Introduction

Co-processing refers to the simultaneous treatment of biogenic feedstocks and petroleum feedstocks in refinery process units to produce blended fossil and renewable fuel products. The renewable feedstocks are typically inserted into an existing petroleum refinery at the Hydrotreater, Hydrocracker or Fluid Catalytic Cracker.

Quantifying the volume of renewable fuel produced through co-processing is challenging. Traditional methods cannot directly measure the renewable fuel volume, which is completely integrated in and indistinguishable from the fossil fuel volume. This is important as only the renewable portion of the fuel is eligible for positive compliance units under the BC Low Carbon Fuel Standard (LCFS). The LCFS considers the fossil portion a base fuel, which does not generate positive compliance units. Determining the carbon intensity (CI) of the renewable portion is also challenging because the energy and chemical inputs attributed to the production of the renewable fuel portion cannot be directly measured, with hydrogen consumption being the most important input.

This document provides guidance on how to quantify the inputs and co-products attributable to the renewable fraction of co-processed fuels, which is critical for submitting a carbon intensity (CI) application under the BC Low Carbon Fuel Standard (BC-LCFS). It also distinguishes between the requirements for 1-year and 3-year fuel codes

Additionally, this document provides guidance on how to quantify the volume of renewable fuel produced. Fuel volume is needed for compliance reporting, as well as for some calculations in the CI Application.

While this document focuses specifically on special considerations for co-processed fuels, general guidance for completing CI Applications is available in RLCF-008: Carbon Intensity Applications.

Applicability

This Methodology applies to renewable or alternative fuels produced through co-processing renewable and petroleum feedstocks in a refinery. While other types of co-processing methods exist, they are not covered by this methodology. Please contact the Low Carbon Fuels Branch (LCFB) at lcfs@gov.bc.ca for more information.

Glossary

Table 1 provides definitions for this Methodology.

Table 1: Glossary

Baseline	Operating data that describes the operations of the refinery prior to feeding a renewable feedstock.
Co-products	A secondary product that is produced alongside the primary product during the refining process. Examples: sponge gas, LPG, etc.
Incremental Allocation	An estimation method where energy and chemical inputs (hydrogen, electricity, etc.) are allocated to the renewable portion of the co-processed fuel by measuring the incremental change of the input used when co-processing compared to Baseline (petroleum-only) production, while assuming a constant petroleum feedstock rate. If the petroleum feedstock rate varies, the input rate is normalized to ensure equal comparison. In Incremental Allocation, Baseline consumption is determined over an extended period (minimum 3 consecutive months). For accurate results, Incremental Allocation requires refinery operating conditions to be steady. Steady state operation is unlikely as operating conditions change to accommodate variations in composition of the crude oil, catalyst age, and finished fuel specifications, among other factors. It is unlikely that co-processing will occur at the established Baseline conditions, which can lead to an underestimation of inputs required for the renewable portion of the co-processed fuel and an under estimation of the fuel's CI. For this reason, the use of Incremental Allocation is limited to certain scenarios.
Intermediates	Partially refined products produced at the refinery which are not finished products and are intended to be further refined.
Method B	Carbon-14 testing via accelerator mass spectrometry (ASTM D6866 - Method B). This method is more accurate than Method C.
Method C	Carbon-14 testing via liquid scintillating counting (ASTM D6866 - Method C).

Significant Impact	Any input or output that impacts the co-processed fuel's CI calculation by more than the greater of: • 1% of fuel's CI, or • 0.05 gCO2e/MJ
Statistical Regression	A method used to estimate the hydrogen consumption needed to produce the renewable portion of the co-processed fuel based on a multi-variable regression. This statistical method evaluates the effects of various operating parameters on hydrogen consumption to isolate the impact of the renewable feedstock on hydrogen consumption. Once developed, Statistical Regression is simple to use, as the hydrogen consumption can be estimated by a simple formula according to the operating conditions present at the refinery. However, it is important that the developed model is accurate and that the variables included are the most significant contributors to hydrogen consumption. Various statistical methods exist for evaluating the efficacy of regression models, but they cannot ensure accuracy. This approach is suitable when the Step Test, Stoichiometric Allocation, or Incremental Allocation are not viable. Any proposed Statistical Regression model would need to be reviewed by the LCFB for accuracy and conservativeness before acceptance.
Step Test	An allocation method for energy and chemical inputs similar to Incremental Allocation, but which uses a Baseline of a few days instead of several month. Applicants must justify the baseline period by providing evidences for the stability of the feedstock properties and steady process conditions (e.g., temperature, pressure, flow rate). Inputs are allocated to the renewable portion of the co-processed fuel according to the incremental change of input used when co-processing compared to the Baseline, while assuming a constant petroleum feedstock rate. Evidence of each step of incremental change in renewable content and the impact on parameters of interest (e.g., Hydrogen, energy, etc) must be provided.

	This approach is more accurate than Incremental Allocation for refineries with large tank storage where consistency of the petroleum feedstock is ensured for the duration of the Step Test. Refineries that directly process petroleum feedstock arriving by pipeline should not use this approach unless they can provide evidence that the petroleum feedstock properties are consistent.
Stoichiometric Allocation	An allocation method used to determine the fraction of hydrogen used to produce the renewable portion of the co-processed fuel. Hydrogen use is estimated as the stoichiometric amount required to hydrogenate the triglyceride and remove oxygen. A triglyceride can be converted into a renewable product via two pathways: hydro-deoxygenation, which involves the removal of oxygen in the presence of hydrogen, and decarboxylation, which involves the elimination of a carboxyl group and the release of carbon dioxide. The hydro-deoxygenation of a single triglyceride requires 12 molecules of hydrogen, whereas the decarboxylation process consumes 6 molecules of hydrogen. Both reactions occur simultaneously and the ratio between them is influenced by hydrotreatment conditions. This ratio can be estimated by measuring the amounts of carbon monoxide and carbon dioxide produced, as these gases are exclusively generated from the decarboxylation reaction. In the absence of specific data for the quantities of carbon monoxide and carbon dioxide produced, a conservative estimate is made by assuming all triglycerides are converted via hydro-deoxygenation and all olefins within the triglycerides were saturated with hydrogen. Applicants may use this conservative estimate provided they measure the fatty acid composition of the feedstock. This method is acceptable for refineries where the properties of petroleum feedstock cannot be consistently maintained for a Step Test and co-processing occurs in a hydrotreater. Refineries co-processing in a Fluid Catalytic Cracking (FCC) unit cannot use this method as the de-oxygenation of lipids occurs through alternative mechanisms.

Turnaround	A scheduled major shutdown event for maintenance at a refinery. Frequency is dependent on the refinery; approximately every 4 years.

Carbon 14 Testing Requirements

Carbon-14 (C14) testing is used to determine the amount of renewable carbon present in a fuel or co-product. Under the BC-LCFS, C14 testing is required to determine the fraction of renewable fuel in co-processed fuels as well as the fraction of co-products and intermediates attributable to the renewable fuel volume. This data is required for compliance reports and CI calculation.

For co-products and intermediates possessing renewable content, C-14 testing is required only when the co-product or intermediate has a Significant Impact (as defined in Table 1) on the CI of the fuel.

In situations where C14 testing of co-products and/or intermediates is not feasible, Incremental Allocation or Step Test methods may be used to estimate the renewable content. Justification for the use of these alternative methods must be provided, along with evidence supporting the accuracy and conservativeness of the results.

Table 2 outlines eligible methods for measuring the renewable content of co-products and intermediates. Table 3 outlines eligible methods for measuring renewable fuel volume. Table 4 details the C14 sampling locations required under the LCFS.

Table 2: Carbon 14 testing requirements for co-products and intermediates

1-year fuel code application	3-year fuel code application
1. One representative Method B sample, 2. Design data, with 1 representative Method B sample submitted following one month of representative co-processing, or 3. Incremental Allocation or Step Test with supporting evidence of the method's accuracy and conservativeness.	1. Quarterly representative Method B samples, 2. Annual representative Method B samples, and monthly Method C samples, or 3. Incremental Allocation or Step Test with supporting evidence of the method's accuracy and conservativeness.

Table 3: Carbon 14 testing requirements for co-processed fuels

1-year fuel code application	3-year fuel code application	Compliance reporting
1. One representative Method B sample, or 2. Design data, with 1 representative Method B sample submitted following one month of representative co-processing.	1. Monthly representative Method B samples, or 2. Weekly representative Method C samples, and quarterly representative Method B samples.	1. Monthly representative Method B samples, or 2. Weekly representative Method C samples, and quarterly representative Method B samples.

Table 4: Carbon 14 sampling locations

Flow	Sampling Location
Co-products & Intermediates	Directly after the co-processing unit
Co-processed Fuels	1. From the final holding tank, or 2. Directly after the co-processing unit

Hydrogen Consumption Estimation Requirements

Hydrogen is a major contributor to the CI of co-processed fuels. Accurate quantification of the hydrogen used to produce the renewable portion of the co-processed fuel is required when determining a fuel's CI. The following hydrogen consumption estimation methods are eligible within this Methodology:

1. Step Test
2. Stoichiometric Allocation,
3. Incremental Allocation, or
4. Statistical Regression

The applicant must apply the most accurate estimation method for calculating hydrogen consumption. Figure 1 outlines how to select the appropriate hydrogen estimation method. Where sulphur content (wt%) is required, the applicant must submit 3 months of data based on weekly samples.

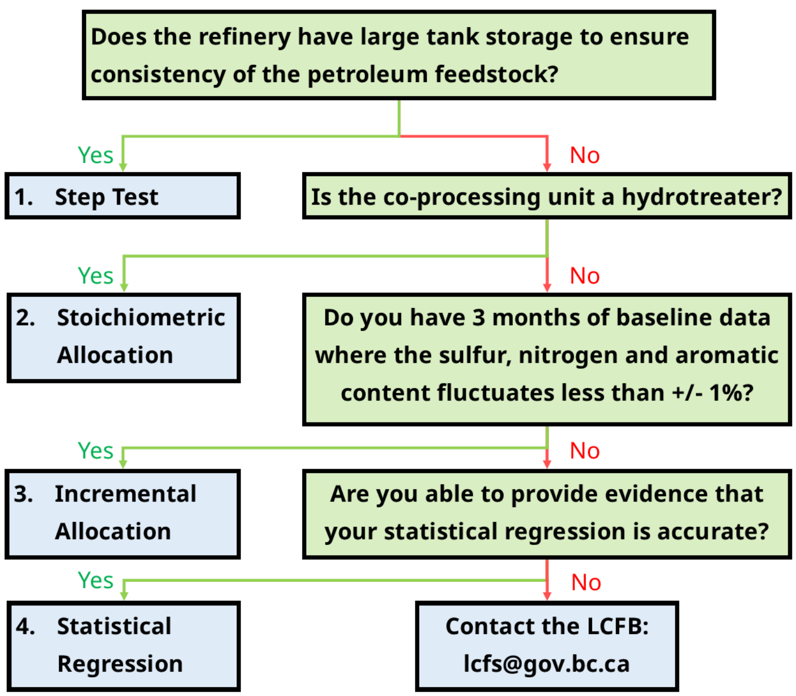

Figure 1: Hydrogen estimation methodology decision tree

If the applicant is prescribed the Stoichiometric Allocation method by Figure 1, the following requirements must be met:

- The ratio of hydro-deoxygenation and decarboxylation reactions must be determined by measuring of the amount of carbon monoxide and carbon dioxide produced, or
- The conservative assumption that all triglycerides are converted via hydro-deoxygenation and that all the olefins within the triglycerides are saturated with hydrogen must be applied. Fatty acid profile testing of the feedstock is required to apply this assumption.

Hydrogen consumption must be calculated using data with the following frequencies:

1. Daily average data, or
2. Alternative data frequency supported by evidence of accuracy and conservativeness and approved by the LCFB.

To obtain a 3-year fuel code, applicants must use 12+ consecutive months of recent (within the last 3 years) operational data to determine the renewable fuel's CI. A 1-year fuel code will be issued for applications based on design data, a trial run, or less than 1 year of representative operational data.

Energy and Chemical Consumption Estimation Requirements

Energy and chemical inputs attributable to the renewable portion of the co-processed fuel must be determined to calculate the renewable fuel's CI. For all energy and chemical inputs (excluding hydrogen) with a Significant Impact on the CI of the renewable fuel portion, the most accurate allocation method of the following must be used. Applicants must provide justification supporting the accuracy and conservativeness of the chosen allocation method.

1. Incremental Allocation, or
2. Step Test, or
3. Another method, if the applicant can justify that it would be more accurate and conservative than Incremental Allocation or the Step Test.

Energy and chemical consumption rates must be calculated using data with the following frequencies:

1. Daily average data, or
2. Alternative data frequency supported by evidence of accuracy and conservativeness and approved by the LCFB.

To obtain a 3-year fuel code, applicants must use 12+ consecutive months of recent (within the last 3 years) operational data to determine the renewable fuels CI. A 1-year fuel code will be issued for applications based on design data, a trial run, or less than 1 year of representative operational data.

Flowmeter Requirements

The fuel manufacturer must meet the flowmeter requirements detailed in Table 5.

Table 5: Flowmeter requirements

Metered Flows	Options
Co-products & Intermediates	1. Flowmeter with +/-5% accuracy (e.g., orifice meters), or 2. Submission of a plan outlining the installation timeline for a flowmeter with +/-5% accuracy by the next turnaround cycle. Applicants must specify the current metering system, including its location, accuracy level, and relevant standards met.
Co-processed Fuel	1. Custody transfer grade flowmeter (e.g., Coriolis meter), or 2. Submission of a plan outlining the installation timeline for a custody transfer grade flowmeter by the next turnaround cycle. Applicants must specify the current metering system, including its location, accuracy level, and relevant standards met.

Co-processing Methodology Checklist

Table 6 provides a checklist for applicants to ensure they are meeting the requirements of this Methodology. The applicant must meet all 3-year fuel code requirements to receive a 3-year fuel code. Refer to the glossary in Table 1 for definitions, and to RLCF-008: Carbon Intensity Applications for additional guidance on completing CI Applications.

Table 6: Co-processing methodology checklist

<table>
<tr><th colspan="2">Category</th><th>Requirements</th></tr>
<tr><td colspan="2" rowspan="2">Data collection period</td><td>1-year fuel code:
1. Trial run data,
2. Design Data
3. Less than 12 months of operational data</td></tr>
<tr><td>3-year fuel code:
12+ consecutive months of operational data collected within the last 3 years</td></tr>
<tr><td rowspan="3">Renewable content testing requirements</td><td rowspan="2">Co-products & intermediates</td><td>1-year fuel code:
1. One representative Method B sample,
2. Design data, with 1 representative Method B sample submitted following one month of representative co-processing, or
3. Incremental Allocation or Step Test with supporting evidence of the method's accuracy and conservativeness.</td></tr>
<tr><td>3-year fuel code:
1. Quarterly representative Method B samples,
2. Annual representative Method B, and monthly Method C samples, or
3. Incremental Allocation or Step Test with supporting evidence of the method's accuracy and conservativeness.</td></tr>
<tr><td>Co-processed fuels</td><td>1-year fuel code:
1. 1 representative Method B sample, or
2. Design data, with 1 representative Method B sample submitted following one month of representative co-processing.</td></tr>
</table>

		3-year fuel code: 1. Monthly representative Method B samples, or 2. Weekly representative Method C samples, and quarterly representative Method B samples.
		Compliance reporting: 1. Monthly representative Method B samples, or 2. Weekly representative Method C samples, and quarterly representative Method B samples.
Renewable content sampling location	Co-products & intermediates:	Directly after the co-processing unit.
	Co-processed fuels:	1. The final holding tank, or 2. Directly after the co-processing unit
Energy and chemical input estimation methodologies	Hydrogen consumption	1. Step Test 2. Stoichiometric Allocation, 3. Incremental Allocation, or 4. Statistical Regression. *Selected according to Figure 1*
	Other energy & chemical inputs consumption	1. Incremental Allocation, 2. Step Test, or 3. Another method, if shown to be more accurate than Incremental Allocation or the Step Test. *With justification for choice of method*
Petroleum feed sulphur content testing		Co-processing units that do not consume hydrogen: • No sulphur testing requirement Applications that use the Step Test or Stoichiometric Allocation: • No sulphur testing requirement All other applications: • Provide 3 months of sulphur content (%wt) data based on weekly samples

Stoichiometric Allocation estimation requirements		1. Determine hydro-deoxygenation and decarboxylation reaction ratios by measuring the CO and CO_2 produced, or 2. Provide fatty acid profile testing data of the feedstock and use the conservative assumption that all triglycerides are converted via hydro-deoxygenation and that all the olefins within the triglycerides are saturated with hydrogen.
Hydrogen, energy and chemical input data frequency		1. Daily average data, or 2. Alternative data frequency supported by evidence of accuracy and conservativeness and approved by the LCFB.
Meter accuracy requirements	Co-products & intermediates	1. Flowmeter with +/-5% accuracy (e.g., orifice meters), or 2. Submit a plan for installing a flowmeter with +/-5% accuracy by the next turnaround cycle, and detail the current metering system including its: • Location(s), • Accuracy level, and • Relevant standards met.
	Co-processed fuel	1. Custody transfer grade flowmeter (e.g., Coriolis meter), or 2. Submit a plan outlining the installation timeline for a custody transfer grade flowmeter by the next turnaround cycle, and detail the current metering system, including its: • Location(s), • Accuracy level, and • Relevant standards met.

Need more information?

Please visit the Renewable & Low Carbon Fuel website or email the Low Carbon Fuels Branch at lcfs@gov.bc.ca.

This information is provided solely for your convenience and guidance and does not represent a legal interpretation of the legislation. The Low Carbon Fuels Act, Low Carbon Fuels (General) Regulation and Low Carbon Fuels (Technical) Regulation are accessible at: http://www.bclaws.ca.