{HARD}$
- Solar electricity generation: 0.06 kWh/  $L_{HARD}$
- $E_{net} = E_{purchased} - E_{sold} = \frac{0.2 \text{ kWh}}{L_{HARD}} - \frac{0.12 \text{ kWh}}{L_{HARD}} - \frac{0.06 \text{ kWh}}{L_{HARD}} = \frac{0.02 \text{ kWh}}{L_{HARD}}$

Since this facility produces less electricity through the CHP system than is consumed by the plant, the solar generation is included in the  $E_{net}$  calculation to reduce the quantity of electricity purchased. As  $E_{net}$  is positive 0.02 kWh/L is entered in cell CD243 of the Input sheet and 0.0 kWh/L of electricity is entered as a co-product in cell BC107 of the Coprods sheet.

If for the above scenario the inclusion of solar generation made  $E_{net}$  negative, 0.0 kWh/L would be entered in both cell CD243 of the Input sheet and cell BC107 of the Coprods sheet.

### 4.3.2 Diesel

Diesel is used at some RHF plants for rail car shuttles, front end loaders, etc. This value, in  $L_{diesel} / L_{RHF}$ , is entered in row 244 of the main product's corresponding column shown in **Table 4-1**. If light fuel oil (LFO) is used in the process, the row for diesel (244) can also be used for LFO in GHGenius since they have a similar energy content.

### 4.3.3 Natural Gas

Natural gas consumed in the RHF production process is entered in row 245 of the main product's corresponding column shown in **Table 4-1**. The input unit for natural gas is entered on a higher heating value basis in  $MJ_{Natural \text{ gas}} / L_{RHF}$ .

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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#### 4.3.4 Coal

Coal consumed in the RHF production process is entered in row 246 of the main product's corresponding column shown in **Table 4-1**. The input unit for coal is entered in  $\text{kg}_{\text{coal}}/\text{L}_{\text{RHF}}$ .

#### 4.3.5 Biomass in CHP

Some fuel production facilities utilize biomass, such as wood waste, as a fuel source for their CHP system. Biomass consumption in a CHP system is entered on a dry-mass basis in row 247 of the Input sheet. The **Table 4-5** details the CHP feedstocks that can be modelled using row 247 of the Input sheet for each RHF pathway, along with the lifecycle stages included.

**Table 4-5 RHF CHP feedstocks**

| RHF  | CHP Feedstocks  | Lifecycle Stages Included                                                                                                                                                      |
|------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BtLF | SRF             | <ol style="list-style-type: none"> <li>1. Feedstock production</li> <li>2. Feedstock recovery</li> <li>3. Feedstock transportation</li> <li>4. Feedstock combustion</li> </ol> |
|      | Standing timber | <ol style="list-style-type: none"> <li>1. Feedstock recovery</li> <li>2. Feedstock transportation</li> <li>3. Feedstock combustion</li> </ol>                                  |
|      | Wood residue    | <ol style="list-style-type: none"> <li>1. Feedstock transportation</li> <li>2. Feedstock combustion</li> </ol>                                                                 |
| CPRF | Wood residue    | <ol style="list-style-type: none"> <li>1. Feedstock combustion</li> </ol>                                                                                                      |
| HDRF | Wood residue    | <ol style="list-style-type: none"> <li>1. Feedstock combustion</li> </ol>                                                                                                      |

##### 4.3.5.1 BtLF CHP Systems

For wood-derived BtLF pathways the CHP system biogenic input is added to the feedstock input in cells D247 or I247 of the Input sheet on a dry-mass basis for BtLD and BtLG pathways, respectively. To accurately model the transportation emissions of the feedstock and biogenic CHP system feedstock a weighted average on a wet-mass basis of the transport distances of the feedstock and biomass should be determined and entered cells J76-J86 of the Input sheet.

##### 4.3.5.2 Example: BtLD Plant with Biogenic CHP Feedstocks

A BtLD facility utilizes the feedstocks detailed in **Table 4-6**.

|                                                                                   |                                                                                      |                                                                                                                                                                              |
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**Table 4-6 BtLD plant with CHP**

| Description     | Use           | Wet mass (kg <sub>wet</sub> /L <sub>HDRD</sub> ) | Moisture Content | Dry mass (kg <sub>wet</sub> /L <sub>HDRD</sub> ) | Feedstock Transport |
|-----------------|---------------|--------------------------------------------------|------------------|--------------------------------------------------|---------------------|
| Standing timber | Feedstock     | 8.00                                             | 50%              | 4.00                                             | 50 km by truck      |
| Wood residue    | CHP Feedstock | 1.0                                              | 50%              | 0.5                                              | On-site             |

The total dry mass of the agricultural residues and wood consumed in the CHP system is entered as 4.5 kg/ L<sub>BtLD</sub> in cell D247 of the Input sheet. The wet-mass basis weighted average feedstock truck transportation distance is 44.44 km and entered in cell J80 of the Input sheet along with setting the trucking fraction in cell J86 of the Input sheet to 1.

#### 4.3.5.3 CPRF and HDRF CHP Systems

CPRF and HDRF pathways can only model wood residue as a biogenic CHP feedstock input and does not include upstream emissions such as transportation or feedstock recovery. The wood residue CHP system consumption rate is entered in row 247 of the Input sheet on a dry mass-basis. Unlike BtLF pathways a wet-mass weighted average feedstock transportation distance calculation is not required as feedstock transportation of the wood residue is excluded.

#### 4.3.5.4 Example: HARD Plant with Biogenic CHP Feedstocks

An HARD facility utilizes the feedstocks detailed in **Table 4-7**.

**Table 4-7 HARD plant with CHP**

| Description  | Use           | Wet mass (kg <sub>wet</sub> /L <sub>HDRD</sub> ) | Moisture Content | Dry mass (kg <sub>wet</sub> /L <sub>HDRD</sub> ) |
|--------------|---------------|--------------------------------------------------|------------------|--------------------------------------------------|
| Canola Oil   | Feedstock     | 0.94                                             | 0%               | 0.94                                             |
| Wood residue | CHP Feedstock | 1.2                                              | 50%              | 0.6                                              |

The total dry mass of the agricultural residues and wood consumed in the CHP system is entered as 0.6 kg/ L<sub>HDRD</sub> in cell CD247 of the Input sheet in GHGenius.

#### 4.3.6 Energy For Hydrogen Production

If an RHF plant produces its hydrogen internally by consuming energy (e.g. steam methane reforming of natural gas), the quantity of each energy source that was

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consumed to produce hydrogen must be provided in the Technical Report that accompanies the CI application as determined in Section 4.4.1.2.

#### 4.3.7 Steam

Some fuel production facilities use steam produced outside of the fuel production system boundary (e.g. an adjacent CHP facility). GHGenius does not include a steam input and requires the user to convert the steam to the equivalent energy input used to produce the steam. For example, if the steam is produced in a natural-gas-fired-boiler, the applicant must convert the quantity of steam used to an equivalent natural gas consumption rate.

It is assumed that steam is generated with 80% efficiency. If applicants can demonstrate data that their steam generation process is more efficient, they can use their specific conversion efficiency.

The steps to convert steam to an equivalent energy input are as follows:

1. Determine the specific enthalpy of saturated steam consumed in MJ, based on the steam pressure and temperature. Refer to the [Thermodynamic Properties of Saturated Steam: Data & Charts in Bar](#) webpage.
2. Divide the energy content by the boiler efficiency (80%) to determine the energy required into the boiler.
3. Convert the energy required to the equivalent energy input in GHGenius by dividing by the energy input's higher heating value (HHV) shown in .
4. Table 4-8.

**Table 4-8 Energy Input HHVs**

| Energy Input                | HHV   | Unit   | Reference                                                  |
|-----------------------------|-------|--------|------------------------------------------------------------|
| Electricity                 | 3.6   | MJ/kWh |                                                            |
| Diesel                      | 38.65 | MJ/L   | Fuel Char sheet cell B85                                   |
| Natural gas                 | 1     | MJ/MJ  |                                                            |
| Coal                        | 21.9  | MJ/kg  | Fuel Char sheet cell K116<br>(GHGenius set to BC and 2025) |
| Wood                        | 20.0  | MJ/kg  | Fuel Char sheet cell K133                                  |
| Generic Grass               | 20.00 | MJ/kg  | Fuel Char sheet cell K134                                  |
| Switch Grass                | 17.40 | MJ/kg  | Fuel Char sheet cell K135                                  |
| Corn stover (field residue) | 18.06 | MJ/kg  | Fuel Char sheet cell K136                                  |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Energy Input       | HHV   | Unit  | Reference                 |
|--------------------|-------|-------|---------------------------|
| Wheat Straw        | 18.30 | MJ/kg | Fuel Char sheet cell K137 |
| Hay                | 17.40 | MJ/kg | Fuel Char sheet cell K138 |
| Wet corn stover    | 17.10 | MJ/kg | Fuel Char sheet cell K139 |
| Sugar cane trash   | 12.30 | MJ/kg | Fuel Char sheet cell K140 |
| Sugar cane bagasse | 18.30 | MJ/kg | Fuel Char sheet cell K141 |
| Manure             | 18.90 | MJ/kg | Fuel Char sheet cell K142 |
| Organic Waste      | 16.20 | MJ/kg | Fuel Char sheet cell K144 |

Add the equivalent energy input to GHGenius into the following rows of the Input sheet of GHGenius:

- Electricity: 243
- Diesel (light fuel oil): 244
- Natural gas: 245
- Coal: 246
- Biomass: 247

#### 4.3.7.1 Steam Energy Example

An HARD facility consumes steam from an adjacent boiler facility. The steam has the following characteristics:

- Steam properties:
  - Consumption: 2.62 kg/L<sub>HARD</sub>
  - Pressure: 10 bar
  - Temperature: 184 °C
  - Specific enthalpy: 2.78 MJ/kg<sub>steam</sub>

The amount of steam is converted to an equivalent energy required for the boiler assuming an 80% boiler efficiency as follows:

1. Calculate the total steam energy consumed:



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$$\frac{2.62 \text{ kg}_{\text{steam}}}{L_{\text{HARD}}} \times \frac{2.78 \text{ MJ}}{\text{kg}_{\text{steam}}} = \frac{7.28 \text{ MJ}_{\text{steam}}}{L_{\text{HARD}}}$$

2. Calculate the total equivalent energy required for the boiler:

$$\frac{\text{Total Steam Energy Consumed } \left( \frac{\text{MJ}_{\text{steam}}}{L_{\text{HARD}}} \right)}{\text{Boiler Efficiency}} = \frac{7.28}{80\%} = 9.1 \frac{\text{MJ}_{\text{Input}}}{L_{\text{HARD}}}$$

3. The total boiler input is converted to an equivalent energy input as follows:

a) If the boiler consumes light fuel oil (LFO)

i) Convert the total LFO energy consumed into L:

$$\frac{\text{Total LFO Energy Content } \left( \frac{\text{MJ}_{\text{LFO}}}{L_{\text{HARD}}} \right)}{\text{LFO Energy Density } \left( \frac{\text{MJ}_{\text{LFO}}}{L_{\text{LFO}}} \right)} = \frac{9.1 \frac{\text{MJ}_{\text{LFO}}}{L_{\text{HARD}}}}{38.65 \frac{\text{MJ}_{\text{LFO}}}{L_{\text{LFO}}}} = 0.24 \frac{L_{\text{LFO}}}{L_{\text{HARD}}}$$

ii) Add  $0.24 L_{\text{LFO}}/L_{\text{HARD}}$  to cell CD244 of the Input sheet.

b) If the boiler consumes natural gas (NG)

i) Add  $9.1 \text{ MJ}_{\text{NG}}/L_{\text{HARD}}$  to cell CD245 of the Input sheet.

c) If the boiler consumes coal

i) Convert the total coal energy consumed into kg:

$$\frac{\text{Total Coal Energy Content } \left( \frac{\text{MJ}_{\text{coal}}}{L_{\text{HARD}}} \right)}{\text{Coal Energy Density } \left( \frac{\text{MJ}_{\text{coal}}}{\text{kg}_{\text{coal}}} \right)} = \frac{9.1}{21.9} = 0.42 \frac{\text{kg}_{\text{coal}}}{L_{\text{HARD}}}$$

ii) Add  $0.42 \text{ kg}_{\text{coal}}/L_{\text{HARD}}$  to cell CD246 of the Input sheet.

d) If the boiler consumes wood biomass:

i) Convert the total biomass energy consumed into kg:

$$\frac{\text{Total Wood Energy Content } \left( \frac{\text{MJ}_{\text{wood}}}{L_{\text{HARD}}} \right)}{\text{Wood Energy Density } \left( \frac{\text{MJ}_{\text{wood}}}{\text{kg}_{\text{wood}}} \right)} = \frac{9.1}{20.0} = 0.46 \frac{\text{kg}_{\text{wood}}}{L_{\text{HARD}}}$$

ii) Add  $0.46 \text{ kg}_{\text{wood}}/L_{\text{HARD}}$  to cell CD247 of the Input sheet.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 4.4 Material Inputs

Material inputs into RHF pathways can be specified in rows 29-81 of the Alt Fuel Prod sheet of the main product's corresponding column (see **Table 4-1**). The RG pathway also has a default LPG material input in cell CO89 of the Alt Fuel Prod sheet that can be modified.

**Table 4-9** details the default material inputs in the Alt Fuel Prod sheet of GHGenius 5.02b. RHF plants may also use acids and bases for pretreatment of the feedstock which is accounted for in Section 3.3.1. Note that the default values in the table are rounded compared to what is in the model.

**Table 4-9 Default RHF Pathway Material Inputs**

| Chemical                     | Alt Fuel Prod Row | BtLD Default | BtLG Default | HDRD Default | RG Default |
|------------------------------|-------------------|--------------|--------------|--------------|------------|
| Hydrogen, kg/L               | 44                | 0            | 0            | 0.03         | 0.03       |
| LPG, L/L                     | 89                | 0            | 0            | 0            | 0.2        |
| NaOH, kg/L                   | 53                | 0.0003       | 0            | 0.0009       | 0.0009     |
| Nitrogen – liquid, kg/L      | 55                | 0            | 0            | 0.0002       | 0.0002     |
| Petroleum <sup>2</sup> , L/L | 60                | 0.008        | 0            | 0            | 0          |
| Phosphoric acid, kg/L        | 62                | 0            | 0            | 0.0006       | 0.0006     |

All material inputs are based on 100% purity, and input values may need to be adjusted based on their purity. For example, a 93% pure sulphuric acid should be multiplied by 0.93 before being input into the model.

### 4.4.1 Hydrogen

Hydrogen (H<sub>2</sub>) consumption can have a significant impact on the CI of RHF pathways. H<sub>2</sub> can either be sourced from outside the system boundary (off-site) and/or produced on-site through processes such as steam methane reforming (SMR) of natural gas.

#### 4.4.1.1 Off-site Hydrogen

H<sub>2</sub> sourced from outside the system boundary is entered in kg<sub>H<sub>2</sub></sub>/ L<sub>RHF</sub> in row 44 of the Alt Fuel Prod sheet of the appropriate column (see **Table 4-1**).

<sup>2</sup> Hexane is used in solvent extraction processes but is not an available material input in the Alt Fuel Prod sheet. Petroleum (Alt Fuel Prod sheet row 60) can be used as a proxy for hexane in GHGenius.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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The H<sub>2</sub> on the Alt Fuel Prod sheet represents hydrogen produced through SMR of natural gas (NG), with the emission factor changing slightly depending on the region and year modelled. If the applicant knows the technology used to produce the hydrogen cell L120 on the Alt Fuel Prod sheet can be changed to reflect the production method as shown in **Figure 4-1**.

|                             |     |       |     |     |       |          |       |       |                       |
|-----------------------------|-----|-------|-----|-----|-------|----------|-------|-------|-----------------------|
| 120 Hydrogen (kg) see below | 0.0 | 200.9 | 0.0 | 0.0 | 206.5 | 12,895.0 | 0.0   | 202.1 | SMR (Grey)            |
| 121 Hydrogen Peroxide (kg)  | 0.0 | 15.0  | 0.0 | 0.0 | 350.4 | 1,321.2  | 0.0   | 17.3  | SMR (Grey)            |
| 122 Iron Chloride (kg)      | 0.0 | 11.6  | 0.0 | 0.0 | 90.6  | 820.5    | 0.0   | 12.1  | Electrolysis          |
| 123 Iron Ore (kg)           | 0.0 | 0.0   | 0.0 | 0.0 | 0.0   | 69.8     | 1.0   | 0.8   | SMR with CCS (Blue)   |
| 124 Limestone (kg)          | 0.0 | 0.6   | 0.0 | 0.0 | 31.3  | 107.4    | 476.7 | 1.2   | Pyrolysis (Turquoise) |
| 125 Magnesium silicate (kg) | 0.0 | 3.1   | 0.0 | 0.0 | 470.1 | 663.5    | 0.0   | 6.0   | SMR from RNG          |
| 126 Magnesium sulphate (kg) | 0.0 | 3.9   | 0.0 | 0.0 | 51.0  | 299.9    | 0.0   | 4.3   |                       |
| 127 Methanol (L)            | 0.0 | 6.7   | 0.0 | 0.0 | 0.0   | 422.9    | 0.0   | 6.7   |                       |

**Figure 4-1 Hydrogen technology selection drop-down**

#### 4.4.1.2 On-site Hydrogen Production

When H<sub>2</sub> is produced internally (e.g. steam methane reforming (SMR) of NG) the H<sub>2</sub> input in row 44 on the Alt Fuel Prod sheet can be set to zero, as the emissions associated with H<sub>2</sub> are accounted for in other inputs in GHGenius. Feedstocks that can be used to produce H<sub>2</sub> on-site include, but are not limited to:

- NG,
- RNG,
- Coproducts (e.g. RN or LPG from the RHF production),
- Electricity, and
- Steam

In cases where hydrogen is produced on-site the applicant must:

1. Indicate the technology that was used to produce the H<sub>2</sub> (e.g. SMR of NG without carbon capture and sequestration).
2. For each feedstock used to produce H<sub>2</sub>, provide the feedstock consumption rate associated with H<sub>2</sub> production per litre of RHF (e.g. MJ<sub>NG</sub> for H<sub>2</sub> / L<sub>HDRD</sub> or L<sub>LPG</sub> for H<sub>2</sub> / L<sub>HDRD</sub>) either by:
  - a. Providing the measured feedstock consumption rate for H<sub>2</sub> production, or

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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- b. If the feedstock consumption rate for H<sub>2</sub> production is not measured, the applicant must provide an estimate of the feedstock consumption rate for H<sub>2</sub> production along with details on how the estimate was determined.
3. Convert all feedstock consumption rates to an energy basis using their HHV and provide the total feedstock energy consumption rate for H<sub>2</sub> production in MJ<sub>All feedstocks</sub>/L<sub>RHF</sub>.
4. Provide the H<sub>2</sub> consumption rate in kg<sub>H2</sub>/L<sub>RHF</sub> (e.g. kg<sub>H2</sub> /L<sub>HDRD</sub>) either by:
  - a. Providing the measured H<sub>2</sub> consumption rate, or
  - b. If the quantity of H<sub>2</sub> consumed is not measured, the applicant must provide an estimate of the H<sub>2</sub> consumption rate along with details on how the estimate was determined.

The information in points 1 to 4 are not used in GHGenius but must be included in the Technical Report in the format detailed in **Table 4-10**. The feedstock HHV column is used for converting feedstocks that are not entered on an energy basis (e.g. diesel or coal). Greyed and italicized values are to be replaced.

**Table 4-10 On-site H<sub>2</sub> Production Template**

| Hydrogen Production Technology: |                  |                                                |                             |               |
|---------------------------------|------------------|------------------------------------------------|-----------------------------|---------------|
| Description                     | Consumption Rate | Unit                                           | Measured or Estimated Value | Feedstock HHV |
| Feedstock 1                     |                  |                                                |                             |               |
| Feedstock 2 (if applicable)     |                  |                                                |                             |               |
| <b>Total feedstock</b>          |                  | <b>MJ<sub>feedstocks</sub>/L<sub>RHF</sub></b> |                             |               |
| <b>H<sub>2</sub></b>            |                  | <b>Kg<sub>H2</sub>/L<sub>RHF</sub></b>         |                             |               |

#### 4.4.1.2.1 Example: On-site hydrogen production from SMR of NG

A fuel production facility uses NG to produce H<sub>2</sub> on-site through SMR for use in HDRD production. The NG consumption rate of the SMR and the H<sub>2</sub> consumption rate of the fuel production facility are measured and are presented in **Table 4-11**.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 4-11 On-site H<sub>2</sub> production through SMR of NG example**

| Hydrogen Production Technology: |                  | SMR of NG                               |                             |               |
|---------------------------------|------------------|-----------------------------------------|-----------------------------|---------------|
| Description                     | Consumption Rate | Unit                                    | Measured or Estimated Value | Feedstock HHV |
| Natural gas                     | 6                | MJ <sub>NG</sub> /L <sub>HARD</sub>     | Measured                    | 1 MJ/MJ       |
| H <sub>2</sub>                  | <b>0.03</b>      | <b>Kg<sub>H2</sub>/L<sub>HARD</sub></b> | <b>Measured</b>             |               |

The NG consumed to produce H<sub>2</sub> is included in cell CD245 of the Input sheet in GHGenius 5.02b along with an additional 0.25 MJ<sub>NG</sub>/L<sub>HARD</sub> used in the production facility. As a result, 6.25 MJ<sub>NG</sub>/L<sub>HARD</sub> is entered in cell CD245. As the H<sub>2</sub> is produced on-site, cell CM44 of the Alt Fuel Prod sheet can be set to zero.

#### 4.4.1.2.2 Example: On-site H<sub>2</sub> production from the SMR of NG, coproduct RN, and LPG

A fuel production facility uses the naphtha and LPG coproducts of the HARD production process to supplement the NG consumed in an SMR. The naphtha, LPG, and NG consumption rate for H<sub>2</sub> production as well as the H<sub>2</sub> consumption rate are measured.

**Table 4-12** details this example.

**Table 4-12 On-site H<sub>2</sub> production through SMR of NG and coproducts**

| Hydrogen Production Technology: |                  | SMR of NG, LPG, and RN                  |                             |               |
|---------------------------------|------------------|-----------------------------------------|-----------------------------|---------------|
| Description                     | Consumption Rate | Unit                                    | Measured or Estimated Value | Feedstock HHV |
| Natural Gas                     | 4.0              | MJ <sub>NG</sub> /L <sub>HARD</sub>     | Measured                    | 1 MJ/MJ       |
| LPG                             | 0.04             | L <sub>LPG</sub> /L <sub>HARD</sub>     | Measured                    | 25.62 MJ/L    |
| RN                              | 0.04             | L <sub>naphtha</sub> /L <sub>HARD</sub> | Measured                    | 34.51 MJ/L    |
| H <sub>2</sub>                  | <b>0.05</b>      | <b>Kg<sub>H2</sub>/L<sub>HARD</sub></b> | <b>Measured</b>             |               |

All the coproducts are used in SMR to supplement NG consumption, therefore cells BC135 (LPG) and BC137 (naphtha) of the Coprods sheet are set to zero. The NG consumed to produce H<sub>2</sub> is included in cell CD245 of the Input sheet in GHGenius 5.02b along with an added 0.25 MJ<sub>NG</sub>/L<sub>HARD</sub> used in the production facility. As a result, 4.25 MJ<sub>NG</sub>/L<sub>HARD</sub> is entered in cell CD245. As the H<sub>2</sub> is produced on-site, cell CM44 of the Alt Fuel Prod sheet can be set to zero.

## 4.5 Coproducts

RHF production can produce several coproducts, which can be:

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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- Consumed in the plant as a fuel or a feedstock to produce hydrogen,
- Marketed as a separate fuel, or
- Used as an energy source outside the system boundary.

**Table 4-13** details the RHF coproducts available in GHGenius 5.02b along with their location in the Coprods sheet and their unit.

**Table 4-13 RHF Coproducts**

| RHF  | Coproducts            | Unit  | Coproduct Location |       |
|------|-----------------------|-------|--------------------|-------|
|      |                       |       | Sheet              | Cell  |
| BtLD | Electricity           | kWh/L | Input              | Y274  |
|      | Hydrogen              | Kg/L  | Input              | Y275  |
| BtLG | Electricity           | kWh/L | Input              | AC274 |
|      | LPG/RP                | L/L   | Coprods            | AQ135 |
| HDRD | AjF                   | L/L   | Coprods            | BC143 |
|      | Electricity           | kWh/L | Coprods            | BC107 |
|      | Fuel gas (RNG)        | MJ/L  | Coprods            | BC138 |
|      | LPG/RP                | L/L   | Coprods            | BC135 |
|      | RN                    | L/L   | Coprods            | BC137 |
| RG   | AjF                   | L/L   | Coprods            | BE143 |
|      | FCC unit RD           | L/L   | Coprods            | BE145 |
|      | Electricity           | kWh/L | Coprods            | BE107 |
|      | FCC Coke              | Kg/L  | Coprods            | BE132 |
|      | Fuel gas (RNG)        | MJ/L  | Coprods            | BE138 |
|      | Heavy cycle oil (HCO) | Kg/L  | Coprods            | BE133 |
|      | LPG/RP                | L/L   | Coprods            | BE135 |
|      | RN                    | L/L   | Coprods            | BE137 |

#### 4.5.1 Coproduct Allocation

When coproducts of the fuel production process can be used as a drop-in fuel for transportation or can be upgraded and used as transportation fuels, their emissions should be allocated based on their energy content to avoid double-counting of emissions.

**Table 4-14** details the default RHF coproduct allocation methodologies and where they are selected in GHGenius 5.02b.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 4-14 RHF Coproduct Allocation Methodologies**

| Coproduct                                              | Default Allocation Methodology        | Allocation Selection Location |      |
|--------------------------------------------------------|---------------------------------------|-------------------------------|------|
|                                                        |                                       | Sheet                         | Cell |
| AJF                                                    | Energy                                | Coprods                       | B198 |
| Electricity                                            | Energy                                | Input                         | B268 |
| FCC Coke                                               | Displacement                          | Coprods                       | B187 |
| FCC Renewable Diesel                                   | Energy                                | Coprods                       | B200 |
| Renewable fuel gas<br>(Labelled RNG in GHGenius 5.02b) | Displacement                          | Coprods                       | B193 |
| Heavy cycle oil<br>(HCO)                               | Displacement                          | Coprods                       | B188 |
| LPG                                                    | Displacement<br>(see Section 4.5.1.1) | Coprods                       | B190 |
| RP                                                     | Energy<br>(see Section 4.5.1.1)       | Coprods                       | B190 |
| RN                                                     | Energy                                | Coprods                       | B192 |

The following changes must be made to the default allocation methodologies in GHGenius 5.02b:

- GHGenius 5.02b uses allocation by displacement by default for FCC renewable diesel, this must be changed to energy allocation in cell B200 of the Coprods sheet, and
- If the LPG/RP coproduct meets the specifications detailed in Section 4.5.1.1 cell B190 of the Coprods sheet must be changed to energy allocation,
  - If the LPG/RP does not meet the specifications cell B190 of the Coprods sheet can remain allocation by displacement.

#### 4.5.1.1 LPG and RP Allocation

GHGenius allocates emissions for LPG coproducts using the displacement method by default. However, applicants must use the energy allocation method if the LPG meets the following criteria<sup>3</sup> for RP:

- Propane volume percentage exceeding 90%,

<sup>3</sup> Taken from definition of Grade 1 Propane in CAN/CGSB-3.14-2023

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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- Propene volume percentage less than 5%, and
- Butane and heavier hydrocarbons combined volume percentage less than 2.5%.

If the LPG composition aligns with above specifications the coproduct is classified as RP, and the applicant must change the allocation method in cell B190 of the Coprods sheet to Energy. For LPG that does not meet the requirements above, allocation by displacement can be used.

If an applicant has a compelling reason to use allocation by displacement for their LPG coproduct that meets the above requirements, they should apply for an alternative method. The application should be accompanied by evidence supporting the LPG's composition and justifying the use of the alternative method ([see RLCF-025: Use of Alternative Methods for Determining Carbon Intensities](#)).

#### 4.5.1.2 Out-of-Model Energy Allocation Calculation

Energy allocation divides the lifecycle emissions between the main product and coproducts, based on their energy contents. The portion of lifecycle emissions assigned to the coproducts reduces the CI of the main product. This reduction is the coproduct credit.

In GHGenius, the higher heating value (HHV) of the main product and coproducts are multiplied by the quantity of each product to determine their energy content. The energy contents are then used to divide the total lifecycle emissions for the following lifecycle stages:

1. Direct land use change
2. Feedstock production or cultivation
3. Feedstock upgrading
4. Feedstock transport
5. Feedstock coproducts production
6. Avoided emissions
7. Fuel production
8. Fuel coproducts production

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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a. Excluding other coproducts that use energy allocation

An out-of-model calculation is required for pathways that meet the following criteria:

- Feedstock and fuel production happens in separate regions (e.g. Canola from Saskatchewan is used to produce HDRD in Alberta), and
- Coproduct(s) are allocated by energy.

The out-of-model calculation is required to capture the upstream emissions associated with both the feedstock and fuel production run, as GHGenius assumes that the feedstock and fuel production happens in the same region when performing an energy allocation calculation.

If an out-of-model calculation is not done the coproduct credit will be inaccurate as GHGenius will use the feedstock production emissions from the fuel production region instead of from the actual feedstock production region.

To perform an out-of-model calculation the following must be done:

1. Perform the feedstock production region model run and save the results from the following lifecycle stages:
  - a. Direct land use change
  - b. Feedstock production or cultivation
  - c. Feedstock upgrading
  - d. Feedstock transport
  - e. Feedstock coproducts production
  - f. Avoided emissions
2. Run the fuel production region model run with all coproduct quantities entered and save the Fraction of Energy Coproduct value from the location in the Coprods sheet detailed in **Table 4-15**.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 4-15 Fraction of Energy Coproduct Location**

| Main Product | Fraction of Energy Coproduct Location |
|--------------|---------------------------------------|
| BtLD         | AM163                                 |
| BtLG         | AQ163                                 |
| HDRD         | BC163                                 |
| RG           | BE163                                 |

3. Set all coproducts allocated by energy to 0. Run the model again and then save the lifecycle results from the fuel production region model run for the following lifecycle stages:
  - a. Fuel production
  - b. Fuel coproducts production
4. Sum the results of Steps 1 and 3 and multiply them by the fraction of the energy coproduct determined in Step 2 to determine the energy allocation coproduct credit.
5. Subtract the energy allocation coproduct credit determined in Step 4 from the coproduct credit determined in Step 3 (Fuel coproduct production stage) to determine the total coproduct credit.

#### 4.5.1.2.1 Out-of-Model Energy Allocation Calculation Example

An HDRF facility in Alberta produces HDRD from Saskatchewan canola oil with the coproducts detailed in **Table 4-16**.

**Table 4-16 Out-of-Model Calculation - Example Coproducts**

| Coproduct | Allocation Methodology | Value    | Note                                                    |
|-----------|------------------------|----------|---------------------------------------------------------|
| AJF       | Energy                 | 0.02 L/L |                                                         |
| LPG       | Displacement           | 0.03 L/L | Does not meet specification detailed in Section 4.5.1.1 |
| Naphtha   | Energy                 | 0.02 L/L |                                                         |

1. The feedstock production run in Saskatchewan has the lifecycle emissions detailed in **Table 4-17**.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 4-17 Out-of-Model Calculation - Feedstock Results**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 0                                       |
| Feedstock production or cultivation | 3,367                                   |
| Feedstock upgrading                 | 5,388                                   |
| Feedstock transport                 | 932                                     |
| Feedstock coproducts production     | -5,324                                  |
| Avoided emissions                   | 0                                       |

- The fuel production run in Alberta is then run to determine the Fraction of Energy Coproduct found in cell BC163 of the Coprods sheet which is 0.036.
- The coproducts allocated by energy (AJF and naphtha) are set to zero and the fuel production run for Alberta is run again. The resulting lifecycle emissions are detailed in **Table 4-18**.

**Table 4-18 Out-of-Model Calculation - Fuel Production Results**

| Stage                                      | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|--------------------------------------------|-----------------------------------------|
| Fuel production                            | 11,388                                  |
| Fuel coproducts production                 | -1,402                                  |
| Fuel distribution and storage <sup>4</sup> | 1,025                                   |

- The lifecycle results from Step 1 and Step 3 are summed (with the fuel distribution and storage lifecycle stage excluded) to determine the total feedstock and fuel production emissions, as shown in **Table 4-19**.

**Table 4-19 Out-of-Model Calculation - Feedstock and Fuel Production Results**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 0                                       |
| Feedstock production or cultivation | 3,367                                   |
| Feedstock upgrading                 | 5,388                                   |
| Feedstock transport                 | 932                                     |
| Feedstock coproducts production     | -5,324                                  |
| Avoided emissions                   | 0                                       |
| Fuel production                     | 11,388                                  |
| Fuel coproducts production          | -1,402                                  |
| <b>Total</b>                        | <b>14,349</b>                           |

<sup>4</sup> Fuel distribution and storage is excluded from the out-of-model energy allocation calculation.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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5. The energy allocation coproduct credit is determined to be 517 g CO<sub>2</sub>e/GJ by multiplying the Fraction of Energy Coproduct from Step 2 by the total feedstock and fuel production results from Step 4 (14,349 x 0.036 = 517)
6. The energy allocation coproduct is subtracted from the fuel coproducts production lifecycle stage found in Step 3 and 4 to determine the total fuel coproduct which is -1,919 g CO<sub>2</sub>e/GJ (-1,402 - 517 = -1,919).
7. The total emissions associated for the Saskatchewan and Alberta model runs are shown in **Table 4-20**.

**Table 4-20 Out-of-Model Calculation - Results**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 0                                       |
| Feedstock production or cultivation | 3,367                                   |
| Feedstock upgrading                 | 5,388                                   |
| Feedstock transport                 | 932                                     |
| Feedstock coproducts production     | -5,324                                  |
| Avoided emissions                   | 0                                       |
| Fuel production                     | 11,388                                  |
| Fuel coproducts production          | -1,919                                  |
| Fuel distribution and storage       | 1,025                                   |
| <b>Total</b>                        | <b>14,857</b>                           |

If an out-of-model calculation were not done for this pathway the feedstock production emissions would be the same but there would be a different fuel coproduct credit as shown in **Table 4-20**. For this example, the difference is 177 g CO<sub>2</sub>e/GJ between using the out-of-model calculation and not using it.

**Table 4-21 Without Out-of-Model Calculation - Results**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 0                                       |
| Feedstock production or cultivation | 3,367                                   |
| Feedstock upgrading                 | 5,388                                   |
| Feedstock transport                 | 932                                     |
| Feedstock coproducts production     | -5,324                                  |
| Avoided emissions                   | 0                                       |
| Fuel production                     | 11,388                                  |
| Fuel coproducts production          | -2,096                                  |
| Fuel distribution and storage       | 1,025                                   |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Stage        | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|--------------|-----------------------------------------|
| <b>Total</b> | <b>14,680</b>                           |

## 4.5.2 Coproduct Fuels

RHF production can produce coproducts that can be used as a transportation fuel under the BC LCFS. The applicant has the option to receive a unique fuel code for the coproduct to be used as a transportation fuel. The coproduct fuel will have the same CI as the main product (see Section 1.2), except for the following lifecycle stages due to coproduct's differing fuel density and combustion emissions when compared to the main product:

1. Fuel distribution and storage,
2. Fuel dispensing, and
3. Vehicle or Vessel operation

The following are eligible coproduct fuels under the BC LCFS:

- AJF
- FCC renewable diesel
- HDRD
- RP
- RN

The following examples can be changed to be used for determining CIs for other coproduct fuel pathways. To modify the examples below the columns in the Input sheet and the BC LCFS result sheet must change to match the main fuel product and coproduct fuel(s).

### 4.5.2.1 Example: HDRD with Coproduct RN CI

A HDRF facility in Alberta uses local canola to produce a HDRD main fuel product with a RN coproduct fuel pathway, which is also eligible for a fuel code.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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The pathway inputs for the Alberta model run are shown in **Table 4-22**, to model the RN pathway the same fuel transportation distances used for the HDRD main product are entered in cells BB91-BB102.

**Table 4-22 HDRD with coproduct RN: Alberta run inputs**

| Sheet         | Cell    | Description                                            | Value        |
|---------------|---------|--------------------------------------------------------|--------------|
| Input         | B4      | Region                                                 | Alberta      |
| Input         | C3-D5   | Install Regional Defaults                              | Press button |
| Input         | B7      | Year                                                   | 2025         |
| Input         | B53     | HDRD feedstock                                         | Canola       |
| Input         | L76     | Canola rail distance, km                               | 0            |
| Input         | L80     | Canola truck distance, km                              | 50           |
| Input         | L82     | Canola rail fraction                                   | 0            |
| Input         | L86     | Canola truck fraction                                  | 1            |
| Input         | AZ91    | HDRD transloading                                      | No           |
| Input         | BB91    | RN transloading                                        | No           |
| Input         | AZ92    | HDRD rail distance, km                                 | 1,200        |
| Input         | BB92    | RN rail distance, km                                   | 1,200        |
| Input         | AZ96    | HDRD truck distance, km                                | 0            |
| Input         | BB96    | RN truck distance, km                                  | 0            |
| Input         | AZ98    | HDRD rail fraction                                     | 1            |
| Input         | BB98    | RN rail fraction                                       | 1            |
| Input         | AZ102   | HDRD truck fraction                                    | 0            |
| Input         | BB102   | RN truck fraction                                      | 0            |
| Input         | CD241   | HDRD production data year                              | 2025         |
| Input         | CD243   | Electricity for HDRD production, kWh/L <sub>HDRD</sub> | 0.08         |
| Input         | CD245   | NG for HDRD production, MJ/L <sub>HDRD</sub>           | 0.2          |
| Input         | CD248   | Canola oil for HDRD production, kg/L <sub>HDRD</sub>   | 0.95         |
| Alt Fuel Prod | CM29-81 | All chemicals                                          | 0            |
| Alt Fuel Prod | CM44    | Hydrogen, kg/L <sub>HDRD</sub>                         | 0.03         |
| Coprods       | BC135   | RP coproduct (LPG), L/L <sub>HDRD</sub>                | 0.0          |
| Coprods       | BC137   | RN coproduct, L/L <sub>HDRD</sub>                      | 0.05         |
| Coprods       | B192    | RN coproduct allocation method                         | Energy       |

The lifecycle results for the Alberta run for both the HDRD and RN pathways are shown in **Table 4-23**. Lifecycle results for HDRD are taken from cells AK8 to AK16 of the BC LCFS sheet, with the RN results taken from AK8-AK15 and AM16 of the same sheet.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 4-23 HDRD with coproduct RN: Alberta run CI results**

| Lifecycle Stage                     | Alberta Run Emissions, g CO <sub>2</sub> e/GJ (HHV) |             |             |              |              |
|-------------------------------------|-----------------------------------------------------|-------------|-------------|--------------|--------------|
|                                     | HDRD and RN                                         | HDRD        | RN          | HDRD         | RN           |
|                                     |                                                     |             |             | Total        | Total        |
| Direct land use change              | 0                                                   |             |             | 0            | 0            |
| Feedstock production or cultivation | 14,854                                              |             |             | 14,854       | 14,854       |
| Feedstock upgrading                 | 4,947                                               |             |             | 4,947        | 4,947        |
| Feedstock transport                 | 922                                                 |             |             | 922          | 922          |
| Feedstock coproducts production     | -11,467                                             |             |             | -11,467      | -11,467      |
| Avoided emissions                   | 0                                                   |             |             | 0            | 0            |
| Fuel production                     | 10,972                                              |             |             | 10,972       | 10,972       |
| Fuel coproducts production          | -881                                                |             |             | -881         | -881         |
| Fuel distribution and storage       |                                                     | 437         | 451         | 437          | 451          |
| Total                               | 19,347                                              | 437         | 451         | 19,784       | 19,798       |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  | <b>19.35</b>                                        | <b>0.44</b> | <b>0.45</b> | <b>19.78</b> | <b>19.80</b> |

The pathway inputs for the BC model run are shown in **Table 4-24**, like the Alberta run the same fuel transportation distances used for the HDRD main product are entered in cells BB91-BB102 for the RN coproduct.

**Table 4-24 HDRD with coproduct RN: BC run inputs**

| Sheet | Cell  | Description               | Value        |
|-------|-------|---------------------------|--------------|
| Input | B4    | Region                    | BC           |
| Input | C3-D5 | Install Regional Defaults | Press button |
| Input | B7    | Year                      | 2025         |
| Input | AZ91  | HDRD transloading         | Yes          |
| Input | BB91  | RN transloading           | Yes          |
| Input | AZ92  | HDRD rail distance, km    | 0            |
| Input | BB92  | RN rail distance, km      | 0            |
| Input | AZ96  | HDRD truck distance, km   | 80           |
| Input | BB96  | RN truck distance, km     | 80           |
| Input | AZ98  | HDRD rail fraction        | 0            |
| Input | BB98  | RN rail fraction          | 0            |
| Input | AZ102 | HDRD truck fraction       | 1            |
| Input | BB102 | RN truck fraction         | 1            |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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The lifecycle results for the BC run for both the HDRD and RN pathways are shown in **Table 4-25**. The lifecycle results for HDRD are taken from cells AK16-AK18 of the BC LCFS sheet, while the RN results are taken from cells AM16-AM18 of the same sheet.

**Table 4-25 HDRD with coproduct RN: BC run CI results**

| Lifecycle Stage                    | BC Run Emissions, g CO <sub>2</sub> e/GJ (HHV) |             |
|------------------------------------|------------------------------------------------|-------------|
|                                    | HDRD                                           | RN          |
| Fuel distribution and storage      | 392                                            | 407         |
| Fuel dispensing                    | 83                                             | 85          |
| Vehicle or Vessel operation        | 1,523                                          | 2,040       |
| Total                              | 1,998                                          | 2,532       |
| <b>Total, g CO<sub>2</sub>e/MJ</b> | <b>2.00</b>                                    | <b>2.53</b> |

The results of the Alberta and BC runs are added together to determine the total CI of the main product and the coproduct RN as shown in **Table 4-26**. The RN pathway has a slightly higher caused by the difference in fuel properties when compared to HDRD.

**Table 4-26 HDRD with coproduct RN: Total CI results**

| Fuel         | HDRD CI<br>(g CO <sub>2</sub> e/MJ) | RN CI<br>(g CO <sub>2</sub> e/MJ) |
|--------------|-------------------------------------|-----------------------------------|
| Alberta run  | 19.78                               | 19.80                             |
| BC run       | 2.00                                | 2.53                              |
| <b>Total</b> | <b>21.78</b>                        | <b>22.33</b>                      |

#### 4.5.2.2 Example: CPRG with Coproduct AJF CI

A CPRF facility in BC uses local yellow grease to produce RG, which is the main product, with a AJF coproduct fuel pathway, which is also eligible for a fuel code.

The pathway inputs for the BC run are shown in **Table 4-27**, to model the RN pathway the same fuel transportation distances used for the RG main product are entered in cells BA91-BA102.

**Table 4-27 CPRG with coproduct AJF: BC run inputs**

| Sheet | Cell  | Description               | Value        |
|-------|-------|---------------------------|--------------|
| Input | B4    | Region                    | BC           |
| Input | C3-D5 | Install Regional Defaults | Press button |
| Input | B7    | Year                      | 2025         |



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| Sheet         | Cell    | Description                                          | Value         |
|---------------|---------|------------------------------------------------------|---------------|
| Input         | B53     | RG feedstock                                         | Yellow grease |
| Input         | Z76     | Yellow grease rail distance, km                      | 0             |
| Input         | Z80     | Yellow grease truck distance, km                     | 20            |
| Input         | L82     | Yellow grease rail fraction                          | 0             |
| Input         | L86     | Yellow grease truck fraction                         | 1             |
| Input         | BA91    | AJF transloading                                     | No            |
| Input         | BB91    | RG transloading                                      | No            |
| Input         | BA92    | AJF rail distance, km                                | 0             |
| Input         | BB92    | RG rail distance, km                                 | 0             |
| Input         | BA96    | AJF truck distance, km                               | 80            |
| Input         | BB96    | RG truck distance, km                                | 80            |
| Input         | BA98    | AJF rail fraction                                    | 0             |
| Input         | BB98    | RG rail fraction                                     | 0             |
| Input         | BA102   | AJF truck fraction                                   | 1             |
| Input         | BB102   | RG truck fraction                                    | 1             |
| Input         | CF241   | RG production data year                              | 2025          |
| Input         | CF243   | Electricity for RG production, kWh/L <sub>RG</sub>   | 0.1           |
| Input         | CF245   | NG for RG production, MJ/ L <sub>RG</sub>            | 0.25          |
| Input         | CF248   | Yellow grease for RG production, kg/ L <sub>RG</sub> | 1             |
| Alt Fuel Prod | CO29-81 | All chemicals                                        | 0             |
| Alt Fuel Prod | CO44    | Hydrogen, kg/L <sub>RG</sub>                         | 0.02          |
| Alt Fuel Prod | CO89    | LPG (Oil), L/ L <sub>RG</sub>                        | 0             |
| Coprods       | BE135   | RP coproduct (LPG), L/L <sub>RG</sub>                | 0.0           |
| Coprods       | BE143   | AJF coproduct, L/L <sub>RG</sub>                     | 0.05          |
| Coprods       | B198    | AJF coproduct allocation method                      | Energy        |

The lifecycle results for the BC run for both the RG and AJF pathways are shown in **Table 4-28**. Lifecycle results for RG are taken from cells AM8 to AM18 of the BC LCFS sheet, with the AJF results taken from AM8-AM15 and AL16-AL18 of the same sheet.

**Table 4-28 RG with coproduct AJF: BC run CI results**

| Lifecycle Stage                     | BC Run Emissions, g CO <sub>2</sub> e/GJ (HHV) |    |     |       |       |
|-------------------------------------|------------------------------------------------|----|-----|-------|-------|
|                                     | RG and AJF                                     | RG | AJF | RG    | AJF   |
|                                     |                                                |    |     | Total | Total |
| Direct land use change              | 0                                              |    |     | 0     | 0     |
| Feedstock production or cultivation | 0                                              |    |     | 0     | 0     |
| Feedstock upgrading                 | 1,037                                          |    |     | 1,037 | 1,037 |
| Feedstock transport                 | 412                                            |    |     | 412   | 412   |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Lifecycle Stage                    | BC Run Emissions, g CO <sub>2</sub> e/GJ (HHV) |             |             |              |              |
|------------------------------------|------------------------------------------------|-------------|-------------|--------------|--------------|
|                                    | RG and AJF                                     | RG          | AJF         | RG           | AJF          |
|                                    |                                                |             |             | Total        | Total        |
| Feedstock coproducts production    | 0                                              |             |             | 0            | 0            |
| Avoided emissions                  | 0                                              |             |             | 0            | 0            |
| Fuel production                    | 21,960                                         |             |             | 21,960       | 21,960       |
| Fuel coproducts production         | -2,522                                         |             |             | -2,522       | -2,522       |
| Fuel distribution and storage      |                                                | 215         | 213         | 215          | 213          |
| Fuel dispensing                    |                                                | 85          | 84          | 85           | 84           |
| Vehicle or Vessel operation        |                                                | 2,040       | 572         | 2,040        | 572          |
| Total                              | 20,888                                         | 2,340       | 869         | 23,228       | 21,757       |
| <b>Total, g CO<sub>2</sub>e/MJ</b> | <b>20.89</b>                                   | <b>2.34</b> | <b>0.87</b> | <b>23.23</b> | <b>21.76</b> |

The RG main product has a slightly higher CI than the AJF coproduct fuel due to difference in fuel properties such as energy density and combustion emissions.

## 4.6 Carbon Capture and Sequestration

Fuel production facilities can include a carbon capture and sequestration (CCS) system that captures CO<sub>2</sub> from the fuel production process and permanently sequesters the CO<sub>2</sub>. Fuel production facilities that sequester CO<sub>2</sub> can receive a CCS credit for their fuel pathways that will reduce the CI of their fuel.

CCS systems are more common in ethanol production plants due to the higher level of CO<sub>2</sub> available from the fermentation process, and the low energy requirements required to capture the CO<sub>2</sub>. There is potential for CCS systems to be integrated into RHF plants, but GHGenius 5.02b only has the capability to give a CCS credit to BtLF pathways and does not have the capability for HDRF and CPRF pathways. Future versions of GHGenius may include the capability to model a CCS credit for HDRF and CPRF pathways.

### Note:

This user guide is for guidance purposes only. If this user guide conflicts with documentation related to CCS under the BC LCFS, applicants must follow that documentation.

|                                                                                   |                                                                                      |                                                                                                                                                                              |
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#### 4.6.1 BtLF CCS

GHGenius 5.02b has the capability to model a CCS credit for BtLF pathways. GHGenius 5.02b requires the user to enter the sequestration rate as a fraction ( $CCS_{fraction}$ ) of the maximum CCS rate ( $CCS_{max\ rate}$ ). The  $CCS_{max\ rate}$  for BtLF production is not fixed and is dependent on the inputs used in the model, which makes it difficult to accurately determine the CCS rate.

Under the Low Carbon Fuels (Technical) Regulation, GHGenius version 5.02b is the currently approved lifecycle analysis model. The Ministry is in the process of updating the regulation to adopt a newer version of GHGenius that improves the accuracy of the BtLF CCS credit calculation. In the interim, applicants can use the alternative method detailed below to model the BtLF CCS credit in GHGenius 5.02b.

##### 4.6.1.1 BtLF CCS Credit Alternative Method

Applicants can use this alternative method, provided they submit an alternative method application. See [RLCF-025: Use of Alternative Methods for Determining Carbon Intensities](#) for more details.

The following steps detail how to model BtLF CCS credit in GHGenius 5.02b using the Alternative Method:

1. Enter 1 in cell B69 of the Input sheet to turn on sequestration in GHGenius
2. Update the fuel production formulas in Upstream Results HHV sheet as detailed in the table below.

**Table 4-29: Alternative method modification to Upstream Results HHV sheet**

| Fuel | Cell | Alternative Method Formula                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------|------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BtLD | BW11 | $=((\text{'Alt Fuel Prod'!D10-SUMPRODUCT('Alt Fuel Prod'!D29:D81,'Alt Fuel Prod'!C105:C157)})*\text{'Fuel Char'!Q$127/'Alt Fuel Prod'!D26*Elec Emissions'!B55+'Energy Use'!E115*Equip Emis Factors'!H27+'Energy Use'!E116*Equip Emis Factors'!X27 +'Energy Use'!E118*Equip Emis Factors'!S27})*(\text{'Energy Use'!BS10-'Alt Fuel Prod'!D94*Energy Use'!$E61+1})+(\text{'Alt Fuel Prod'!D82+SUMPRODUCT('Alt Fuel Prod'!D29:D81,'Alt Fuel Prod'!H105:H157)}/\text{'Fuel Char'!$B88*1000})*\text{'Energy Use'!E61+'Alt Fuel Prod'!D95*Energy Use'!$E61-'Sequestration'!D30}$ |

|                                                                                   |                                                                                      |                                                                                                                                                                              |
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| Fuel | Cell | Alternative Method Formula                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|------|------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| BtLG | CB11 | $= ((\text{'Alt Fuel Prod'!I10} + \text{SUMPRODUCT('Alt Fuel Prod'!I29:I81, 'Alt Fuel Prod'!C105:C157)}) * \text{'Fuel Char'!$Q$127} / \text{'Alt Fuel Prod'!I26} * \text{'Elec Emissions'!B55} + \text{'Energy Use'!J115} * \text{'Equip Emis Factors'!H27} + \text{'Energy Use'!J116} * \text{'Equip Emis Factors'!X27} + \text{'Energy Use'!J118} * \text{'Equip Emis Factors'!S27}) * (\text{'Energy Use'!BX10} - \text{'Alt Fuel Prod'!I94} * \text{'Energy Use'!$C$61} + 1) + (\text{'Alt Fuel Prod'!I82} + \text{SUMPRODUCT('Alt Fuel Prod'!I29:I81, 'Alt Fuel Prod'!H105:H157)}) / \text{'Fuel Char'!$B100} * 1000) * \text{'Energy Use'!$C$61} + \text{'Alt Fuel Prod'!I95} * \text{'Energy Use'!$C$61} - \text{'Sequestration'!H30}$ |

- Set the fraction emissions sequestered to 0 in the following cells of the Sequestration sheet:
  - BtLD: D19
  - BtLG: H19
- Determine the energy consumption associated with sequestration per litre of BtLF and enter them in the Sequestration sheet in the cells detailed in **Table 4-30**.

**Table 4-30 BtLF CCS Energy Consumption Inputs**

| Pathway | Sequestration Sheet Cells |
|---------|---------------------------|
| BtLD    | D22-D26                   |
| BtLG    | H22-H26                   |

- Determine the amount of CO<sub>2</sub> sequestered permanently in g CO<sub>2</sub>/L<sub>BtLF</sub> (CCS<sub>rate, L</sub>) using facility data which excludes losses of CO<sub>2</sub> to the atmosphere such as uncaptured CO<sub>2</sub>, fugitive emissions and venting at the injection site.

The following formula is an example of a calculation of CCS<sub>rate, L</sub>:

$$CCS_{rate,L} = CO_{2\text{ captured}} - CO_{2\text{ injection, fugitives}} - CO_{2\text{ injection, subsurface}} - CO_{2\text{ injection, venting}}$$

- CO<sub>2</sub> captured: captured CO<sub>2</sub>
- CO<sub>2</sub> injection, fugitives: Fugitive CO<sub>2</sub> emissions at injection site
- CO<sub>2</sub> injection, subsurface: CO<sub>2</sub> emissions from subsurface to atmosphere
- CO<sub>2</sub> injection, venting: CO<sub>2</sub> venting at injection site

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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6. Divide the  $CCS_{rate, L}$  by the BtLF's HHV ( $GJ/L_{BtLF}$ ) to determine the  $CCS_{rate, GJ}$ 
  - BtLD:  $0.03651^5 GJ/L_{BtLD}$  or facility specific HHV
  - BtLG:  $0.03469^6 GJ/L_{BtLG}$  or facility specific HHV
7. Modify the calculated  $g_{sequestered}/GJ_{produced}$  value by entering the  $CCS_{rate, GJ}$  in the following cells of the Sequestration sheet:
  - BtLD: D30
  - BtLG: H30

The emissions associated with the CCS system are included in the fuel production lifecycle stage's emissions in the following cells of the BC LCFS sheet:

- BtLD: BF14
- BtLG: BK14

### BtLD CCS Alternative Method Example:

A BtLD facility in BC has a CCS system that captures and permanently sequesters  $CO_2$  in a nearby well. The BtLD plant and CCS system has the data detailed in **Table 4-31**.

**Table 4-31 BtLD CCS Example Data**

| Description                                      | Value |
|--------------------------------------------------|-------|
| Electricity consumption for CCS, kWh/ $L_{BtLD}$ | 0.3   |
| Natural gas consumption for CCS, MJ/ $L_{BtLD}$  | 6.0   |
| $CO_2$ captured, g $CO_2/L_{BtLD}$               | 750   |
| $CO_2$ injection, fugitives, g $CO_2/L_{BtLD}$   | 10    |
| $CO_2$ injection, subsurface, g $CO_2/L_{BtLD}$  | 5     |
| $CO_2$ injection, venting, g $CO_2/L_{BtLD}$     | 35    |

The CCS system is modelled as follows:

1. Cell B69 of the Input sheet is set to 1 to turn on sequestration

<sup>5</sup> Taken from cell B88 of Fuel Char sheet divided by 1000 MJ/GJ

<sup>6</sup> Taken from cell B99 of Fuel Char sheet divided by 1000 MJ/GJ

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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- Cell BW11 of the Upstream Results HHV sheet is set to:

=('Alt Fuel Prod'!D10-SUMPRODUCT('Alt Fuel Prod'!D29:D81,'Alt Fuel Prod'!C105:C157))\*'Fuel Char'!\$Q\$127/'Alt Fuel Prod'!D26\*'Elec Emissions'!B55+'Energy Use'!E115\*'Equip Emis Factors'!H27+'Energy Use'!E116\*'Equip Emis Factors'!X27 +'Energy Use'!E118\*'Equip Emis Factors'!S27)\*('Energy Use'!BS10-'Alt Fuel Prod'!D94\*'Energy Use'!\$E61+1)+('Alt Fuel Prod'!D82+SUMPRODUCT('Alt Fuel Prod'!D29:D81,'Alt Fuel Prod'!H105:H157))/'Fuel Char'!\$B88\*1000)\*'Energy Use'!E61+'Alt Fuel Prod'!D95\*'Energy Use'!\$E61-'Sequestration'!D30

- Cell D19 of the Sequestration sheet is set to 0
- Energy consumption associated with sequestration is entered in the following cells of the Sequestration sheet:

- D22: 0.3 kWh<sub>electricity</sub>/L<sub>BtLD</sub>
- D24: 6.0 MJ<sub>natural gas</sub>/L<sub>BtLD</sub>

- The CCS<sub>rate, L</sub> is 700 g CO<sub>2</sub>/L<sub>BtLD</sub> as determined using the following formula:

$$CCS_{rate,L} = CO_{2\text{ captured}} - CO_{2\text{ injection, fugitives}} - CO_{2\text{ injection, subsurface}} - CO_{2\text{ injection, venting}}$$

$$700 \text{ g } \frac{CO_2}{L_{BtLD}} = (750 - 10 - 5 - 35) \text{ g } \frac{CO_2}{L_{BtLD}}$$

- The CCS<sub>rate, GJ</sub> is calculated to be 19,173 g CO<sub>2</sub>/GJ<sub>BtLD</sub> by:

- Dividing 700 g CO<sub>2</sub>/L<sub>BtLD</sub> by the HHV of BtLD<sup>7</sup> which is 0.03651 GJ/ L<sub>BtLD</sub>

- The CCS<sub>rate, GJ</sub> is entered in cell D30 of the Sequestration sheet (19,173 g CO<sub>2</sub>/GJ<sub>BtLD</sub>)

The emissions associated with the CCS system are included in the fuel production lifecycle stage's emissions in cell BF14 of the BC LCFS sheet.

<sup>7</sup> Taken from cell B88 of Fuel Char sheet divided by 1000 MJ/GJ

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 4.7 RHF Transportation

RHF transportation is entered in rows 91-102 of the Input sheet in the fuel's column specified in **Table 4-32**.

**Table 4-32 RHF finished fuel transportation columns**

| RHF  | Energy and Mass Column<br>Input sheet |
|------|---------------------------------------|
| AJF  | BA                                    |
| BtLD | F                                     |
| BtLG | J                                     |
| HDRD | AZ                                    |
| RG   | BB                                    |
| RP   | BC                                    |

### 4.7.1 Transloading

Transloading refers to the process of transferring the product from one type of transportation to another (e.g. from truck to rail or vice versa). Within the GHGenius model, transloading is used to account for electricity consumption associated with fuel transferring, blending and/or storage.

- Transloading on:
  - If any transloading, blending, or storage of fuel occurs between the production facility and its delivery to a location within BC, toggle transloading on.
  - To do this set the cell in row 91 under the column that corresponds to the RHF (see **Table 4-32** above) of the Input sheet to "Yes".
- Transloading off:
  - If there is a single type of transportation used between the production facility and delivery to a location in BC and no blending or storage occurs, toggle the transloading off.
  - To do this set the cell in row 91 under the column that corresponds to the RHF (see **Table 4-32** above) of the Input sheet to "No".

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 5 BC Distribution, Dispensing, and Use

RHF pathways must include the emissions associated with BC distribution, dispensing, and use.

The default inputs to model the BC distribution, dispensing and use emissions are shown in **Table 5-1**. If the applicant has data supporting different BC distribution, dispensing and use they must detail the rationale in their Technical Report.

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

| GHGenius Location |                |        | Description                                      | Value        |
|-------------------|----------------|--------|--------------------------------------------------|--------------|
| Sheet             | Column(s)      | Row(s) |                                                  |              |
| Input             | B              | 4      | Region                                           | BC           |
|                   | C-D            | 3-5    | Install Regional Defaults                        | Press button |
|                   | See Table 4-32 | 91     | Fuel Transloading                                | Yes          |
|                   |                | 92     | Fuel rail distance, km                           | 0            |
|                   |                | 93     | Fuel domestic water distance, km                 | 0            |
|                   |                | 94     | Fuel international water distance, km            | 0            |
|                   |                | 95     | Fuel pipeline, tram and/or conveyor distance, km | 0            |
|                   |                | 96     | Fuel truck distance, km                          | 80           |
|                   |                | 98     | Fuel rail fraction                               | 0            |
|                   |                | 99     | Fuel domestic water fraction                     | 0            |
|                   |                | 100    | Fuel international water fraction                | 0            |
|                   |                | 101    | Fuel pipeline, tram, and/or conveyor fraction    | 0            |
|                   |                | 102    | Fuel truck fraction                              | 1            |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 6 Material Balance Calculation

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

If hydrogen is produced on-site the measured quantity or estimated quantity of hydrogen consumed as determined in Section 4.4.1.2 should be used in the mass balance.

### 6.1 HARD Material Balance Example

HARD is produced from canola oil in a facility with the input data shown in **Table 6-1**. Other material inputs are considered immaterial as they contribute <1% to the total input mass or they are excluded because they are an energy input.

**Table 6-1 Material Balance Example Inputs**

| Input Stream          | GHGenius Location  | GHGenius Input | Input (g/L) | Function  | Notes                         |
|-----------------------|--------------------|----------------|-------------|-----------|-------------------------------|
| Canola oil            | Input CD248        | 0.95 kg/L      | 950         | Feedstock |                               |
| Hydrogen <sup>8</sup> | Alt Fuel Prod CM44 | 0.04 kg/L      | 40          | Hydrogen  |                               |
| Other Inputs          | N/A                | N/A            | N/A         | Other     | Excluded due to immateriality |
| <b>Total Input</b>    |                    |                | <b>990</b>  |           |                               |

The output data for the facility is shown in **Table 6-2**. The HARD production process includes 3 coproducts. The coproducts volumes are converted to mass using the densities found on the Fuel Char sheet of GHGenius. The mass of waste is calculated as the difference between the total input mass and the total of the other output masses.

<sup>8</sup> If the hydrogen was produced internally the measured or estimated mass of hydrogen consumed would be used (see Section 4.4.1.2).

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 6-2 Material Balance Example Outputs**

| Output Stream        | GHGenius Location | GHGenius Input            | Output (g/L) | Function     | Notes                                                 |
|----------------------|-------------------|---------------------------|--------------|--------------|-------------------------------------------------------|
| AJF <sup>9</sup>     | Coprods BC143     | 0.015 L/L <sub>HDRD</sub> | 11           | Coproduct    | Density (760 g/L) from cell E87 of Fuel Char sheet    |
| HDRD                 | N/A               | N/A                       | 782          | Main Product | Density (782 g/L) from cell E89 of Fuel Char sheet    |
| LPG <sup>9</sup>     | Coprods BC135     | 0.02 L/L <sub>HDRD</sub>  | 10           | Coproduct    | Density (510 g/L) from cell E123 of Fuel Char sheet   |
| Naphtha <sup>9</sup> | Coprods BC137     | 0.015 L/L <sub>HDRD</sub> | 10           | Coproduct    | Density (678 g/L) from cell E121 of Fuel Char sheet   |
| Waste                | N/A               | N/A                       | 177          | Waste        | Unmetered streams. Calculated using material balance. |
| <b>Total Output</b>  |                   |                           | <b>990</b>   |              |                                                       |

<sup>9</sup> If the hydrogen was produced internally using coproducts, the measured or estimated mass of each coproduct consumed would be used (see Section 4.4.1.2).

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 7 Appendix 1: Soybean Oil HDRD and Coproduct Fuels Example

Below is an example of a HDRD pathway that has the following characteristics:

- The feedstock is soybean oil (SBO) from the US Central (USC) region,
  - Only the SBO transportation distances are known.
    - Applicant uses default crushing inputs in cells AT241-AT248 of the Input sheet.
    - Applicant uses default soybean transportation distances to the soybean crusher in cells M76-M86 of the Input sheet.
- The HDRD plant is in Texas (USC region)
  - The main product is HDRD.
  - The fuel producer is applying for AJF, RP and RN coproduct fuel codes.
    - The RP meets the specifications detailed in Section 4.5.1.1 and must use energy allocation, regardless of whether the RP is receiving a fuel code.
  - The facility produces a fuel gas coproduct which is modelled as renewable natural gas (RNG) in the Coproduct sheet.
  - The HDRD plant purchases hydrogen from off-site.
  - An out-of-model energy allocation calculation is not required as the feedstock and fuel production occurs in the same region (see Section 4.5.1.2)
- The HDRD and coproduct fuels are railed to BC.

As the feedstock and HDRD production facility are in the same region this pathway will require 2 model runs:

- Feedstock and fuel production and transportation: USC region, and
- Fuel distribution and use: BC

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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The first model run is for feedstock and fuel production and transportation in the USC region. **Table 7-1** shows the USC run model inputs.

**Table 7-1 SBO HDRD and Coproduct Fuels: Model Inputs for USC Run**

| Sheet         | Cell(s)                          | Description                                            | Value        |
|---------------|----------------------------------|--------------------------------------------------------|--------------|
| Input         | B4                               | Region                                                 | US Central   |
| Input         | C3-D5                            | Install Regional Defaults                              | Press button |
| Input         | B7                               | Year                                                   | 2025         |
| Input         | B53                              | HDRD feedstock                                         | Soybean oil  |
| Input         | N76                              | SBO rail distance, km                                  | 300          |
| Input         | N80                              | SBO truck distance, km                                 | 0            |
| Input         | N82                              | SBO rail fraction                                      | 1            |
| Input         | N86                              | SBO truck fraction                                     | 0            |
| Input         | AZ91<br>BA91<br>BB91<br>BC91     | Fuel transloading                                      | No           |
| Input         | AZ92<br>BA92<br>BB92<br>BC92     | Fuel rail distance, km                                 | 3000         |
| Input         | AZ96<br>BA96<br>BB96<br>BC96     | Fuel truck distance, km                                | 0            |
| Input         | AZ98<br>BA98<br>BB98<br>BC98     | Fuel rail fraction                                     | 1            |
| Input         | AZ102<br>BA102<br>BB102<br>BC102 | Fuel truck fraction                                    | 0            |
| Input         | CD241                            | HDRD production data year                              | 2025         |
| Input         | CD243                            | Electricity for HDRD production, kWh/L <sub>HDRD</sub> | 0.05         |
| Input         | CD245                            | NG for HDRD production, MJ/L <sub>HDRD</sub>           | 0.2          |
| Input         | CD248                            | SBO for HDRD production, kg/L <sub>HDRD</sub>          | 0.95         |
| Alt Fuel Prod | CM44                             | Hydrogen, kg/L <sub>HDRD</sub>                         | 0.03         |
| Alt Fuel Prod | CM53                             | NaOH, kg/L <sub>HDRD</sub>                             | 0            |
| Alt Fuel Prod | CM55                             | Nitrogen –liquid, kg/L <sub>HDRD</sub>                 | 0            |
| Alt Fuel Prod | CM62                             | Phosphoric acid, kg/L <sub>HDRD</sub>                  | 0            |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Sheet   | Cell(s) | Description                                                  | Value        |
|---------|---------|--------------------------------------------------------------|--------------|
| Coprods | BC135   | RP coproduct (LPG), L/L <sub>HDRD</sub>                      | 0.02         |
| Coprods | BC137   | RN coproduct, L/L <sub>HDRD</sub>                            | 0.015        |
| Coprods | BC138   | RNG (fuel gas), MJ/L <sub>HDRD</sub>                         | 0.5          |
| Coprods | BC143   | AJF (HRJ) coproduct, L/L <sub>HDRD</sub>                     | 0.015        |
| Coprods | B190    | RP (LPG) coproduct allocation method                         | Energy       |
| Coprods | B192    | RN coproduct allocation method                               | Energy       |
| Coprods | B193    | Renewable natural gas (fuel gas) coproduct allocation method | Displacement |
| Coprods | B198    | AJF (HRJ) coproduct allocation method                        | Energy       |

The results are shown in **Table 7-2**. These values are from the BC LCFS sheet, column AK, rows 8 to 16. This exercise also details how to model the CI of the AJF, RN and RP coproduct fuels. The coproduct fuels will use the same the same lifecycle results from the USC run, except for the fuel distribution and storage lifecycle stage, which will be calculated using the coproduct fuels respective pathway.

**Table 7-2 SBO HDRD and Coproduct Fuels: USC Run Results**

| Stage                                       | HDRD                                        | AJF   | RN    | RP    |
|---------------------------------------------|---------------------------------------------|-------|-------|-------|
|                                             | USC Emissions, g CO <sub>2</sub> e/GJ (HHV) |       |       |       |
| Direct land use change                      | 0                                           |       |       |       |
| Feedstock production or cultivation         | 33,478                                      |       |       |       |
| Feedstock upgrading                         | 14,357                                      |       |       |       |
| Feedstock transport                         | 1,875                                       |       |       |       |
| Feedstock coproducts production             | -40,746                                     |       |       |       |
| Avoided emissions                           | 0                                           |       |       |       |
| Fuel production                             | 11,092                                      |       |       |       |
| Fuel coproducts production                  | -1,630                                      |       |       |       |
| Fuel distribution and storage <sup>10</sup> | 1,207                                       | 1,234 | 1,257 | 1,192 |

The second run will be in the BC region to calculate final distribution of 80 km, dispensing, and fuel use emissions. Changes from the US Central run required for the BC run are outlined in **Table 7-3**.

<sup>10</sup> The fuel distribution and storage emissions are different for the coproduct fuels

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 7-3 SBO HDRD and Coproduct Fuels: Model Inputs for BC Run**

| Sheet | Cell                             | Description               | Value        |
|-------|----------------------------------|---------------------------|--------------|
| Input | B4                               | Region                    | BC           |
| Input | C3-D5                            | Install Regional Defaults | Press button |
| Input | AZ91<br>BA91<br>BB91<br>BC91     | Fuel Transloading         | Yes          |
| Input | AZ92<br>BA92<br>BB92<br>BC92     | Fuel rail distance, km    | 0            |
| Input | AZ96<br>BA96<br>BB96<br>BC96     | Fuel truck Distance, km   | 80           |
| Input | AZ98<br>BA98<br>BB98<br>BC98     | Fuel rail fraction        | 0            |
| Input | AZ102<br>BA102<br>BB102<br>BC102 | Fuel truck fraction       | 1            |

The results for the BC region are below and are taken from the BC LCFS sheet rows 16 to 18 in the columns shown in **Table 7-4**.

**Table 7-4 SBO HDRD and Coproduct Fuels: BC Run Results**

| Stage                         | HDRD                                       | AJF | RN    | RP    |
|-------------------------------|--------------------------------------------|-----|-------|-------|
|                               | BC Emissions, g CO <sub>2</sub> e/GJ (HHV) |     |       |       |
| Fuel distribution and storage | 392                                        | 401 | 407   | 454   |
| Fuel dispensing               | 83                                         | 84  | 85    | 88    |
| Vehicle or Vessel operation   | 1,523                                      | 572 | 2,040 | 2,971 |
| BC LCFS Results Column        | AK                                         | AL  | AM    | AN    |

The fuel pathway CIs for the main product HDRD and coproduct fuels (AJF, RN and RP) are determined by combining the results of the USC and BC model runs as shown in **Table 7-5**

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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to **Table 7-8**. The CIs differ due to the different fuel properties and combustion emissions for each fuel.

**Table 7-5 SBO HARD: Total Results**

| Stage                               | HARD USC                                | HARD BC      | HARD Total    |
|-------------------------------------|-----------------------------------------|--------------|---------------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |              |               |
| Direct land use change              | 0                                       |              | 0             |
| Feedstock production or cultivation | 33,478                                  |              | 33,478        |
| Feedstock upgrading                 | 14,357                                  |              | 14,357        |
| Feedstock transport                 | 1,875                                   |              | 1,875         |
| Feedstock coproducts production     | -40,746                                 |              | -40,746       |
| Avoided emissions                   | 0                                       |              | 0             |
| Fuel production                     | 11,092                                  |              | 11,092        |
| Fuel coproducts production          | -1,630                                  |              | -1,630        |
| Fuel distribution and storage       | 1,207                                   | 392          | 1,599         |
| Fuel dispensing                     |                                         | 83           | 83            |
| Vehicle or Vessel operation         |                                         | 1,523        | 1,523         |
| <b>Total</b>                        | <b>19,633</b>                           | <b>1,998</b> | <b>21,631</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  |                                         |              | <b>21.63</b>  |

**Table 7-6 SBO AJF: Total Results**

| Stage                               | AJF USC                                 | AJF BC       | AJF Total     |
|-------------------------------------|-----------------------------------------|--------------|---------------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |              |               |
| Direct land use change              | 0                                       |              | 0             |
| Feedstock production or cultivation | 33,478                                  |              | 33,478        |
| Feedstock upgrading                 | 14,357                                  |              | 14,357        |
| Feedstock transport                 | 1,875                                   |              | 1,875         |
| Feedstock coproducts production     | -40,746                                 |              | -40,746       |
| Avoided emissions                   | 0                                       |              | 0             |
| Fuel production                     | 11,092                                  |              | 11,092        |
| Fuel coproducts production          | -1,630                                  |              | -1,630        |
| Fuel distribution and storage       | 1,234                                   | 401          | 1,635         |
| Fuel dispensing                     |                                         | 84           | 84            |
| Vehicle or Vessel operation         |                                         | 572          | 572           |
| <b>Total</b>                        | <b>19,660</b>                           | <b>1,057</b> | <b>20,717</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  |                                         |              | <b>20.72</b>  |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 7-7 SBO RN: Total Results**

| Stage                               | RN USC                                  | RN BC        | RN Total      |
|-------------------------------------|-----------------------------------------|--------------|---------------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |              |               |
| Direct land use change              | 0                                       |              | 0             |
| Feedstock production or cultivation | 33,478                                  |              | 33,478        |
| Feedstock upgrading                 | 14,357                                  |              | 14,357        |
| Feedstock transport                 | 1,875                                   |              | 1,875         |
| Feedstock coproducts production     | -40,746                                 |              | -40,746       |
| Avoided emissions                   | 0                                       |              | 0             |
| Fuel production                     | 11,092                                  |              | 11,092        |
| Fuel coproducts production          | -1,630                                  |              | -1,630        |
| Fuel distribution and storage       | 1,257                                   | 407          | 1664          |
| Fuel dispensing                     |                                         | 85           | 85            |
| Vehicle or Vessel operation         |                                         | 2,040        | 2040          |
| <b>Total</b>                        | <b>19,683</b>                           | <b>2,532</b> | <b>22,215</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  |                                         |              | <b>22.22</b>  |

**Table 7-8 SBO RP: Total Results**

| Stage                               | RP USC                                  | RP BC        | RP Total      |
|-------------------------------------|-----------------------------------------|--------------|---------------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |              |               |
| Direct land use change              | 0                                       |              | 0             |
| Feedstock production or cultivation | 33,478                                  |              | 33478         |
| Feedstock upgrading                 | 14,357                                  |              | 14357         |
| Feedstock transport                 | 1,875                                   |              | 1875          |
| Feedstock coproducts production     | -40,746                                 |              | -40746        |
| Avoided emissions                   | 0                                       |              | 0             |
| Fuel production                     | 11,092                                  |              | 11092         |
| Fuel coproducts production          | -1,630                                  |              | -1630         |
| Fuel distribution and storage       | 1,192                                   | 454          | 1646          |
| Fuel dispensing                     |                                         | 88           | 88            |
| Vehicle or Vessel operation         |                                         | 2,971        | 2971          |
| <b>Total</b>                        | <b>19,618</b>                           | <b>3,513</b> | <b>23,131</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  |                                         |              | <b>23.13</b>  |

## 7.1 SBO HDRD Material Balance

**Table 7-9** details the material balance inputs for the SBO HDRD pathway. Other material inputs are considered immaterial as they contribute <1% to the total input mass or they are excluded because they are an energy input.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 7-9 SBO HARD: Material Balance Inputs**

| Input Stream       | GHGenius Location  | GHGenius Input            | Input (g/L) | Function       | Notes                                                                            |
|--------------------|--------------------|---------------------------|-------------|----------------|----------------------------------------------------------------------------------|
| SBO                | Input CD248        | 0.95 kg/L <sub>HARD</sub> | 950         | Feedstock      | N/A                                                                              |
| H <sub>2</sub>     | Alt Fuel Prod CM44 | 0.03 kg/L <sub>HARD</sub> | 30          | H <sub>2</sub> | Purchased H <sub>2</sub>                                                         |
| Other Inputs       | N/A                | N/A                       | N/A         | Other          | NG excluded as it is an energy source and not used for H <sub>2</sub> production |
| <b>Total Input</b> |                    |                           | <b>980</b>  |                |                                                                                  |

The output data for the facility is shown in **Table 7-10**. The HARD production process includes 3 coproducts. The coproduct volumes are converted to mass using the densities found on the Fuel Char sheet of GHGenius. The mass of waste is calculated as the difference between the total input mass and the total of the other output masses.

**Table 7-10 SBO HARD: Material Balance Outputs**

| Output Stream       | GHGenius Location | GHGenius Input            | Output (g/L) | Function     | Notes                                                  |
|---------------------|-------------------|---------------------------|--------------|--------------|--------------------------------------------------------|
| AJF                 | Coproducts BC143  | 0.015 L/L <sub>HARD</sub> | 11.4         | Coproduct    | Density (760 g/L) from cell E87 of Fuel Char sheet     |
| HARD                | N/A               | N/A                       | 782          | Main Product | Density (782 g/L) from cell E89 of Fuel Char sheet     |
| RP (LPG)            | Coproducts BC135  | 0.02 L/L <sub>HARD</sub>  | 10.2         | Coproduct    | Density (510 g/L) from cell E123 of Fuel Char sheet    |
| RN                  | Coproducts BC137  | 0.015 L/L <sub>HARD</sub> | 10.2         | Coproduct    | Density (678 g/L) from cell E121 of Fuel Char sheet    |
| RNG (fuel gas)      | Coproducts BC138  | 0.5 MJ/L <sub>HARD</sub>  | 9.3          | Coproduct    | Density (18.68 g/MJ) from cell D119 of Fuel Char sheet |
| Waste               | N/A               | N/A                       | 156.9        | Waste        | Unmetered streams. Calculated using material balance.  |
| <b>Total Output</b> |                   |                           | <b>980</b>   |              |                                                        |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 8 Appendix 2: Tallow HDRD with On-Site Hydrogen Example

Below is an example of a HDRD pathway that has the following characteristics:

- The feedstock is tallow from the US Central (USC) region, and the fuel producer has data regarding:
  - Energy and animal carcass consumption at rendering plant.
  - Animal carcass transport to rendering plant.
- The fuel production facility is in Washington, and its main product is HDRD with naphtha and LPG coproducts:
  - Washington is in the US West (USW) region.
  - The fuel production facility produces hydrogen internally using steam methane reforming (SMR) of natural gas and LPG and naphtha coproducts.
    - Hydrogen purchased set to 0
    - LPG and naphtha coproducts set to zero
- The HDRD is railed to BC.
- An out-of-model energy allocation calculation is not required (see Section 4.5.1.2), as the coproducts are fully used internally.

This example will require three model runs of GHGenius:

- Feedstock production and transportation: USC
- Fuel production and transportation: USW
- Fuel distribution and use: BC

**Table 8-1** shows the USC run model inputs.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 8-1 Tallow HDRD: Model Inputs for USC Run**

| Sheet | Cell  | Description                                          | Value        |
|-------|-------|------------------------------------------------------|--------------|
| Input | B4    | Region                                               | US Central   |
| Input | C3-D5 | Install Regional Defaults                            | Press button |
| Input | B7    | Year                                                 | 2025         |
| Input | B53   | HDRD feedstock                                       | Tallow       |
| Input | W80   | Animal carcass truck distance to renderer, km        | 50           |
| Input | W86   | Animal carcass truck fraction to renderer            | 1            |
| Input | X76   | Tallow rail distance to HDRD plant, km               | 2,000        |
| Input | X80   | Tallow truck distance to HDRD plant, km              | 0            |
| Input | X82   | Tallow rail fraction to HDRD plant                   | 1            |
| Input | X86   | Tallow truck fraction to HDRD plant                  | 0            |
| Input | BC241 | Rendering data year                                  | 2025         |
| Input | BC243 | Electricity for rendering, kWh/L <sub>Tallow</sub>   | 0.3          |
| Input | BC245 | NG for rendering, MJ/L <sub>Tallow</sub>             | 10           |
| Input | BC248 | Animal carcass for rendering, kg/L <sub>Tallow</sub> | 4.0          |
| Input | CD241 | HDRD production data year                            | 2025         |
| Input | CD248 | Tallow for HDRD production, kg/L <sub>HDRD</sub>     | 0.95         |

The results for the USC run are shown in **Table 8-2**. These values are from the BC LCFS sheet cells AK8 to AK13.

**Table 8-2 Tallow HDRD: USC Run Results**

| Stage                               | USC Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|---------------------------------------------|
| Direct land use change              | 0                                           |
| Feedstock production or cultivation | 0                                           |
| Feedstock upgrading                 | 20,607                                      |
| Feedstock transport                 | 1,632                                       |
| Feedstock coproducts production     | -10,167                                     |
| Avoided emissions                   | 0                                           |

This facility produces H<sub>2</sub> internally using SMR of NG and the LPG and naphtha coproducts produced in the HDRD production process. The amount of H<sub>2</sub> consumed in fuel production, as well as the NG, LPG and naphtha consumed by the SMR are metered. **Table 8-3** details the on-site H<sub>2</sub> production facility following the requirements detailed in Section 4.4.1.2)

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 8-3 Tallow HDRD: On-site H<sub>2</sub> production**

| Hydrogen Production Technology: |                  | SMR of NG, LPG, and RN                          |                             |               |
|---------------------------------|------------------|-------------------------------------------------|-----------------------------|---------------|
| Description                     | Consumption Rate | Description                                     | Measured or Estimated Value | Feedstock HHV |
| Natural Gas                     | 4.0              | MJ <sub>NG</sub> /L <sub>HDRD</sub>             | Measured                    | 1 MJ/MJ       |
| LPG                             | 0.04             | L <sub>LPG</sub> /L <sub>HDRD</sub>             | Measured                    | 25.62 MJ/L    |
| RN                              | 0.04             | L <sub>RN</sub> /L <sub>HDRD</sub>              | Measured                    | 34.51 MJ/L    |
| <b>Total feedstock</b>          | <b>6.4</b>       | <b>MJ<sub>feedstocks</sub>/L<sub>HDRD</sub></b> |                             |               |
| <b>H<sub>2</sub></b>            | <b>0.05</b>      | <b>Kg<sub>H2</sub>/L<sub>HDRD</sub></b>         | <b>Measured</b>             |               |

The HDRD plant consumes an additional 0.25 MJ<sub>NG</sub>/L<sub>HDRD</sub> in the HDRD production process, so the facility consumes 4.25 MJ<sub>NG</sub>/L<sub>HDRD</sub>.

The second run is a US West (USW) run, that accounts for fuel production from the tallow. The GHGenius inputs used for the USW run are shown in **Table 8-4**.

**Table 8-4 Tallow HDRD: Model Inputs for USW Run**

| Sheet         | Cell  | Description                                            | Value        |
|---------------|-------|--------------------------------------------------------|--------------|
| Input         | B4    | Region                                                 | US West      |
| Input         | C3-D5 | Install Regional Defaults                              | Press button |
| Input         | AZ91  | HDRD Transloading                                      | No           |
| Input         | AZ92  | HDRD rail distance, km                                 | 2,000        |
| Input         | AZ96  | HDRD truck distance, km                                | 0            |
| Input         | AZ98  | HDRD rail fraction                                     | 1            |
| Input         | AZ102 | HDRD truck fraction                                    | 0            |
| Input         | CD241 | HDRD production data year                              | 2025         |
| Input         | CD243 | Electricity for HDRD production, kWh/L <sub>HDRD</sub> | 0.05         |
| Input         | CD245 | NG for HDRD production, MJ/L <sub>HDRD</sub>           | 4.25         |
| Input         | CD248 | Tallow for HDRD production, kg/L <sub>HDRD</sub>       | 0.95         |
| Alt Fuel Prod | CM44  | Hydrogen, kg/L <sub>HDRD</sub>                         | 0            |
| Alt Fuel Prod | CM53  | NaOH, kg/L <sub>HDRD</sub>                             | 0.001        |
| Alt Fuel Prod | CM55  | Nitrogen - liquid, kg/L <sub>HDRD</sub>                | 0            |
| Alt Fuel Prod | CM62  | Phosphoric acid, kg/L <sub>HDRD</sub>                  | 0            |
| Coprods       | BC135 | LPG coproduct, L/L <sub>HDRD</sub>                     | 0            |
| Coprods       | BC137 | Naphtha coproduct, L/L <sub>HDRD</sub>                 | 0            |

The results for USW run are shown in **Table 8-5**. These values are from the BC LCFS sheet cells AK14 to AK16.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

**Table 8-5 Tallow: USW Run Results**

| Stage                         | USW Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------|---------------------------------------------|
| Fuel production               | 7,713                                       |
| Fuel coproducts production    | 0                                           |
| Fuel distribution and storage | 814                                         |

The third run is in the BC region to calculate final distribution of 80km, dispensing, and fuel use emissions. Changes from the previous run are outlined in **Table 8-6**.

**Table 8-6 Tallow HDRD: Model Inputs for BC Run**

| Sheet | Cell  | Description               | Value        |
|-------|-------|---------------------------|--------------|
| Input | B4    | Region                    | BC           |
| Input | C3-D5 | Install Regional Defaults | Press button |
| Input | AZ91  | HDRD transloading         | Yes          |
| Input | AZ92  | HDRD rail distance, km    | 0            |
| Input | AZ96  | HDRD truck distance, km   | 80           |
| Input | AZ98  | HDRD rail fraction        | 0            |
| Input | AZ102 | HDRD truck fraction       | 1            |

The results for the BC region are shown in **Table 8-7**. These are from the BC LCFS sheet, column AK rows 16 to 18.

**Table 8-7 Tallow HDRD: BC Run Results**

| Stage                         | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------|-----------------------------------------|
| Fuel distribution and storage | 392                                     |
| Fuel dispensing               | 83                                      |
| Vehicle or Vessel operation   | 1,523                                   |

The values from the USC, USW and BC run are summed as shown in **Table 8-8** to determine the HDRD CI results.

**Table 8-8 Tallow HDRD: Total Results**

| Stage                               | USC                                     | USW | BC | Total   |
|-------------------------------------|-----------------------------------------|-----|----|---------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |     |    |         |
| Direct land use change              | 0                                       |     |    | 0       |
| Feedstock production or cultivation | 0                                       |     |    | 0       |
| Feedstock upgrading                 | 20,607                                  |     |    | 20,607  |
| Feedstock transport                 | 1,632                                   |     |    | 1,632   |
| Feedstock coproducts production     | -10,167                                 |     |    | -10,167 |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Stage                              | USC                                     | USW          | BC           | Total         |
|------------------------------------|-----------------------------------------|--------------|--------------|---------------|
|                                    | Emissions, g CO <sub>2</sub> e/GJ (HHV) |              |              |               |
| Avoided emissions                  | 0                                       |              |              | 0             |
| Fuel production                    |                                         | 7,713        |              | 7,713         |
| Fuel coproducts production         |                                         | 0            |              | 0             |
| Fuel distribution and storage      |                                         | 814          | 392          | 1,206         |
| Fuel dispensing                    |                                         |              | 83           | 83            |
| Vehicle or Vessel operation        |                                         |              | 1,523        | 1,523         |
| <b>Total</b>                       | <b>12,072</b>                           | <b>8,527</b> | <b>1,998</b> | <b>22,597</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b> |                                         |              |              | <b>22.60</b>  |

## 8.1 Tallow HARD Material Balance

**Table 8-9** details the material balance inputs for the tallow HARD pathway. Other material inputs (e.g. NaOH) are considered immaterial as they contribute <1% to the total input mass or they are excluded because they are an energy input.

**Table 8-9 Tallow HARD: Material Balance Inputs**

| Input Stream       | GHGenius Location | GHGenius Input            | Input (g/L) | Function       | Notes                                                                       |
|--------------------|-------------------|---------------------------|-------------|----------------|-----------------------------------------------------------------------------|
| Tallow             | Input CD248       | 0.95 kg/L <sub>HARD</sub> | 950         | Feedstock      |                                                                             |
| H <sub>2</sub>     | N/A               | 0.05 kg/L <sub>HARD</sub> | 50          | H <sub>2</sub> | On-site H <sub>2</sub> not used in GHGenius. Measured value from Table 8-3. |
| Other Inputs       | N/A               | N/A                       | N/A         | Other          | NG excluded as it is an energy input and NaOH excluded due to immateriality |
| <b>Total Input</b> |                   |                           | <b>1000</b> |                |                                                                             |

The output data for the facility is shown in **Table 8-10**. The mass of waste is calculated as the difference between the total input mass and the total of the other output masses.

**Table 8-10 Tallow HARD: Material Balance Outputs**

| Output Stream | GHGenius Location | GHGenius Input | Output (g/L) | Function     | Notes                                              |
|---------------|-------------------|----------------|--------------|--------------|----------------------------------------------------|
| HARD          | N/A               | N/A            | 782.0        | Main Product | Density (782 g/L) from cell E89 of Fuel Char sheet |



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| Output Stream       | GHGenius Location | GHGenius Input           | Output (g/L) | Function                  | Notes                                                                                                                                             |
|---------------------|-------------------|--------------------------|--------------|---------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------|
| LPG                 | N/A               | 0.04 L/L <sub>HDRD</sub> | 20.4         | H <sub>2</sub> production | Used for on-site H <sub>2</sub> . Not used in GHGenius. Measured value from Table 8-3.<br><br>Density (510 g/L) from cell E123 of Fuel Char sheet |
| RN                  | N/A               | 0.04 L/L <sub>HDRD</sub> | 27.1         | H <sub>2</sub> Production | Used for on-site H <sub>2</sub> . Not used in GHGenius. Measured value from Table 8-3.<br><br>Density (678 g/L) from cell E121 of Fuel Char sheet |
| Waste               | N/A               | N/A                      | 170.5        | Waste                     | Unmetered streams.<br>Calculated using material balance.                                                                                          |
| <b>Total Output</b> |                   |                          | <b>1000</b>  |                           |                                                                                                                                                   |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 9 Appendix 3: Canola Oil Co-processed in an FCC with Out-of-Model Energy Allocation Calculation Example

Below is an example of a renewable gasoline pathway that has the following characteristics:

- The feedstock is canola oil from Saskatchewan (SK), and the fuel producer does not have any feedstock specific data other than the feedstock transportation distance from the crusher to the fuel production facility.
- The canola oil is co-processed in an Alberta (AB) refinery FCC along with crude oil and the main product is RG. The following coproducts are also produced:
  - Fuel coproducts:
    - AJF
    - FCC RD
  - Non-fuel coproducts:
    - FCC coke
    - HCO
- The pathway follows the guidance outlined under Information Bulletin [RLCF-019: Co-processing Methodology](#)
- The RG and fuel coproducts are shipped by pipeline to BC.
- An out-of-model energy allocation calculation is required (see Section 4.5.1.2), as:
  - Feedstock and fuel production occurs in different regions, and
  - AJF and FCC renewable diesel are allocated by energy.

This example will require three model runs in GHGenius:

- Feedstock production and transportation: Saskatchewan

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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- Fuel production and transportation: Alberta
- Fuel distribution and use: BC

**Table 9-1** shows the Saskatchewan run model inputs. A GHGenius user would replace these values with their actual values.

**Table 9-1 Canola oil in FCC: Model Inputs for Saskatchewan Run**

| Sheet | Cell  | Description                                        | Value        |
|-------|-------|----------------------------------------------------|--------------|
| Input | B4    | Region                                             | Saskatchewan |
| Input | C3-D5 | Install Regional Defaults                          | Press button |
| Input | B7    | Year                                               | 2025         |
| Input | B55   | RG feedstock                                       | Canola Oil   |
| Input | L76   | Canola oil rail distance to RG plant, km           | 800          |
| Input | L80   | Canola oil truck distance to RG plant, km          | 0            |
| Input | L82   | Canola oil rail fraction to RG plant               | 1            |
| Input | L86   | Canola oil truck fraction to RG plant              | 0            |
| Input | CF241 | RG production data year                            | 2025         |
| Input | CF248 | Canola oil for RG production, kg/L <sub>HDRD</sub> | 1.10         |

The results for the Saskatchewan run are shown in **Table 9-2**. These values are from the BC LCFS sheet cells AM8 to AM13.

**Table 9-2 Canola oil in FCC: SK Run Results**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 0                                       |
| Feedstock production or cultivation | 4,462                                   |
| Feedstock upgrading                 | 6,523                                   |
| Feedstock transport                 | 1,374                                   |
| Feedstock coproducts production     | -6,663                                  |
| Avoided emissions                   | 0                                       |

The second region is an Alberta run, that accounts for fuel production from the canola oil. This facility is applying for fuel codes for the AJF and FCC RG, so separate fuel distribution and storage, fuel dispensing and combustion emissions need to be calculated. The GHGenius inputs used for the Alberta run are shown in **Table 9-3**.

**Table 9-3 Canola oil in FCC: Model Inputs for AB Run**

| Sheet | Cell | Description | Value   |
|-------|------|-------------|---------|
| Input | B4   | Region      | Alberta |



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| Input         | C3-D5                   | Install Regional Defaults                          | Press button |
|---------------|-------------------------|----------------------------------------------------|--------------|
| Input         | AZ91<br>BA91<br>BB91    | Fuel transloading                                  | No           |
| Input         | AZ92<br>BA92<br>BB92    | Fuel rail distance, km                             | 0            |
| Input         | AZ95<br>BA95<br>BB95    | Fuel pipeline distance, km                         | 1,000        |
| Input         | AZ96<br>BA96<br>BB96    | Fuel truck distance, km                            | 0            |
| Input         | AZ98<br>BA98<br>BB98    | Fuel rail fraction                                 | 0            |
| Input         | AZ101<br>BA101<br>BB101 | Fuel pipeline fraction                             | 1            |
| Input         | AZ102<br>BA102<br>BB102 | Fuel truck fraction                                | 0            |
| Input         | CF241                   | RG production data year                            | 2025         |
| Input         | CF243                   | Electricity for RG production, kWh/L <sub>RG</sub> | 0.1          |
| Input         | CF245                   | NG for RG production, MJ/L <sub>RG</sub>           | 0.25         |
| Input         | CF248                   | Canola oil for RG production, kg/L <sub>RG</sub>   | 1.1          |
| Alt Fuel Prod | CO44                    | Hydrogen, kg/L <sub>RG</sub>                       | 0.03         |
| Alt Fuel Prod | CO53                    | NaOH, kg/L <sub>RG</sub>                           | 0.001        |
| Alt Fuel Prod | CO55                    | Nitrogen - liquid, kg/L <sub>RG</sub>              | 0.0002       |
| Alt Fuel Prod | CO62                    | Phosphoric acid, kg/L <sub>RG</sub>                | 0            |
| Alt Fuel Prod | CO89                    | LPG, L/L <sub>RG</sub>                             | 0.2          |
| Coprods       | BE132                   | FCC coke coproduct, kg/L <sub>RG</sub>             | 0.02         |
| Coprods       | BE133                   | HCO coproduct, kg/L <sub>RG</sub>                  | 0.01         |
| Coprods       | BE135                   | LPG coproduct, L/L <sub>RG</sub>                   | 0            |
| Coprods       | BE137                   | RN coproduct, L/L <sub>RG</sub>                    | 0            |
| Coprods       | BE143                   | AJF coproduct, L/L <sub>RG</sub>                   | 0.15         |
| Coprods       | BE144                   | FCC RD coproduct, L/L <sub>RG</sub>                | 0.15         |
| Coprods       | B187                    | FCC coke coproduct allocation method               | Displacement |
| Coprods       | B188                    | HCO coproduct allocation method                    | Displacement |
| Coprods       | B198                    | AJF coproduct allocation method                    | Energy       |
| Coprods       | B199                    | FCC RD coproduct allocation method                 | Energy       |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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To perform the out-of-model energy allocation calculation (see Section 4.5.1.2) the inputs above are run and the fraction of energy coproduct value from cell BE163 of the Coprods sheet is calculated as 0.24.

The coproducts that are allocated by energy are then set to zero (cells BE143 and BE145 on the Coprods sheet) and the results of the Alberta run are found with the energy allocation coproduct credit excluded, which is shown in **Table 9-4**. The results are taken from cells AM14 to AM16 of the BC LCFS sheet for the RG, while the fuel distribution and storage emissions for AJF and FCC RD are taken from cells AL16 and AK16 of the BC LCFS sheet, respectively.

**Table 9-4 Canola oil in FCC: AB Run Results**

| Stage                         | RG                                      | AJF | FCC RD |
|-------------------------------|-----------------------------------------|-----|--------|
|                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |     |        |
| Fuel production               | 23,585                                  |     |        |
| Fuel coproducts production    | -2,434                                  |     |        |
| Fuel distribution and storage | 833                                     | 826 | 807    |

The energy allocation coproduct credit is then calculated by multiplying the fraction of the energy coproduct value (0.24) by the sum of the upstream emissions taken from **Table 9-2** and **Table 9-4** (excluding fuel distribution and storage). The upstream emissions are shown in **Table 9-5**.

**Table 9-5 Canola oil in FCC: Out-of-Model Calculation Upstream Emissions**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 0                                       |
| Feedstock production or cultivation | 4,462                                   |
| Feedstock upgrading                 | 6,523                                   |
| Feedstock transport                 | 1,374                                   |
| Feedstock coproducts production     | -6,663                                  |
| Avoided emissions                   | 0                                       |
| Fuel production                     | 23,585                                  |
| Fuel coproducts production          | -2,434                                  |
| <b>Total</b>                        | <b>26,847</b>                           |

Multiplying the upstream emissions of 26,847 g CO<sub>2</sub>e/GJ and the 0.24 fraction of the energy coproduct value produces a total energy allocation coproduct credit of 6,443 g CO<sub>2</sub>e/GJ which is subtracted from the non-energy allocation fuel coproduct production credit (-2,434 - 6,443 = -8,877) to get the total fuel coproduct production credit.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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The third run will be in the BC region to calculate final distribution of 80km, dispensing, and fuel use emissions. Most of the inputs can be left the same as the other two runs. Required changes for the BC run are outlined in **Table 9-6**.

**Table 9-6 Canola oil in FCC: Model Inputs for BC Run**

| Sheet | Cell                    | Description                | Value        |
|-------|-------------------------|----------------------------|--------------|
| Input | B4                      | Region                     | BC           |
| Input | C3-D5                   | Install Regional Defaults  | Press button |
| Input | AZ91<br>BA91<br>BB91    | Fuel Transloading          | Yes          |
| Input | AZ92<br>BA92<br>BB92    | Fuel rail distance, km     | 0            |
| Input | AZ95<br>BA95<br>BB95    | Fuel pipeline distance, km | 0            |
| Input | AZ96<br>BA96<br>BB96    | Fuel truck distance, km    | 80           |
| Input | AZ98<br>BA98<br>BB98    | Fuel rail fraction         | 0            |
| Input | AZ101<br>BA101<br>BB101 | Fuel pipeline fraction     | 0            |
| Input | AZ102<br>BA102<br>BB102 | Fuel truck fraction        | 1            |

The results for the BC region are in **Table 9-7** for the RG and coproduct fuels, which are taken from columns AM, AL, and AK rows 16-18 of the BC LCFS sheet for the RG, AJF and FCC RD, respectively.

**Table 9-7 Canola oil in FCC: BC Run Results**

| Stage                         | RG                                      | AJF | FCC RD |
|-------------------------------|-----------------------------------------|-----|--------|
|                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |     |        |
| Fuel distribution and storage | 407                                     | 401 | 392    |
| Fuel dispensing               | 85                                      | 84  | 83     |
| Vehicle or Vessel operation   | 2,040                                   | 572 | 1,523  |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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The fuel pathway CIs for the main product RG and coproduct fuels (AJF and FCC RD) are determined by combining the results of the SK, AB and BC model runs as well as the energy allocation credit as shown in **Table 9-8** to **Table 9-10**. The CIs differ due to different fuel properties and combustion emissions for each fuel.

**Table 9-8 Canola oil in FCC RG: Total Results**

| Stage                               | SK                                      | AB            | Energy Allocation Credit | BC           | Total         |
|-------------------------------------|-----------------------------------------|---------------|--------------------------|--------------|---------------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |               |                          |              |               |
| Direct land use change              | 0                                       |               |                          |              | 0             |
| Feedstock production or cultivation | 4,462                                   |               |                          |              | 4,462         |
| Feedstock upgrading                 | 6,523                                   |               |                          |              | 6,523         |
| Feedstock transport                 | 1,374                                   |               |                          |              | 1,374         |
| Feedstock coproducts production     | -6,663                                  |               |                          |              | -6,663        |
| Avoided emissions                   | 0                                       |               |                          |              | 0             |
| Fuel production                     |                                         | 23,585        |                          |              | 23,585        |
| Fuel coproducts production          |                                         | -2,434        | -6,443                   |              | -8,877        |
| Fuel distribution and storage       |                                         | 833           |                          | 407          | 1,240         |
| Fuel dispensing                     |                                         |               |                          | 85           | 85            |
| Vehicle or Vessel operation         |                                         |               |                          | 2,040        | 2,040         |
| <b>Total</b>                        | <b>5,696</b>                            | <b>21,984</b> | <b>-6,443</b>            | <b>2,532</b> | <b>23,769</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  |                                         |               |                          |              | <b>23.77</b>  |

**Table 9-9 Canola oil in FCC AJF: Total Results**

| Stage                               | SK                                      | AB     | Energy Allocation Credit | BC  | Total  |
|-------------------------------------|-----------------------------------------|--------|--------------------------|-----|--------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |        |                          |     |        |
| Direct land use change              | 0                                       |        |                          |     | 0      |
| Feedstock production or cultivation | 4,462                                   |        |                          |     | 4,462  |
| Feedstock upgrading                 | 6,523                                   |        |                          |     | 6,523  |
| Feedstock transport                 | 1,374                                   |        |                          |     | 1,374  |
| Feedstock coproducts production     | -6,663                                  |        |                          |     | -6,663 |
| Avoided emissions                   | 0                                       |        |                          |     | 0      |
| Fuel production                     |                                         | 23,585 |                          |     | 23,585 |
| Fuel coproducts production          |                                         | -2,434 | -6,443                   |     | -8,877 |
| Fuel distribution and storage       |                                         | 826    |                          | 401 | 1,227  |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Stage                              | SK                                      | AB            | Energy Allocation<br>Credit | BC           | Total         |
|------------------------------------|-----------------------------------------|---------------|-----------------------------|--------------|---------------|
|                                    | Emissions, g CO <sub>2</sub> e/GJ (HHV) |               |                             |              |               |
| Fuel dispensing                    |                                         |               |                             | 84           | 84            |
| Vehicle or Vessel operation        |                                         |               |                             | 572          | 572           |
| <b>Total</b>                       | <b>5,696</b>                            | <b>21,977</b> | <b>-6,443</b>               | <b>1,057</b> | <b>22,287</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b> |                                         |               |                             |              | <b>22.29</b>  |

**Table 9-10 Canola oil in FCC RD: Total Results**

| Stage                               | SK                                      | AB            | Energy Allocation<br>Credit | BC           | Total         |
|-------------------------------------|-----------------------------------------|---------------|-----------------------------|--------------|---------------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |               |                             |              |               |
| Direct land use change              | 0                                       |               |                             |              | 0             |
| Feedstock production or cultivation | 4,462                                   |               |                             |              | 4,462         |
| Feedstock upgrading                 | 6,523                                   |               |                             |              | 6,523         |
| Feedstock transport                 | 1,374                                   |               |                             |              | 1,374         |
| Feedstock coproducts production     | -6,663                                  |               |                             |              | -6,663        |
| Avoided emissions                   | 0                                       |               |                             |              | 0             |
| Fuel production                     |                                         | 23,585        |                             |              | 23,585        |
| Fuel coproducts production          |                                         | -2,434        | -6,443                      |              | -8,877        |
| Fuel distribution and storage       |                                         | 807           |                             | 392          | 1,199         |
| Fuel dispensing                     |                                         |               |                             | 83           | 83            |
| Vehicle or Vessel operation         |                                         |               |                             | 1,523        | 1,523         |
| <b>Total</b>                        | <b>5,696</b>                            | <b>21,958</b> | <b>-6,443</b>               | <b>1,998</b> | <b>23,209</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  |                                         |               |                             |              | <b>23.21</b>  |

## 9.1 Canola Oil FCC Material Balance

**Table 9-11** details the material balance inputs for the canola oil RG, AJF and FCC RD pathways. Other material inputs are deemed immaterial as they contribute <1% to the total input mass or they are excluded because they are an energy input.

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 9-11 Canola oil in FCC: Material Balance Inputs**

| Input Stream       | GHGenius Location  | GHGenius Input | Input (g/L)  | Function       | Notes                                                                                  |
|--------------------|--------------------|----------------|--------------|----------------|----------------------------------------------------------------------------------------|
| Canola oil         | Input CF248        | 1.1 kg/L       | 1,100        | Feedstock      |                                                                                        |
| H <sub>2</sub>     | Alt Fuel Prod CO44 | 0.03 kg/L      | 30           | H <sub>2</sub> | Purchased H <sub>2</sub>                                                               |
| LPG                | Alt Fuel Prod CO89 | 0.02 L/L       | 11           | Fuel input     | Density (542 g/L) from cell E122 of Fuel Char sheet                                    |
| Other Inputs       | N/A                | N/A            | N/A          | Other          | NaOH and nitrogen excluded due to immateriality. NG excluded as it is an energy input. |
| <b>Total Input</b> |                    |                | <b>1,141</b> |                |                                                                                        |

The output data for the facility is shown in **Table 9-12**. The coproduct volumes are converted using densities found on the Fuel Char sheet of GHGenius. The mass of waste is calculated as the difference between the total input mass and the total of the other output masses. HCO is excluded as it makes up less than 1% of the total output mass.

**Table 9-12 Canola oil in FCC: Material Balance Outputs**

| Output Stream       | GHGenius Location | GHGenius Input          | Output (g/L) | Function     | Notes                                                 |
|---------------------|-------------------|-------------------------|--------------|--------------|-------------------------------------------------------|
| AJF                 | Coprods BE143     | 0.15 L/L <sub>RG</sub>  | 114          | Coproduct    | Density (760 g/L) from cell E87 of Fuel Char sheet    |
| FCC Coke            | Coprods BE132     | 0.02 kg/L <sub>RG</sub> | 20           | Coproduct    |                                                       |
| FCC RD              | Coprods BE145     | 0.15 L/L <sub>RG</sub>  | 117          | Coproduct    | Density (782 g/L) from cell E89 of Fuel Char sheet    |
| HCO                 | N/A               | 0.01 L/L <sub>RG</sub>  | N/A          | Coproduct    | Less than 1% of total output mass, excluded           |
| RG                  | N/A               | N/A                     | 739          | Main Product | Density (739 g/L) from cell E99 of Fuel Char sheet    |
| Waste               | N/A               | N/A                     | 151          | Waste        | Unmetered streams. Calculated using material balance. |
| <b>Total Output</b> |                   |                         | <b>1,141</b> |              |                                                       |

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## 10 Appendix 4: Tall Oil Co-processed in a DHT

Below is an example of a coprocessing pathway that has the following characteristics:

- The feedstock is tall oil from BC, and the fuel producer does not have any feedstock specific data other than the feedstock transportation distance from the feedstock upgrader to the production facility.
- The tall oil is co-processed in a BC refinery DHT along with crude oil. The main product is HDRD. RN and RP are the fuel coproducts.
- The pathway follows the guidance outlined under [RLCF-019: Co-processing Methodology](#).
- The HDRD and fuel coproducts are distributed locally in BC as the refinery is in BC. Transloading can be omitted.
- An out-of-model energy allocation calculation is not required (see Section 4.5.1.2), as the feedstock and fuel production occurs in the same region.

This example will require one model run as the feedstock production and fuel production, distribution and use all occur in BC. **Table 10-1** details the model inputs.

**Table 10-1 Tall oil in DHT: Model Inputs**

| Sheet | Cell                 | Description                             | Value    |
|-------|----------------------|-----------------------------------------|----------|
| Input | B4                   | Region                                  | BC       |
| Input | B7                   | Year                                    | 2025     |
| Input | B53                  | HDRD feedstock                          | Tall Oil |
| Input | AB80                 | Tall oil truck distance to refinery, km | 200      |
| Input | AB86                 | Tall oil truck fraction to refinery     | 1        |
| Input | AZ91<br>BB91<br>BC91 | Fuel transloading                       | No       |
| Input | AZ92<br>BB92<br>BC92 | Fuel rail distance, km                  | 0        |
| Input | AZ96<br>BB96<br>BC96 | Fuel truck distance, km                 | 80       |
| Input | AZ98                 | Fuel rail fraction                      | 0        |



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| Sheet         | Cell                    | Description                                            | Value  |
|---------------|-------------------------|--------------------------------------------------------|--------|
|               | BB98<br>BC98            |                                                        |        |
| Input         | AZ102<br>BB102<br>BC102 | Fuel truck fraction                                    | 1      |
| Input         | CD241                   | HDRD production data year                              | 2025   |
| Input         | CD243                   | Electricity for HDRD production, kWh/L <sub>HDRD</sub> | 0.08   |
| Input         | CD245                   | NG for RG production, MJ/L <sub>HDRD</sub>             | 0.3    |
| Input         | CD248                   | Tall oil for HDRD production, kg/L <sub>HDRD</sub>     | 0.96   |
| Alt Fuel Prod | CM44                    | Hydrogen, kg/L <sub>HDRD</sub>                         | 0.03   |
| Alt Fuel Prod | CM53                    | NaOH, kg/L <sub>HDRD</sub>                             | 0      |
| Alt Fuel Prod | CM55                    | Nitrogen - liquid, kg/L <sub>HDRD</sub>                | 0      |
| Alt Fuel Prod | CM62                    | Phosphoric acid, kg/L <sub>HDRD</sub>                  | 0      |
| Coprods       | BC135                   | RP (LPG) coproduct, L/L <sub>HDRD</sub>                | 0.02   |
| Coprods       | BC137                   | RN coproduct, L/L <sub>HDRD</sub>                      | 0.03   |
| Coprods       | B190                    | RP (LPG) coproduct allocation method                   | Energy |
| Coprods       | B192                    | RN coproduct allocation method                         | Energy |

The results for the BC run are shown in **Table 10-2**. These values are from the BC LCFS sheet cells AK8-18 for the HDRD, with the fuel distribution, dispensing and vehicle operations for RP and RN coming from column AN16-18 and AM16-18, respectively.

**Table 10-2 Tall oil in DHT: Results**

| Stage                               | HDRD                                    | RP            | RN            |
|-------------------------------------|-----------------------------------------|---------------|---------------|
|                                     | Emissions, g CO <sub>2</sub> e/GJ (HHV) |               |               |
| Direct land use change              | 0                                       |               |               |
| Feedstock production or cultivation | 0                                       |               |               |
| Feedstock upgrading                 | 2,670                                   |               |               |
| Feedstock transport                 | 799                                     |               |               |
| Feedstock coproducts production     | 0                                       |               |               |
| Avoided emissions                   | 0                                       |               |               |
| Fuel production                     | 10,077                                  |               |               |
| Fuel coproducts production          | -532                                    |               |               |
| Fuel distribution and storage       | 208                                     | 249           | 215           |
| Fuel dispensing                     | 83                                      | 88            | 85            |
| Vehicle or Vessel operation         | 1,523                                   | 2,971         | 2,040         |
| <b>Total</b>                        | <b>14,829</b>                           | <b>15,355</b> | <b>16,323</b> |
| <b>Total, g CO<sub>2</sub>e/MJ</b>  | <b>14.83</b>                            | <b>15.36</b>  | <b>16.32</b>  |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 10.1 Tall Oil in DHT Material Balance

**Table 10-3** details the material balance inputs for the tall oil DHT pathway. Other inputs are considered immaterial as they contribute <1% to the total input mass or they are excluded because they are an energy input.

**Table 10-3 Tall oil DHT Pathway: Material Balance Inputs**

| Input Stream       | GHGenius Location  | GHGenius Input            | Input (g/L) | Function       | Notes                                |
|--------------------|--------------------|---------------------------|-------------|----------------|--------------------------------------|
| Hydrogen           | Alt Fuel Prod CM44 | 0.03 kg/L <sub>HDRD</sub> | 30          | H <sub>2</sub> | Purchased H <sub>2</sub>             |
| Tall Oil           | Input CD248        | 0.96 kg/L <sub>HDRD</sub> | 960         | Feedstock      |                                      |
| Other Inputs       | N/A                | N/A                       | N/A         | Other          | NG excluded as it is an energy input |
| <b>Total Input</b> |                    |                           | <b>990</b>  |                |                                      |

The output data for the facility is shown in **Table 10-4**. The coproduct volumes are converted using densities found on the Fuel Char sheet of GHGenius. The mass of waste is calculated as the difference between the total input mass and the total of the other output masses.

**Table 10-4 Tall oil in DHT: Material Balance Outputs**

| Output Stream       | GHGenius Location | GHGenius Input | Output (g/L) | Function     | Notes                                                 |
|---------------------|-------------------|----------------|--------------|--------------|-------------------------------------------------------|
| HDRD                | N/A               | N/A            | 782          | Main Product | Density (782 g/L) from cell E89 of Fuel Char sheet    |
| RN                  | Coprods BC135     | 0.02           | 14           | Coproduct    | Density (678 g/L) from cell E121 of Fuel Char sheet.  |
| RP                  | Coprods BC137     | 0.03           | 15           | Coproduct    | Density (510 g/L) from cell E123 of Fuel Char sheet.  |
| Waste               | N/A               | N/A            | 179          | Waste        | Unmetered streams. Calculated using material balance. |
| <b>Total Output</b> |                   |                | <b>990</b>   |              |                                                       |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 11 Appendix 5: Standing Timber BtLD with Excess Electricity Example

Below is an example of a BtLD pathway that has the following characteristics:

- The feedstock is standing timber sourced from BC logging slash piles.
  - The applicant was able to demonstrate that 100% of the standing timber used is avoiding slash burning and is eligible to claim a slash burning avoided emission credit.
- The standing timber is gasified and then converted through the Fischer-Tropsch process into BtLD at a BC fuel production facility.
- The BtLD plant has the following electricity generation and consumption data:
  - BtLD plant electricity purchased from grid: 2.0 kWh/L<sub>BtLD</sub>
  - Gasifier electricity sold to grid: 3.0 kWh/L<sub>BtLD</sub>
  - Solar generation sold to grid: 0.5 kWh/L<sub>BtLD</sub>
- The BtLD is then trucked 120 km to a BC fuel supplier before being distributed with the standard 80km.
- Transloading is included to account for blending of the fuel at the supplier.

This example will require one model run as the feedstock production and transportation, and fuel production, distribution and use all occur in BC.

The BtLD plant sells more electricity to the grid from the gasifier than it purchases for the plant, so the solar generation is excluded. The electricity consumption is set to 0 kWh/L<sub>BtLD</sub> in cell D243 of the Input sheet, and the electricity coproduct is set to 1.0 kWh/L<sub>BtLD</sub> in cell Y274 of the Input sheet.

**Table 11-1** details the model inputs.

**Table 11-1      Standing Timber BtLD: Model Inputs**

| Sheet | Cell | Description | Value |
|-------|------|-------------|-------|
| Input | B4   | Region      | BC    |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Sheet         | Cell     | Description                                                                    | Value             |
|---------------|----------|--------------------------------------------------------------------------------|-------------------|
| Input         | C3-D5    | Install Regional Defaults                                                      | Press button      |
| Input         | B7       | Year                                                                           | 2025              |
| Input         | E50      | Credit for avoided slash burning                                               | 1.0               |
| Input         | J80      | Wood truck distance to BtL plant, km                                           | 50                |
| Input         | J86      | Wood truck fraction to BtL plant                                               | 1                 |
| Input         | F91      | BtLD transloading                                                              | Yes               |
| Input         | F92      | BtLD rail distance, km                                                         | 0                 |
| Input         | F96      | BtLD truck distance, km                                                        | 200 <sup>11</sup> |
| Input         | F98      | BtLD rail fraction                                                             | 0                 |
| Input         | F102     | BtLD truck fraction                                                            | 1                 |
| Input         | A120-122 | Standing timber selection button                                               | Press button      |
| Input         | D241     | BtLD production data year                                                      | 2025              |
| Input         | D243     | Electricity for BtLD production, kWh/L <sub>BtLD</sub>                         | 0.0               |
| Input         | D244     | Diesel for BtLD production, L/L <sub>BtLD</sub>                                | 0.001             |
| Input         | D245     | NG for BtLD production, MJ/L <sub>BtLD</sub>                                   | 0.5               |
| Input         | D247     | Standing timber for BtLD production, kg <sub>dry mass</sub> /L <sub>BtLD</sub> | 4.0               |
| Input         | B268     | Electricity coproduct allocation method                                        | Energy            |
| Input         | Y274     | Electricity coproduct, kWh/L <sub>BtLD</sub>                                   | 1.0               |
| Alt Fuel Prod | D53      | NaOH, kg/L <sub>BtLD</sub>                                                     | 0                 |
| Alt Fuel Prod | D59      | Oxygen - gaseous, kg/L <sub>BtLD</sub>                                         | 1.3               |
| Alt Fuel Prod | D60      | Petroleum, L/L <sub>BtLD</sub>                                                 | 0                 |
| Fuel Char     | J133     | Wood moisture content, %                                                       | 50%               |

The results for the BC run are shown in **Table 11-2**. These values are from the BC LCFS sheet cells BF8-18 for the BtLD.

**Table 11-2 Standing Timber BtLD: Results**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 0                                       |
| Feedstock production or cultivation | 4,337                                   |
| Feedstock upgrading                 | 0                                       |
| Feedstock transport                 | 2,765                                   |
| Feedstock coproducts production     | 0                                       |
| Avoided emissions                   | -30,204                                 |
| Fuel production                     | 3,972                                   |

<sup>11</sup> BtLD is transported 120 km to a fuel supplier, before being distributed locally using the prescribed 80km

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Stage                              | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|------------------------------------|-----------------------------------------|
| Fuel coproducts production         | 1,717                                   |
| Fuel distribution and storage      | 723                                     |
| Fuel dispensing                    | 84                                      |
| Vehicle or Vessel operation        | 1,523                                   |
| <b>Total</b>                       | <b>-15,084</b>                          |
| <b>Total, g CO<sub>2</sub>e/MJ</b> | <b>-15.08</b>                           |

## 11.1 Standing Timber BtLD Material Balance

**Table 11-3** details the material balance inputs for the wood BtLD pathway. Other material inputs are deemed immaterial as they contribute <1% to the total input mass or they are excluded as they are an energy input.

**Table 11-3 Standing Timber BtLD: Material Balance Inputs**

| Input Stream       | GHGenius Location | GHGenius Input           | Input (g/L)  | Function     | Notes                                               |
|--------------------|-------------------|--------------------------|--------------|--------------|-----------------------------------------------------|
| Oxygen             | Alt Fuel Prod D59 | 1.3 kg/L <sub>BtLD</sub> | 1,300        | Gasification |                                                     |
| Standing timber    | Input D247        | 4.0 kg/L <sub>BtLD</sub> | 4,000        | Feedstock    | Dry mass                                            |
| Other Inputs       | N/A               | N/A                      | N/A          | Other        | NG and diesel excluded as they are an energy source |
| <b>Total Input</b> |                   |                          | <b>5,300</b> |              |                                                     |

The output data for the facility is shown in **Table 11-4**. The mass of waste is calculated as the difference between the total input mass and the total of the other output masses.

**Table 11-4 Standing Timber BtLD: Material Balance Outputs**

| Output Stream       | GHGenius Location | GHGenius Input | Output (g/L) | Function     | Notes                                                 |
|---------------------|-------------------|----------------|--------------|--------------|-------------------------------------------------------|
| BtLD                | N/A               | N/A            | 770          | Main product | Density (770 g/L) from cell E88 of Fuel Char sheet.   |
| Waste               | N/A               | N/A            | 4,530        | Waste        | Unmetered streams. Calculated using material balance. |
| <b>Total Output</b> |                   |                | <b>5,300</b> |              |                                                       |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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## 12 Appendix 6: Wood Residue BtLG with CCS Example

Below is an example of a BtLG pathway that has the following characteristics:

- The facility will be modelled using the 2025 model year as determined in section 2.2.2.
- The feedstock is BC wood residue from a nearby timber mill.
- The wood residue is gasified and then converted through the Fischer-Tropsch process into BtLG at a BC fuel production facility.
  - The BtLG plant produces an LPG coproduct that does not meet the specifications detailed in 4.5.1.1, and is therefore allocated by displacement.
  - The BtLG plant has a CCS system
- The BtLG is then trucked to a BC fuel supplier.
- Transloading can be omitted.

This example will require one model run as the feedstock production and fuel production, distribution and use all occur in BC.

### 12.1 Wood Residue BtLG CCS Input Determination

The CCS system has the characteristics detailed in **Table 12-1**.

**Table 12-1 BtLG CCS Data**

| Description                                                                  | Value |
|------------------------------------------------------------------------------|-------|
| Electricity consumption for CCS, kWh/L <sub>BtLG</sub>                       | 0.1   |
| Natural gas consumption for CCS, MJ/L <sub>BtLG</sub>                        | 3.0   |
| CO <sub>2</sub> captured, g CO <sub>2</sub> / L <sub>BtLD</sub>              | 666   |
| CO <sub>2</sub> injection, fugitives, g CO <sub>2</sub> / L <sub>BtLD</sub>  | 40    |
| CO <sub>2</sub> injection, subsurface, g CO <sub>2</sub> / L <sub>BtLD</sub> | 5     |
| CO <sub>2</sub> injection, venting, g CO <sub>2</sub> / L <sub>BtLD</sub>    | 15    |

Section 4.6.1 details the following steps for modelling the CCS system that are required to model the CCS system:

1. Cell B69 of the Input sheet is set to 1 to turn on sequestration

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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2. Cell CB11 of the Upstream Results HHV sheet is set to:

=(('Alt Fuel Prod'!I10-SUMPRODUCT('Alt Fuel Prod'!I29:I81,'Alt Fuel Prod'!C105:C157))\*'Fuel Char'!\$Q\$127/'Alt Fuel Prod'!I26\*'Elec Emissions'!B55+'Energy Use'!J115\*'Equip Emis Factors'!H27+'Energy Use'!J116\*'Equip Emis Factors'!X27 + 'Energy Use'!J118\*'Equip Emis Factors'!S27)\*('Energy Use'!BX10-'Alt Fuel Prod'!I94\*'Energy Use'!\$C\$61+1)+('Alt Fuel Prod'!I82+SUMPRODUCT('Alt Fuel Prod'!I29:I81,'Alt Fuel Prod'!H105:H157)/'Fuel Char'!\$B100\*1000)\*'Energy Use'!\$C\$61+'Alt Fuel Prod'!I95\*'Energy Use'!\$C\$61-'Sequestration'!H30

3. Cell H19 of the Sequestration sheet is set to 0

4. Energy consumption associated with sequestration is entered in the following cells of the Sequestration sheet:

- H22: 0.1 kWh<sub>electricity</sub>/L<sub>BtLG</sub>
- H24: 3.0 MJ<sub>natural gas</sub>/L<sub>BtLG</sub>

5. The CCS<sub>rate, L</sub> is 606 g CO<sub>2</sub>/L<sub>BtLG</sub> which was determined using the following formula:

$$CCS_{rate,L} = CO_{2\text{ captured}} - CO_{2\text{ injection, fugitives}} - CO_{2\text{ injection, subsurface}} - CO_{2\text{ injection, venting}}$$

$$606 \text{ g } \frac{CO_2}{L_{BtLG}} = (666 - 40 - 5 - 15) \text{ g } \frac{CO_2}{L_{BtLG}}$$

6. The CCS<sub>rate, GJ</sub> is 17,469 g CO<sub>2</sub>/GJ<sub>BtLG</sub> which is calculated by dividing CCS<sub>rate, L</sub> (606 g CO<sub>2</sub>/L<sub>BtLG</sub>) by the HHV of BtLG<sup>12</sup> which is 0.03469 GJ/ L<sub>BtLG</sub>

7. The CCS<sub>rate, GJ</sub> is entered in cell H30 of the Sequestration sheet (17,469 g CO<sub>2</sub>/GJ<sub>BtLG</sub>)

## 12.2 Wood Residue BtLG Modelling

Following the determination of the sequestration inputs, the rest of the pathway can be modelled. **Table 12-2** details the model inputs.

<sup>12</sup> Taken from cell B99 of Fuel Char sheet divided by 1000 MJ/GJ

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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**Table 12-2 Wood Residue BtLG: Model Inputs**

| Sheet         | Cell     | Description                                                        | Value        |
|---------------|----------|--------------------------------------------------------------------|--------------|
| Input         | B4       | Region                                                             | BC           |
| Input         | C3-D5    | Install Regional Defaults                                          | Press button |
| Input         | B7       | Year                                                               | 2025         |
| Input         | B69      | Carbon sequestration for fuel production toggle                    | 1            |
| Input         | J80      | Wood truck distance to BtLG plant, km                              | 5            |
| Input         | J86      | Wood truck fraction to BtLG plant                                  | 1            |
| Input         | J91      | BtLG transloading                                                  | No           |
| Input         | J92      | BtLG rail distance, km                                             | 0            |
| Input         | J96      | BtLG truck distance, km                                            | 80           |
| Input         | J98      | BtLG rail fraction                                                 | 0            |
| Input         | J102     | BtLG truck fraction                                                | 1            |
| Input         | A117-119 | Wood residue selection button                                      | Press button |
| Input         | I241     | BtLG production data year                                          | 2025         |
| Input         | I243     | Electricity for BtLG production, kWh/L <sub>BtLG</sub>             | 1.0          |
| Input         | I244     | Diesel for BtLG production, L/L <sub>BtLG</sub>                    | 0.01         |
| Input         | I245     | NG for BtLG production, MJ/L <sub>BtLG</sub>                       | 0.1          |
| Input         | I247     | Wood residue for BtLG production, kg/L <sub>BtLG</sub>             | 4.5          |
| Input         | B268     | Electricity coproduct allocation method                            | Energy       |
| Input         | AC274    | Electricity coproduct, kWh/L <sub>BtLG</sub>                       | 0.0          |
| Fuel Char     | J133     | Wood moisture fraction                                             | 0.5          |
| Alt Fuel Prod | I59      | Oxygen - gaseous, kg/L <sub>BtLG</sub>                             | 1.5          |
| Coproducts    | AQ135    | LPG coproduct, L/L <sub>BtLG</sub>                                 | 0.15         |
| Coproducts    | B190     | LPG coproduct allocation method                                    | Displacement |
| Sequestration | H19      | Fraction emissions sequestered                                     | 0            |
| Sequestration | H22      | Electricity for sequestration, kWh/L <sub>BtLG</sub>               | 0.1          |
| Sequestration | H24      | NG for sequestration, MJ/L <sub>BtLG</sub>                         | 3.0          |
| Sequestration | H30      | CO <sub>2</sub> sequestered, g CO <sub>2</sub> /GJ <sub>BtLG</sub> | 17,469       |

The results for the BC run are shown in **Table 12-3** These values are from the BC LCFS sheet cells BK8-18.

**Table 12-3 Wood Residue BtLG: Results**

| Stage                               | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|-------------------------------------|-----------------------------------------|
| Direct land use change              | 85                                      |
| Feedstock production or cultivation | 261                                     |
| Feedstock upgrading                 | -8,423                                  |
| Feedstock transport                 | 164                                     |
| Feedstock coproducts production     | 0                                       |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Stage                              | Emissions, g CO <sub>2</sub> e/GJ (HHV) |
|------------------------------------|-----------------------------------------|
| Avoided emissions                  | 0                                       |
| Fuel production                    | 0                                       |
| Fuel coproducts production         | 0                                       |
| Fuel distribution and storage      | 0                                       |
| Fuel dispensing                    | 0                                       |
| Vehicle or Vessel operation        | 0                                       |
| <b>Total</b>                       | <b>-7,574</b>                           |
| <b>Total, g CO<sub>2</sub>e/MJ</b> | <b>-15,487</b>                          |

### 12.3 Wood Residue BtLG Material Balance

**Table 12-4** details the material balance inputs for the wood residue BtLG pathway. Other material inputs are deemed immaterial as they contribute <1% to the total input mass or they are excluded as they are an energy input.

**Table 12-4 Wood Residue BtLG: Material Balance Inputs**

| Input Stream       | GHGenius Location | GHGenius Input                                | Input (g/L)   | Function     | Notes                                               |
|--------------------|-------------------|-----------------------------------------------|---------------|--------------|-----------------------------------------------------|
| Oxygen             | Alt Fuel Prod I59 | 1.5 kg/L <sub>BtLD</sub>                      | 1,500         | Gasification |                                                     |
| Wood residue       | Input I247        | 4.5 kg <sub>dry mass</sub> /L <sub>BtLD</sub> | 9,000         | Feedstock    | 50% moisture content                                |
| Other Inputs       | N/A               | N/A                                           | N/A           | Other        | NG and diesel excluded as they are an energy source |
| <b>Total Input</b> |                   |                                               | <b>10,500</b> |              |                                                     |

The output data for the facility is shown in **Table 12-5**. The coproduct volumes are converted using densities found on the Fuel Char sheet of GHGenius. The mass of waste is calculated as the difference between the total input mass and the total of the other output masses.

**Table 12-5 Wood Residue BtLG: Material Balance Outputs**

| Output Stream | GHGenius Location | GHGenius Input | Output (g/L) | Function     | Notes                                                          |
|---------------|-------------------|----------------|--------------|--------------|----------------------------------------------------------------|
| BtLG          | N/A               | N/A            | 739.2        | Main product | Gasoline density (739.2 g/L) from cell E99 of Fuel Char sheet. |

|                                                                                   |                                                                                                |                                                                                                                                                                                         |
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| Output Stream               | GHGenius Location | GHGenius Input                                 | Output (g/L)  | Function      | Notes                                                                               |
|-----------------------------|-------------------|------------------------------------------------|---------------|---------------|-------------------------------------------------------------------------------------|
| LPG                         | Coproducts AQ135  | 0.15 L/L <sub>BtLG</sub>                       | 76.4          | Coproduct     | Density (509.6 g/L) from cell E123 of Fuel Char sheet                               |
| Sequestered CO <sub>2</sub> | Sequestration H30 | 17,459.1 g CO <sub>2</sub> /GJ <sub>BtLG</sub> | 605.7         | Sequestration | Cell H30 of Sequestration sheet multiplied by BtLG's HHV <sup>13</sup> 0.03469 GJ/L |
| Waste                       | N/A               | N/A                                            | 9,078.7       | Waste         | Unmetered streams. Calculated using material balance.                               |
| <b>Total Output</b>         |                   |                                                | <b>10,500</b> |               |                                                                                     |

### Need more information?

Please see the [Renewable and Low Carbon Fuel website](#) or email us at [lcfs@gov.bc.ca](mailto:lcfs@gov.bc.ca)

This information is for your convenience and guidance only and does not replace or constitute a legal interpretation of the legislation. It is recommended that parties who may be a Fuel Supplier review the Low Carbon Fuels Act (Act), the Low Carbon Fuels (General) Regulation and the Low Carbon Fuels (Technical) Regulation, and seek independent legal advice to confirm their status, legal obligations, and opportunities. The Act and regulations can be found at [BC Laws](#).

<sup>13</sup> Taken from cell B99 of Fuel Char sheet divided by 1000 MJ/GJ