ISCC
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& Carbon Certification

ISCC 203-01
GUIDANCE FOR THE CERTIFICATION OF CO-PROCESSING

Version 2.0

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Content

1 Introduction

Co-processing is a term used to describe an industrial process that treats different types of inputs together within one production unit at the same time. For the purposes of this guidance document, co-processing refers to a method of producing liquid or gaseous fuels wherein bio-derived and fossil-derived materials are physically mixed and processed simultaneously in a same production unit.

Simultaneous processing of fossil and biomass feedstock

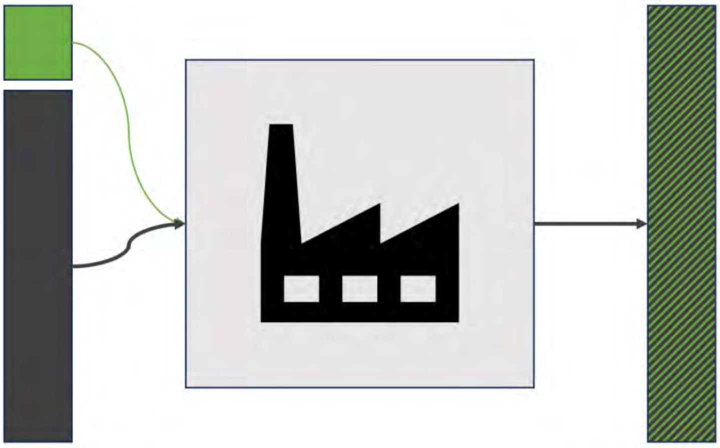

Figure 1 Depiction of a simple co-processing unit treating two inputs to give a single homogenous output.

Co-processing is an attractive route for the production of biofuels because it uses refinery infrastructure, transport and storage facilities that already exist. Further, in many cases, co-processed fuels are "drop-in" fuels that are not subject to biofuel blend limits because they are chemically equivalent to fuels produced from purely fossil feedstocks. The Renewable Energy Directive[1] establishes the overall framework for regulation of the production of energy from renewable sources, including in the transport sector. The revised REDII specifies that biofuels and biogases produced from the co-processing of biomass and fossil feedstocks can contribute to the overall target of at least 29% for the share of renewable energy in the final consumption of energy in transport sector (or to the greenhouse gas intensity reduction of at least 14,5%).

The co-processing of a biomass input (such as vegetable and animal oils, crude tall oil or pyrolysis oil) and fossil inputs results in products with similar chemical properties as products derived solely from fossil inputs. For many co-processed outputs, the chemical composition is not measurably different, using standard or established analytical approaches, from the output of an identical process with only fossil-based inputs. Additionally, the proportions of bio verses fossil content in each output may not reflect the input ratios and

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[1] *Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (recast), hereafter referred to as RED II. Directive (EU) 2023/2413 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards to the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 (hereafter referred to as "revised RED II". The revised RED II is also known as RED III).)*

may be different for each output. As such, specific methods are required to determine the share of biomass-derived liquids and gases in some co-processed outputs.

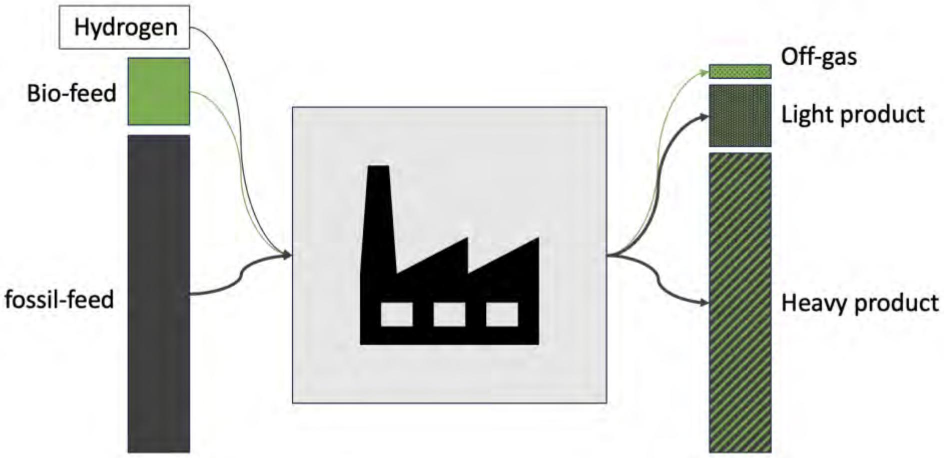

Figure 2 Simplified depiction of a refinery hydrotreater unit co-processing biomass and fossil feedstocks. The height of the bars either side of the factory icon represents relative quantities of flows. The shading of the outputs represents the relative bio/fossil content, with a greener bar representing a higher proportion of bio-content. Illustrative only – not based on actual data.

2 Scope and normative references

This document describes requirements that must be fulfilled for the co-processing of biomass and fossil feedstocks to comply with the International Sustainability and Carbon Certification (ISCC) EU scheme. It is valid in addition to the other ISCC EU system documents. Application of this guideline is voluntary under ISCC PLUS.

Article 28 (5) of RED II states that the EU Commission is responsible for specifying the methodology for determining the share of biofuel and biogas resulting from the common processing of biomass with fossil fuels. The delegated regulation of the EU COM on the methodology to determine the share of biofuel and biogas for transport, produced from biomass being processed with fossil fuels in a common process[2] (hereafter DR) was published to fulfil this requirement and describes several different methods for determining the bio-content of co-processed fuels.

Bio-content is defined as the percentage by mass of biomaterial in a material that is derived from both biomass and fossil feedstocks. Additionally, and for the purposes of this guidance document, the bio-content of a material is defined as being proportional to the ^{14}C content of a material. This is due to the requirements set out in the DR to use ^{14}C analytical methods, or methods calibrated using ^{14}C analysis, to determine the bio-content of co-processed

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[2] Delegated Regulation (EU) 2023/1640 on the methodology to determine the share of biofuel and biogas for transport, produced from biomass being processed with fossil fuels in a common process *(in the following referred to as delegated act on co-processing)*

fuels. Guidance on inclusion of bio-content derived from hydrogen gas produced from biomass is given in section 3.7

The legislation on co-processing sets forth a scope, and some important definitions within that scope, regarding co-processed fuels. Co-processing most commonly refers to an oil refinery unit that processes biomass feedstock alongside fossil feedstocks to transform them into final fuels. Additionally, the methodology laid forth in the DR for co-processed fuels can also be applied to other installations that treat biomass alongside fossil oil or installations that co-process a waste that contains both biological- and non-biological material.

There are some important scenarios that are excluded from the scope of co-processing as regulated by the DR:

(1) The case of a production unit using methane withdrawn from the interconnected infrastructure as biomethane, a feedstock that is certified and traced through mass balance accounting.

(2) The addition of denaturants or other auxiliaries that do not end up in the final molecular structure of the resulting fuel outputs.

(3) Using biological hydrogen in a process to remove impurities where it is not incorporated into the final fuel is excluded from the scope of co-processing.

(4) Blending of bio and fossil derived fuels in not considered co-processing.

Additionally, co-processed outputs must contain a bio-content that is measurable using ^{14}C radiocarbon analysis.

System boundaries for co-processing

In the scope of the DR, economic operators shall consider the system boundaries as the unit, units, or plants within a facility where co-processing is taking place including, but not limited to, the point in the facility at which a ^{14}C measurement is conducted. This could be e.g. a whole refinery, or only the relevant coprocessing units of a larger refinery facility. Blending of co-processed fuels with other fuels shall be considered as being outside the system boundaries of co-processing.

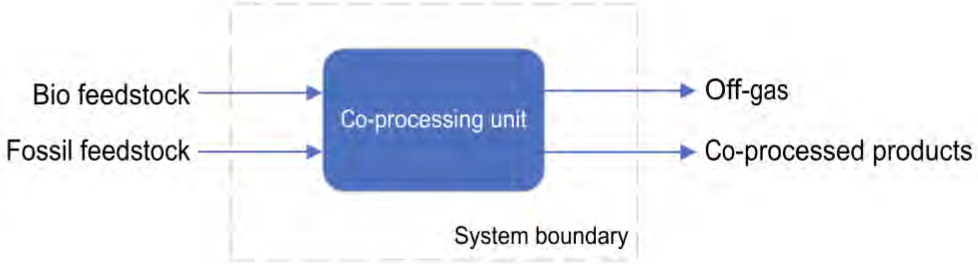

Figure 3 Simplified system boundary for co-processing

The system user is required to calculate the bio-content of the fuels produced through co-processing, using one of the methods described in section 3.2, at a point within the system boundary prior to any blending with fossil fuels or biofuels.

Definition of a batch/ consignment

The ISCC EU Document 203 “Traceability and Chain of Custody” defines a batch or consignment as a specific amount of material with the same sustainability characteristics and GHG emissions savings. For the purposes of this guidance document, it is clarified that, along with the criteria already given, a batch refers to a given quantity of output with a bio-content as determined using one of the methods described in this document.

3 Requirements for the certification of co-processed fuels under ISCC EU

Applicability

The ISCC EU system documents lay down the general rules regarding the audit and certification processes, risk management procedures as well as requirements for traceability and chain of custody and greenhouse gas emissions (GHG) calculation and verification under the ISCC EU system. Under ISCC, as a basic principle, all economic operators that handle sustainable material (e.g. produce or generate, collect, process, store or trade) must be covered by an ISCC certificate. The economic operator supplying the biomass feedstocks, the co-processing facility and all subsequent elements in the downstream supply chain therefore must be certified individually.

The requirements of this document are applicable for all processes that simultaneously process biomass inputs and fossil inputs to produce outputs with a bio-content, that is measurable using radiocarbon ^{14}C testing, to be sold as fuels for the EU market. They apply to any processing steps, where biomass-based inputs (e.g. vegetable oil, used cooking oil, animal fat) are co-processed with fossil feedstocks to produce diesel, gasoline, kerosene, naphtha, LPG, fuel gas or any other product.

3.1 Record keeping and overall mass balance

To facilitate audit verification of the accuracy of claims, system users must maintain an overall mass balance accounting system. This system must describe all quantities and characteristics of biomass inputs entering the co-processing system boundary, the process conditions under which they were processed, as well as all the quantities and characteristics of bio-outputs leaving the co-processing system boundary. The mass balance account should also include the quantities and identities of the fossil feedstocks co-processed with biomass. Appropriate supporting evidence must be provided in order that the presented mass balance can be verified.

In some cases it may be required to conduct radiocarbon ^{14}C testing of inputs, for example where co-processing a waste of mixed bio- and non-bio-origin, such as municipal solid waste. Another example would be when feeding a process unit from a tank where the exact proportions of bio and fossil material in the tank are not known or straightforward to measure.

The amount of bio-content in the co-processed output is related to the quantities of biomass and fossil inputs, and the chemistry that they undergo during the process or processes. Many outputs of co-processing cannot be chemically or physically distinguished from outputs derived from fossil feedstock. Thus, methods to determine the bio-content of co-processed outputs are required.

If within the boundaries of the refinery or other co-processing installation, the economic operator mixes the output of co-processing with other fuels, they shall use a mass balance system that documents the mixing of batches with different characteristics in accordance with Article 30 of the revised RED II and ISCC EU System Document 203 “Traceability and Chain of Custody”.

3.2 Methods to determine the bio-content of outputs from co-processing

Four calculation methodologies for co-processing

The physical measurement of the bio-content of outputs of co-processing is necessary because there are cases where the biogenic material from the biomass inputs is not proportionally distributed to the outputs. For instance, biomass feedstocks have a different oxygen content when compared to fossil feedstocks. When biomass is processed, for example in a hydrotreater, it loses carbon and oxygen containing gases (i.e. CO_2, CO, CH_4, and H_2O). These losses, and other chemical characteristics of biomass that differ from those of fossil inputs, lead to bio-content in outputs from co-processing not matching the bio versus fossil material input shares. This chapter outlines the methods available to determine the bio-content of outputs from co-processing as well as giving details of verification requirements.

The DR stipulates that radiocarbon ^{14}C laboratory analysis should be used to determine the bio-share of outputs from co-processing. This can be done through direct sampling and analysis of outputs or by using a calculation method that has been calibrated using ^{14}C laboratory analysis.

There are four calculation methods given in the DR that system users may apply to determine the bio-content of co-processed fuels:

- Direct radiocarbon ^{14}C analysis (section 3.4)
- Yield model calculation (section 3.5.1)
- Mass balance calculation (section 3.5.2)
- Energy balance calculation (section 3.5.3)

The system users must use the same calculation method for any co-processing units that are connected and/or have any material flow between them. For example, when there are multiple co-processing steps for a single flow of materials, the main calculation method must be used to track the bio-content throughout the whole process.

The following sections describe in more detail the methods that may be used to determine the bio-content of co-processed fuels.

3.3 Direct versus indirect calculation methods

A direct calculation method is one that involves taking a sample from a batch, conducting a radiocarbon ^{14}C analysis of that sample, and calculating the bio-content of the batch according to the result of the radiocarbon ^{14}C analysis. The use of in-line measurements is not applicable when determining the bio-content of a batch using a direct calculation method. An in-line measurement involves analysis of a sample taken from a continuous process or material flow. This type of measurement provides information on the status of a system at a given instant. It may or may not be representative of an entire batch. In-line measurements are however required if using an indirect calculation method.

An indirect calculation method is one where the bio-content of a consignment is not measured by direct radiocarbon ^{14}C analysis of the batch, but instead using a calculation method that has been developed with information on mass flows and process understanding and calibrated using radiocarbon ^{14}C analysis. An indirect calculation method can only be used as part of a broader measurement and calculation approach as outlined in section 3.5.

3.4 Radiocarbon ^{14}C testing for bio-content determination

Rationale for ^{14}C isotope measurements

Radiocarbon ^{14}C testing is an analytical technique that is used to determine the age of historical artifacts. It works because the ^{14}C isotope decays to ^{12}C at a constant rate. Radiocarbon ^{14}C testing is also applicable to the determination of the bio-content in co-processing because fossil fuels have no ^{14}C, whereas biomass is much newer and has a measurable amount of ^{14}C content (for a more detailed explanation on ^{14}C testing see Annex III). Thus, by comparing the ratio of ^{14}C to ^{12}C in an output from coprocessing, one can determine the bio-content of the output.

There are two methods of radiocarbon (^{14}C) testing currently available to system users based on the DR. Economic operators shall apply either:

(1) Accelerator Mass Spectrometry (AMS) or

(2) Liquid Scintillation Counting (LSC) method

Accelerator Mass Spectrometry

AMS works by counting the atoms of ^{14}C and ^{12}C to determine the ratio of ^{14}C to ^{12}C, which can be used to calculate the bio-content of the analysed sample. Because this technique usually only requires a few milligrams of sample for analysis, the system user must ensure the sample taken from the batch they are analysing is physically representative of the batch as a whole, in particular when there is any inhomogeneity in the sample.

Liquid Scintillation Counting

Another radiocarbon measurement method that system users can use as a verification of their main testing method is Liquid Scintillation Counting (LSC). This radiometric method is based on measuring (or counting) the radiation produced from the decay of the ^{14}C in the sample. This method may only be suitable when the bio-content of the sample is expected to exceed 1% of the sample volume. Another consideration is whether the sample will be suitable for this testing method. The method is especially sensitive to the presence of particles in the liquid and does not work for dark coloured samples.

When choosing which radiocarbon (^{14}C) method to use, system users must ensure the type of testing method can reliably detect and quantify the bio-content of the measured sample. Further, system users will be required to document the precision and accuracy of their radiocarbon (^{14}C) testing results.

Loss of carbon from biogenic origin

Radiocarbon ^{14}C analysis should also be used to quantify any loss of carbon from biogenic origin due to the process of removing oxygen from the biogenic feedstock. This should be done by making a comparison of biogenic and fossil carbon in the inputs and output products. This does not mean that all outputs must be analysed using a ^{14}C testing method, as long as conclusive alternative methods for bio-content calculation are available for those outputs. These methods must meet the precision and accuracy requirements as those described for ^{14}C analytical methods. A possible example is the use of infra-red spectroscopy to characterise the composition of off-gas streams.

Direct measurement of bio-content using radiocarbon ^{14}C testing for reporting of a specific share of biomass within an output must be done on a static, homogenous batch. This means the economic operator must discharge the co-processed output to a tank and ensure that it is homogenous before sampling for analysis.

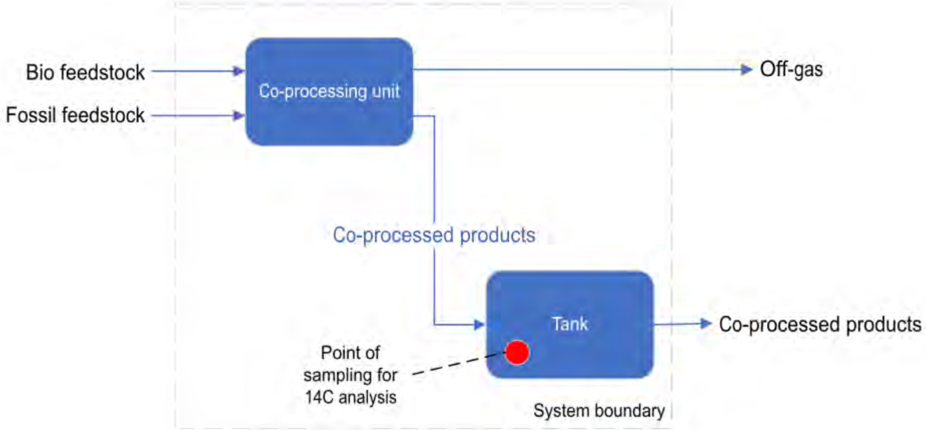

Figure 4 Sampling of outputs from co-processing when using direct radiocarbon ^{14}C testing as the main method of calculation of bio-content

This is required as many refinery operations are continuous and as such an in-line sampling and analysis protocol would give only a snapshot of the process in time.

For the yield calculation methods described in the following section, sampling and radiocarbon ^{14}C testing may take place in-line. This is because yield methods are designed to give bio-content values for outputs of a continuous process within defined processing limits.

3.5 Alternative calculation methods for bio-content determination

System users may develop their own company- or process-specific calculation methods for determining the carbon-based share of bio-content in fuels resulting from co-processing, if it has been calibrated using radiocarbon ^{14}C laboratory analysis.

If system users are using a main calculation method that does not involve direct ^{14}C analysis, they must use a main calculation method that can effectively measure the share of bio-content in the biofuels or biogas. System users must report the accuracy and precision of their main calculation method and describe the reason for any inaccuracies in their calculation method (e.g., error margin of measurement of flows or heating values used in calculations).

3.5.1 Yield model methods

There are two different yield methods that a system user can choose to use as their main calculation method.

(1) **Yield Method A.** To use this method, a system user first performs their desired process with only fossil feedstocks or for specific applications on a pilot scale that is accurately representative of their intended commercial scale operations. Then, the bio-content of the input is gradually increased and the effect of this increase on the total yield of outputs is observed and recorded and then attributed to each product in proportion to the observed increase in production. These are the determined yield factors (YF), and they are only valid for the measured reference inputs and specific process conditions. These yield factors must be verified or calibrated using ^{14}C analytical testing. System users may use different yield factors for different processes or operating conditions, as long as they validate or calibrate the YF with ^{14}C analytical testing. If different YF are used, radiocarbon (^{14}C) testing shall be performed and checked against inputs and process conditions to reconfigure the YF if necessary.

(2) **Yield Method B.** To determine the yield factors using this method, the system user shall fully characterise the inputs and outputs of a process over several batches of biomass feedstock inputs at known co-processing conditions. When a clear correlation between the bio-content of the inputs and outputs is established, these yield factors can be used to determine the bio-content of the output when the co-processing unit is operating with the same type and quality of biogenic feedstock(s), under the same operating conditions.

Defined reference operating conditions

Additionally, Member States (MS) can define YF that must be used by co-processing facilities in their territory, as long as they are compliant with the DR and ISCC requirements.

In cases where a MS has defined a yield factor that does not refer to specific range of process conditions, economic operators shall establish them by performing a 14C verification process to check whether, in the process conditions that are considered representative of the plant, the national yield factor applies. These will be considered the baseline conditions.

It is the responsibility of the economic operator to document the precision and accuracy of the yield method, if not provided by a MS.

3.5.2 Mass balance methods

Mass ratio of bio and fossil inputs

In this approach, the calculation of the bio-content is based on mass ratios of bio-based and fossil inputs. Determination of the bio-content of the input requires the feedstocks' moisture and non-fuel impurities to be taken into account. A full mass balance analysis of the total mass of inputs and outputs must be performed for a process, taking into account any mass lost as off-gases and liquid or solid wastes or residues. The mass balance method shall ensure that the total bio-content of all outputs is equal to the bio-content of all the inputs and that the share of biogenic material identified by the radiocarbon (^{14}C) testing results is allocated to each output. Thus, for the determination of the bio-content of the output(s), conversion factors should be applied for each output that most accurately correspond to their final bio-content (which is verified using radiocarbon ^{14}C testing). The mass balance method shall include additional analytic characterisation of feedstocks and products, such as ultimate and proximate analysis of system mass flows.

3.5.3 Energy balance methods

Using the energy balance method, the energy share of the biogenic content of the output(s) is determined based on the energetic weighted ratios of the bio-based and fossil inputs. The energy content of the biomass and fossil feedstocks are calculated using the mass of the feedstock and the feedstock's lower heating value (LHV, MJ per kg). The energy for the processing of the feedstock should be recorded ("*process energy entering the co-processing facility*"). The bio-content of the output(s) is calculated as the bio energy input divided by the total energy input and using (different) conversion factors for each fuel output that most accurately correspond to their bio-content as verified using radiocarbon ^{14}C testing.

3.5.4 General considerations for using a method other than radiocarbon 14C testing as the main calculation method

The use of indirect calculation methods is only permitted within defined reference operating conditions, including factors such as feedstock composition. All calculation methods require verification or calibration of yield factors by radiocarbon (^{14}C) testing whenever operating conditions, move outside of the range, or baseline, defined during the development of the yield calculation method.

The baseline is defined as either a set of discrete operating conditions, or an area of operating space, where there is a defined and verified relationship between the operating variables and the bio-content of the outputs. Economic operators are obliged to demonstrate which operating parameters influence the bio-content of outputs of their specific set-up. These parameters may include (but are not limited to):

- biomass feedstock chemical characteristics
- bio / fossil feedstock ratio
- hydrogen pressure
- catalyst loading
- catalyst characteristics
- process temperature
- product composition

For further information on processing parameters that may affect bio-yields see Annex I – Technology overviews.

To facilitate auditing of set-ups using a calculation method, economic operators should prepare documentation that describes the following:

- Technical basis for the operating space and yield model, if applicable
- Proof of operating performance
- Procedures for monitoring performance and reacting to out-of-range events

The documentation explaining the technical basis of the yield model should explain how the yield model was developed, which parameters are relevant to the bio-yield of the process, and the operating limits within which the model is valid. It should be written in clear language and be understandable to an auditor. An example layout for such a document is given in Annex II – Technical basis document example outline

The document should describe the relationship between relevant processing parameters and the bio-share of the different product streams, for example by plotting % of biomass in the feed verses % of biomass in a given output stream, as shown in Figure 5.

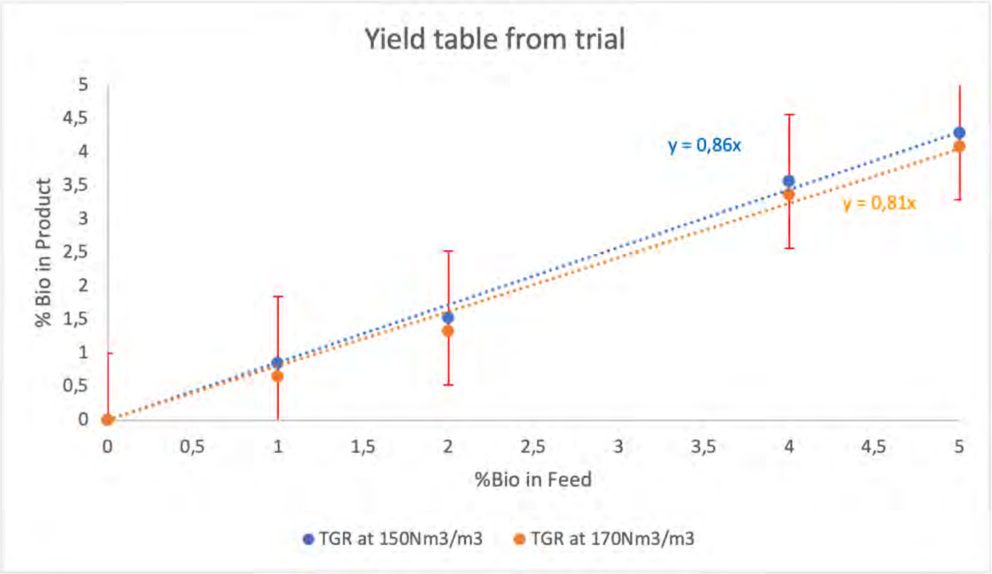

Figure 5 Example plot of % biomass in product versus % biomass in input

In the case of a yield factor established by a MS at a national level, this fact should be indicated in the documentation. In case the MS has not defined the operating limits for the applicability of the national yield factor, these limits shall be described by the economic operator and the documentation shall also include the procedure followed to determine the operating limits.

Proof of operating performance documentation should allow an auditor to check if operating conditions stayed within the defined limits of the yield model. This could be in the form of control charts such as in Figure 6. It should be possible for an auditor to link reported values back to raw data collected from on-line plant monitoring software such as PI-system.

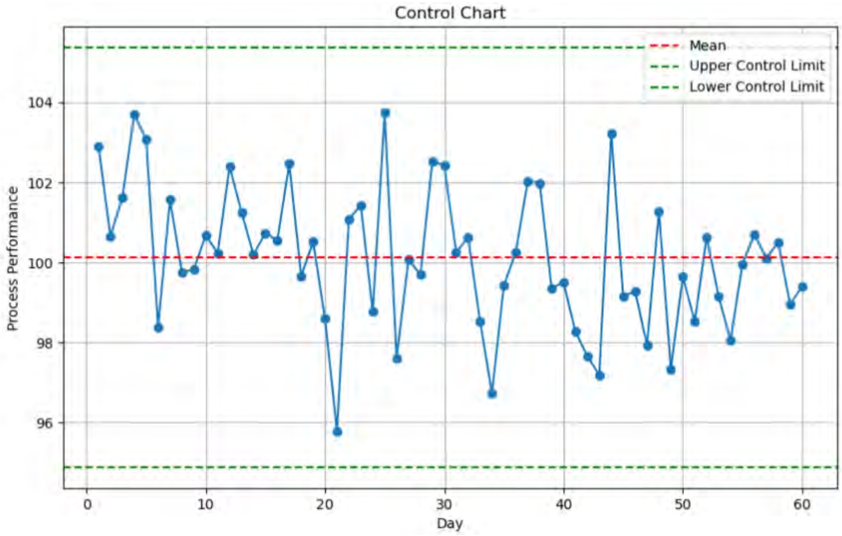

Figure 6 Example of a control chart.

If the bio-content of the co-processing outputs is calculated using the main calculation method, these results shall be verified periodically by comparison with bio-content values derived from a ^{14}C analytical method.

The required frequency for using radiocarbon ^{14}C testing to verify the main calculation method will depend upon the complexity and variability of the key parameters of co-processing. The intention is to ensure that the system user's claims of the bio-content of co-processing outputs always, as far as possible, accurately reflect their actual bio-content. The main calculation method shall be applied to each batch or consignment to calculate its bio-content. The main calculation method must be verified using radiocarbon ^{14}C testing any time there is a change to the baseline co-processing conditions by more than 5%. At a minimum, radiocarbon ^{14}C testing must be used to verify the results of the main calculation method at least once every four months.

Verification of main calculation method

During operation, where the main calculation method is not ^{14}C analysis method, when verifying the main calculation method using ^{14}C analysis, the results of the main calculation method are considered valid if the absolute discrepancy between calculated bio content values of the two methods is not greater than 1% (or 3% within the first year of certification). If the methods result in a discrepancy greater than 1% (3% within the first year of certification), the radiocarbon (^{14}C) testing-determined values are considered valid. That is, the system user must use the values determined by the radiocarbon (^{14}C) testing in lieu of the results of their main calculation method. In cases where the discrepancy exceeds the acceptable absolute value, the radiocarbon (^{14}C) testing-determined values shall be used to review its main calculation methods to correct any system errors leading to such deviation and respectively recalibrate the calculation method if needed.

DR article 6.4 states *"…shows a deviation of more than 1 % in absolute terms"* i.e. numerical limits are determined to one significant figure. Data reported by economic operators to more than one significant figure should only be rounded to a single significant figure when verifying compliance with the DR. This means that if a discrepancy of 1.3% were encountered, this would not be considered to have breached the limit, as 1.3% would be rounded down to 1%. If a discrepancy of 1.5% were encountered, this would be rounded up to 2% and thus would breach the limit and require that the radiocarbon (^{14}C) testing result were used in place of the value calculated using the yield method.

The phrase "in absolute terms" is interpreted as meaning that if the bio-content were calculated as 4.9% using the yield method and the radiocarbon (^{14}C) testing result gave a value of 6.4% this would be a discrepancy of 1.5%. This interpretation of "in absolute terms" is applied to all percentage limits given in the Delegated Regulation.

Handling of discrepancies

The scenarios below show several illustrative examples of how discrepancies between main calculation method results and verification method results should be handled.[3]

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[3] *These examples are adapted from the position paper released by Fuels Europe in November 2023, FuelEurope's Interpretation of DA on Co-processing Methodology (accessed July 2024)*

Table 1 Scenarios illustrating how discrepancies between calculation methods should be handled within the first 12 months of operation.

Scenario	^{14}C analytical result (%)	Main calculation result (%)	Bio-content claim (%)	Is review of main calculation method required?
1	4.0	4.9	4.9	No – discrepancy < 3%
2	3.8	4.9	4.9	No – discrepancy < 3%
3	6.4	4.9	4.9	No – discrepancy < 3%

Table 2 Scenarios illustrating how discrepancies between calculation methods should be handled after the first 12 months of operation.

Scenario	^{14}C analytical result (%)	Main calculation result (%)	Bio-content claim (%)	Is review of main calculation method required?
5	4.0	4.9	4.9	No – discrepancy < 1%
6	3.8	4.9	4.9	No – discrepancy < 1%
7	6.4	4.9	6.4	Yes – discrepancy > 1%

Non-conformities

Any discrepancy relating to a batch of co-processed product within the co-processing system boundary, that is identified by the auditors of the certification body, shall be treated as a potential major non-conformity and ISCC should be notified immediately.

In case of a notification of a potential major non-conformity, relating to a batch of co-processed product placed on the market, from the certification body, auditor, or a national competent authority, ISCC is obliged to take immediate action by investigating the case. In the event of a proven and avoidable non-conformity, the certificate of the economic operator will be immediately suspended by the Certification Body (see ISCC EU System Document 102 “Governance” for further information on non-conformities).

Repeat audit to lift suspension

To rectify the accuracy of the claims made on the implicated batch, the lower bio-content values established by the ^{14}C validation method shall be used as a basis for recalculating the bio-content claims. In addition, the economic operator will be required to review its calculation methods to identify any system, or other, errors that lead to the discrepancy in question. A repeat audit is required before re-issue of the suspended certificate may occur, and re-certification is dependent the effectiveness of the corrective measures taken.

3.6 Requirements relating to suitability of measurements

Economic operators should ensure that all measurement techniques used to determine the bio-content of materials are suitable to meet the requirements of the delegated regulation and this document. This requires determining and documenting the precision and accuracy of all relevant forms of measurement within the co-processing facility. Annex III provides additional advice on this topic.

3.7 Establishing the share of hydrogen of biological origin

Evidence of biological origin of hydrogen

The requirements for processing units that co-process hydrogen gas of biological origin require different analytical methods because the bio-content of hydrogen cannot be quantified with radiocarbon (^{14}C) testing. In this case, the system user must verify and provide evidence confirming the biological origin of the hydrogen gas entering the co-processing unit. Additionally, the system user must provide evidence that the hydrogen gas of biological origin entering the co-processing unit:

(1) has not elsewhere been counted as renewable energy to ensure no double-counting has occurred, AND

(2) for the product of a fuel produced using hydrogen of biological origin to be considered under this co-processing framework, the system user must also provide evidence that the biological hydrogen is incorporated into the final molecular structure of the output fuel (e.g. not used for removal of impurities).

As hydrogen content cannot be measured with radiocarbon ^{14}C testing, the system user should use an analytical testing method such as carbon, hydrogen, nitrogen elemental analysis to quantify the hydrogen content of the material before and after co-processing with biological hydrogen in order to attribute the biological hydrogen to the output biofuel or biogas. Lastly, the biological origin of any hydrogen used for hydro treating or for producing co-processed fuels must be certified either by the supplier or the system user in the case that they are the producers of the biological hydrogen.[4]

3.8 Sustainability requirements for co-processed biofuels

When bio-based inputs are simultaneously co-processed with fossil inputs, the bio-based share must meet the sustainability requirements and greenhouse gas emission requirements as referred to in all relevant ISCC documents. The quantity of the bio-based input co-processed, that does not meet the sustainability and greenhouse gas criteria of the RED II cannot be counted as renewable fuel in accordance with ISCC.

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[4] *Certification is needed to provide evidence of compliance with the sustainability and greenhouse gas (GHG) emissions saving criteria of the Renewable Energy Directive (EU) 2018/2001[4] (often referred to as RED II) of the biological hydrogen.*

Where bio-based inputs with different sustainability characteristics (e.g. type of feedstock, country of origin, greenhouse gas (GHG) emissions) are co-processed with fossil inputs, the quantity and type of the different bio-based oils is taken into account in the calculation of the biofuel output amounts. At least on a bookkeeping basis the product and sustainability characteristics shall be preserved (see ISCC EU System Document 203 “Traceability and Chain of Custody”).

Preservation of sustainability characteristics

3.9 Reporting

For system users claiming a specific share of biofuels or biogas in the fuels they put on the market, records of measurement data and calculations of bio-content in outputs from coprocessing, along with physical samples of outputs from coprocessing related to the fuels placed on the market and certified by ISCC, must be kept for at least two years. These records shall be provided to certification bodies and auditors during an audit for initial ISCC certification or during a renewal audit.

Biofuel samples and data storing

Economic operators shall prepare a detailed description of the main calculation method they used, including an indication of its accuracy and precision as also verified through the application of radiocarbon ^{14}C testing and together with a procedure for its application.

3.10 GHG emissions calculation for co-processed fuels

The GHG emission of a product is determined by the emissions associated with the feedstocks being processed and other processing inputs that drive the process. In general, all or some of the processing inputs consumed by a process unit handling entirely biomass-based feedstock is higher compared to the unit handling entirely fossil-based feedstock.

GHG calculation

To assess the GHG emissions of a co-processing plant processing biomass- and fossil-based feedstocks simultaneously, it is required to determine the processing inputs associated with just the biogenic feedstock. This should be performed by comparing two scenarios: In the first scenario, the refinery is processing only fossil-based feedstocks and in the second scenario the refinery is processing both biomass- and fossil-based feedstocks together, provided that the total energetic content of the feedstock in both scenarios remain the same. Any increase in processing inputs, after considering the two scenarios, shall be attributed entirely to the biomass-based fraction of the feedstock. In Figure 7, this increase is illustrated as ∆ Processing inputs. Such an evaluation is required as often biomass-based feedstocks have a high oxygen content and more hydrogen is consumed to deoxygenate it compared to a fossil-based feedstock. By this approach, the additional emissions from the co-process, such as biogenic material leading to production of heat and CO_2, are aptly linked to the biogenic feedstocks.

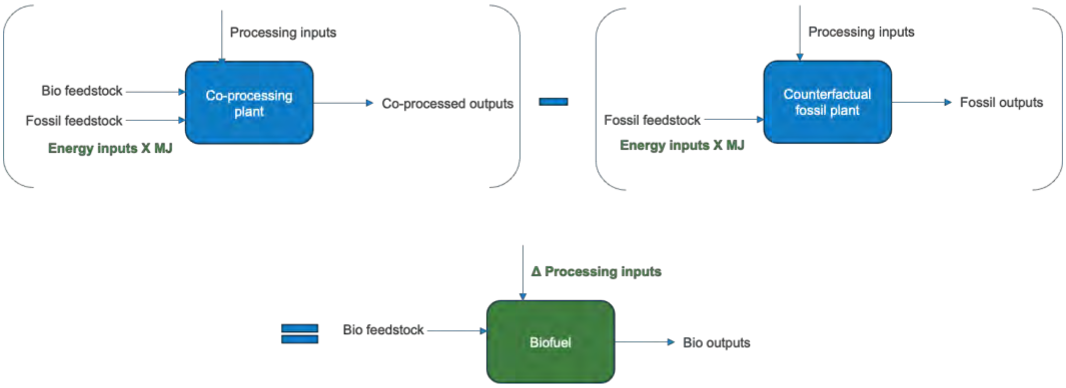


Figure 7 Benchmark scenario where process is fed by only fossil inputs

After the additional process inputs (upon fossil co-process comparison) are attributed to the biogenic feedstocks, the remaining processing inputs of the co-processing scenario, are proportionally attributed to the biogenic and non-biogenic feedstock based on their feedstock fraction. All processing inputs shall be considered to contribute emissions to all outputs, biogenic and non-biogenic – i.e. it is not possible to attribute GHG emissions of a specific processing input to the fossil products only. The above-mentioned concept shall be conceptualised as follows,

With the identification of all processing inputs and related quantities required for the bio-outputs production, it is then possible to define a virtual split of the co-processing plant and calculate the GHG emissions of the bio-outputs separately.

Specifically, the emissions of the bio-content output can be calculated as:

$$E = e_{biogenic\ feed\ in} + e_p + e_{td} + e_u$$

Where,

E	emissions of a specific co-processed fuel, in g CO_2e/MJ
$e_{biogenic\ feed\ in}$	upstream emissions from the biogenic feedstock, calculated according to the RED framework
e_p	emissions from processing of the whole refinery, proportionally distributed among bio and non-biogenic feedstock, plus all additional emissions required for the biogenic feedstock, based on the benchmark
e_{td}	emissions from transport and distribution related to the co-processed biofuels
e_u	emissions from use of the fuel, which are considered 0 for biofuels in line with Annex V point 13 of RED.

If a fuel production process yields one or more products, the greenhouse gas emissions shall be divided between the fuel or its intermediate product and the co-products* by an allocation factor. As outlined in the ISCC EU 205 document, the allocation shall be performed according to the energy content of each bio-product and co-product.

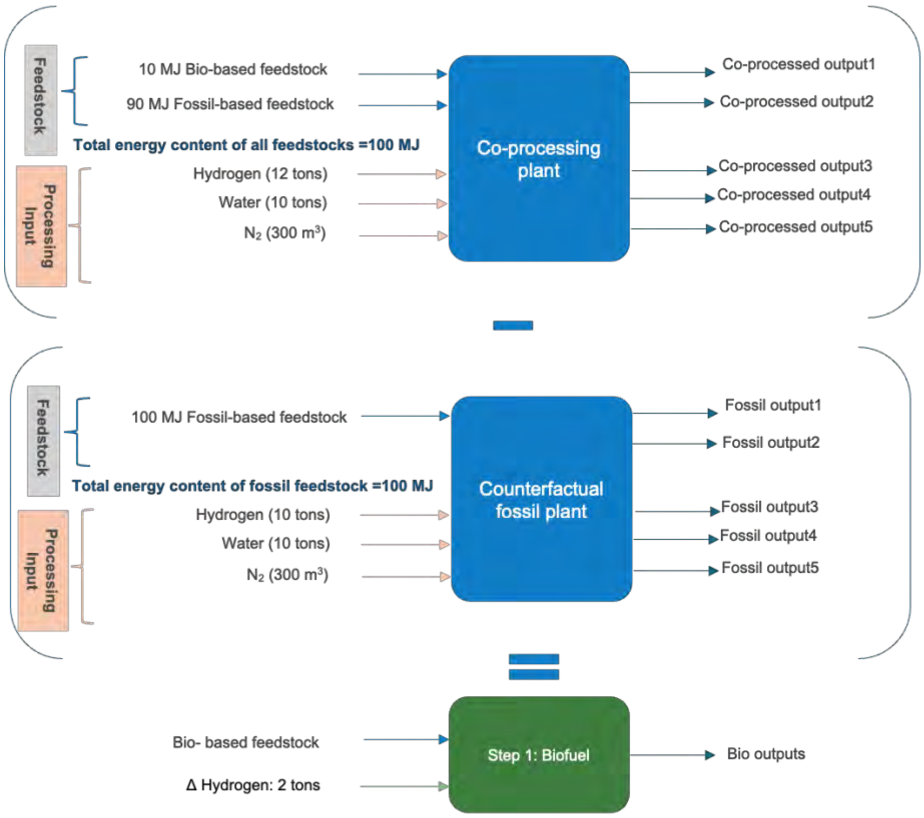
Please note the above method is only applicable to determine the emissions of biofuels in a co-processing plant. If a co-processing plant yields other fuel outputs, such as recycled carbon fuels (RCF) or renewable fuels of non-biological origin (RFNBO), other methodologies as defined by the EC shall be applied.

**Including all fossil and biobased products where overall processing emissions have been calculated.*

3.10.1 Example on how to define virtual split of the co-processing plant

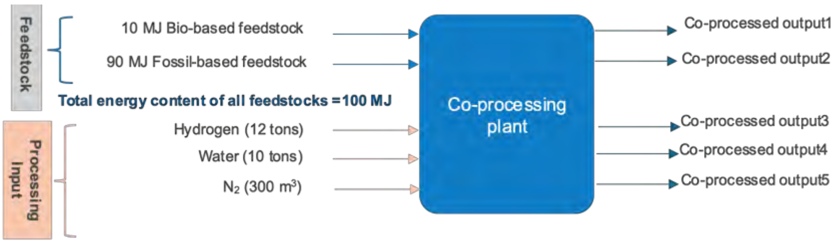
This chapter illustrates how the above-described steps are applied for the definition of a virtual split of the co-processing plant. All numbers used are fictitious.

In the first step, the ∆ processing inputs, which are to be linked to the biomass-based feedstocks in the refinery are defined. This is done by evaluating a counterfactual co-processing plant, as shown in Figure 8.



The Δ of processing inputs are considered to be linked with the biogenic feedstocks

Figure 8 Step 1: Determination of excess (Δ) processing inputs consumed by biomass-based feedstock



The energetic share of biogenic inputs is 10%, which is then used to distribute the remaining processing inputs between the bio- and fossil-based feedstocks.
Out of 12 tons of hydrogen, 2 tons were already identified as Δ of processing inputs.
Therefore, the remaining 10 tons of hydrogen, along with the other processing inputs, are attributed as linked to the bio- or fossil-based process.

Figure 9 Process inputs of an exemplary co-processing plant

In the second step, a proportional attribution of the remaining processing inputs in the co-processing plant takes place, according to the energetic share of biogenic and non-biogenic feedstock. The result of the second step is as depicted in Figure 10.

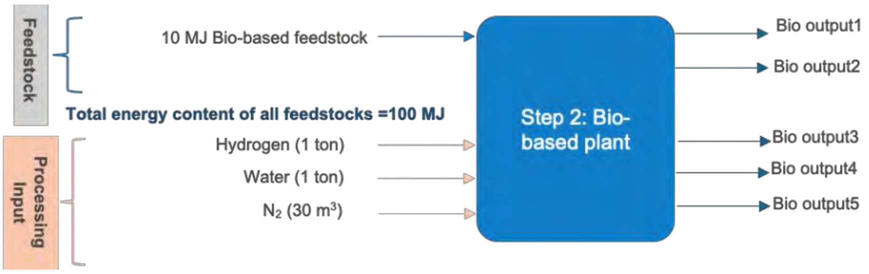


Figure 10 Step 2: Proportional attribution of the remaining processing inputs

Once both steps are performed, it is then possible to define the final virtual split of the co-processing plant, which will be used to assess the GHG emissions of the bio-outputs separately. This is shown in Figure 11. Once this step is completed, the equation described in section 3.10 can be applied.

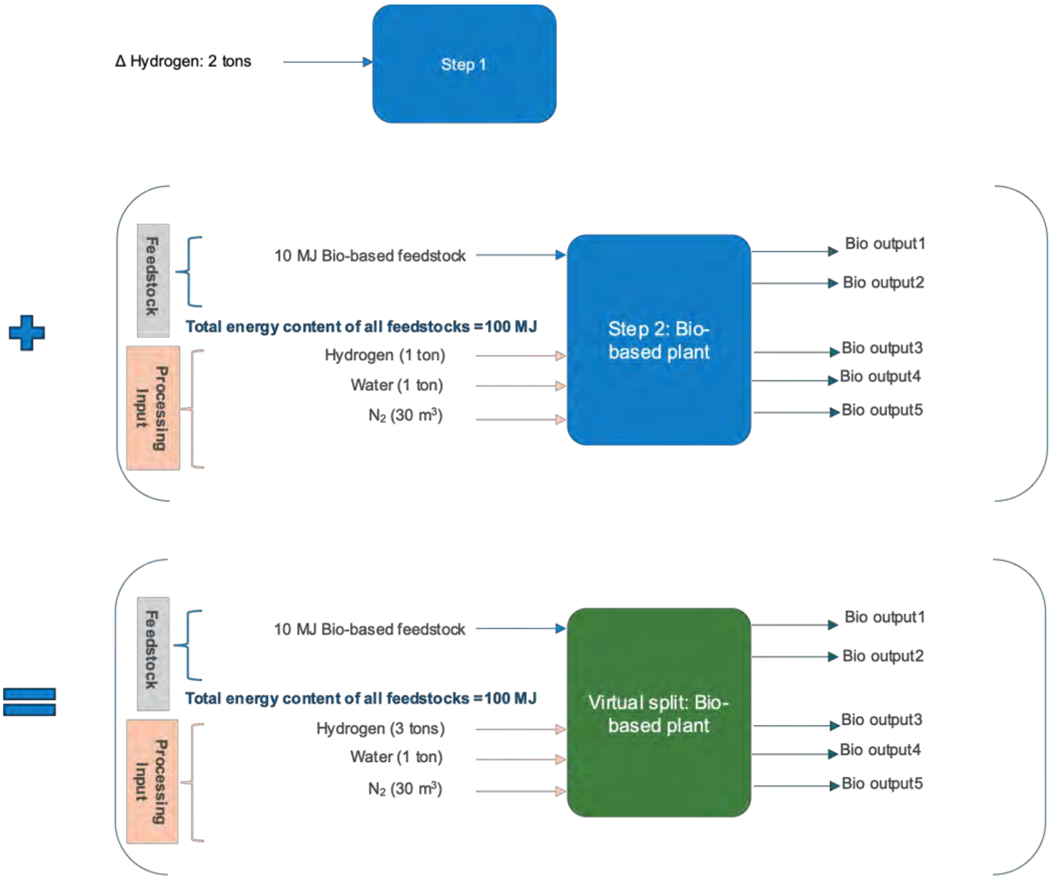


Figure 11 Virtual split: bio-based plant

3.10.2 GHG Emissions calculation for municipal solid waste case

In the context of the DR, the production of biofuels from mixed biogenic and non-biogenic municipal solid waste (MSW) is a non-refinery example case of co-processing. However, in this case, no counterfactual evaluation of a fossil only case is required, as it is not relevant to determine the emissions of processing on non-biogenic MSW only.

To calculate the emissions from fuel derived from MSW, the first step is to determine the quantity of the waste from biomass with the radiocarbon ^{14}C testing (see section 3.4). This allows to separate the biogenic waste fraction input and, thus, apply the above-described co-processing GHG methodology to it only. The non-biomass part of the waste shall be treated in accordance with the other EC documents[5] on RFNBOs and RCFs.

3.11 Monitoring by ISCC

The requirements of the Delegated Regulation are of a highly technical nature. Meeting such requirements will demand that economic operators put in place physical procedures and documentation management systems of considerable complexity. The auditing of such procedures and systems will also be technical. ISCC will provide auditors with relevant training to accompany this guidance. To ensure ISCC guidance and training is effective, ISCC will play an active role in monitoring how economic operators are implementing co-processing. This will be done in several ways:

- ISCC will be involved in pilot audits at economic operators
- ISCC reserves the right to request to see documentation relating to how an economic operator is implementing co-processing
- ISCC will take an active approach to integrity auditing of economic operators that are co-processing

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[5] Commission Delegated Regulation (EU) 2023/1185 of 10 February 2023 supplementing Directive (EU) 2018/2001 of the European Parliament and of the Council by establishing a minimum threshold for greenhouse gas emissions savings of recycled carbon fuels and by specifying a methodology for assessing greenhouse gas emissions savings from renewable liquid and gaseous transport fuels of non-biological origin and from recycled carbon fuels

4 Annexes

4.1 Annex I – Technology overviews

The following section gives an overview of three refinery processing techniques that could be used for co-processing.

4.1.1 Hydrotreating (HT)

Hydrotreatment is traditionally used to remove impurities, such as sulphur, from crude fossil oils.

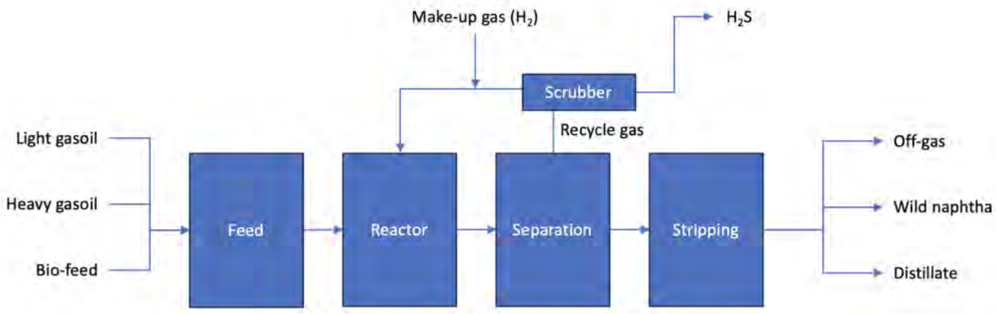

Figure 12 Schematic diagram of a hydrotreatment process

Parameters that affect the bio-yield of outputs of the hydrotreater include:

- Catalyst
- System pressure
- System temperature
- Hydrogen feed ratio

4.1.2 Hydrocracking (HC)

Hydrocracking is designed to not only remove impurities but also to crack and sort, or fractionate, the feed oil into a range of products.

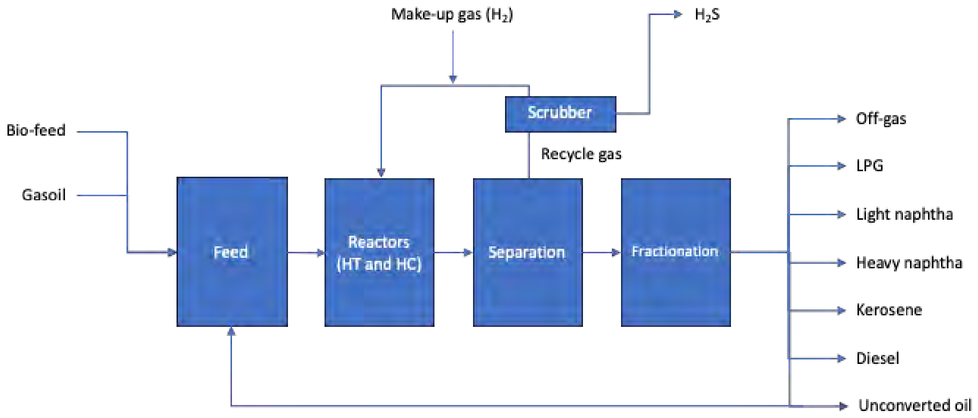

Figure 13 Schematic diagram of a hydrocracking process

Parameters that affect the bio-yield of outputs of the hydrocracker include:

- Catalyst
- System pressure
- System temperature
- Hydrogen feed ratio
- Fractionation temperatures

4.1.3 Fluid Catalytic Cracking (FCC)

Fluid catalytic cracking (FCC) is a process designed to crack heavy oil fractions in to more valuable lighter cuts and olefinic gasses. FCC units are often coupled with downstream units such as alkylation and hydrotreater units. A simplified depiction of an FCC, without the associated downstream units, is shown in Figure 14.

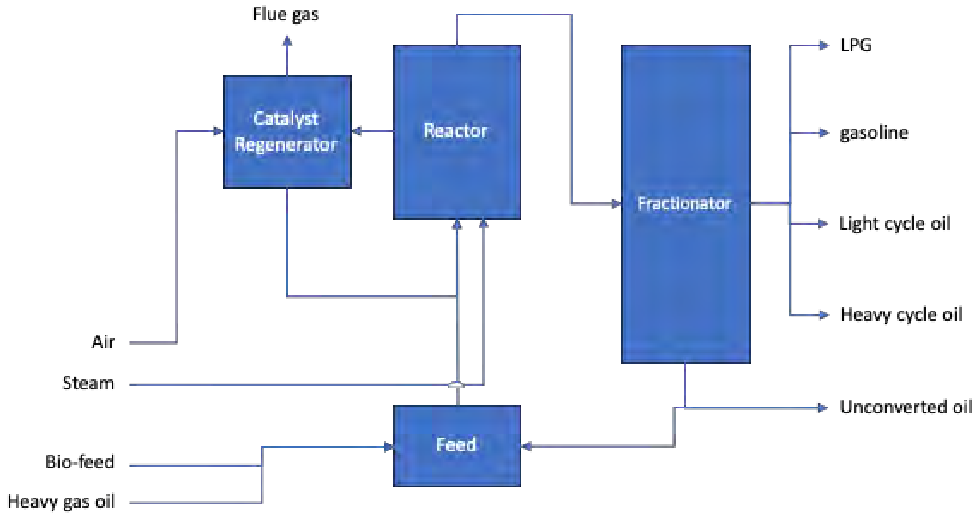

Figure 14 Schematic diagram of a fluid catalytic cracking process

Parameters that affect the bio-yield of outputs of the fluid catalytic include:

- Catalyst
- Riser top temperature
- Fractionation temperatures

System pressure is not expected to be a key parameter for bio-yield performance in the FCC.

4.2 Annex II – Technical basis document example outline

Introduction

- Describe the context and aim of the document

Process technology

- Processing assets and technologies that are covered by this report

Input characterisation

- Feedstocks covered
- Chemical properties of feedstocks, such as fatty acid distribution
- Quality ranges

Theory

- Details of chemistry of the listed feedstocks under the processing conditions

Methods

- Details of experiments conducted to develop a yield model
- Details of analytical procedures used
- Discussion of precision and accuracy of analytical methods
- Details of any modelling used

Results and analysis

- Description of relevant parameters
- Mass flow diagrams explaining bio-shares of outputs
- Yield tables and plots
- Operating limits

Responsibilities

- List of contributing authors
- Description of how this document was reviewed
- Comment on when this document will need to be updated

Version history

- When was each major version published and what were the changes

4.3 Annex III – Analytical chemistry terminology, methods and standards

The following section gives definitions for, and an outline of how to measure, precision and accuracy.

4.3.1 Analytical chemistry terminology

Accuracy refers to how close a measured value is to the true or accepted value. It indicates the absence of systematic errors. Accuracy is typically assessed by comparing experimental results to a known standard or accepted reference value. Common methods to measure accuracy include:

Standard Addition Method: This involves adding known amounts of a standard solution to the sample and measuring the change in the analytical signal.

Internal Standards: Adding a known amount of a substance not normally present in the sample but which behaves similar analytically can improve accuracy.

Precision refers to the reproducibility or consistency of results obtained from repeated measurements under identical conditions. It indicates the absence of random errors. Precision is evaluated by analysing the scatter or spread of data points. Common methods to measure precision include:

Repeatability and Reproducibility: Repeatability refers to the closeness of agreement between independent test results obtained with the same method on identical test items under specified conditions. Reproducibility refers to the closeness of agreement between independent test results obtained with the same method but under different conditions.

Standard Deviation and Variance: Calculating the standard deviation or variance of a set of measurements provides a quantitative measure of precision.

4.3.2 Radiocarbon dating (^{14}C analysis): Fundamentals and analytical methods

Carbon on Earth exists in three major isotopic forms namely carbon-12, carbon-13 and carbon-14. All three isotopes have different number of neutrons and are present in different abundancy as shown in the Table.3. Especially, carbon-14 is unstable, weakly radioactive (**radiocarbon**) and is present in traces amounts. One in 10^{12} atoms of carbon in the earth's atmosphere is of carbon-14.

Table 3. Different isotopes of carbon

Isotopes of carbon	Mass number (A)	No. of protons	No. of neutrons	Abundance on earth
Carbon-12 (^{12}C)	12	6	6	99 %
Carbon-13 (^{13}C)	13	6	7	1 %
Carbon-14 (^{14}C)	14	6	8	trace amounts

Carbon-14 is continually being formed in the upper atmosphere by the effect of cosmic ray neutrons on Nitrogen-14 atoms. It is rapidly oxidised in air to form carbon dioxide and enters the global carbon cycle.[6] Living organisms on earth respirate carbon-14 from carbon dioxide throughout their life and when they die the concentration of carbon-14 decreases at a rate determined by the law of radioactive decay. The carbon-14 concentration decreases by half every 5730 years (half-life of carbon-14) after the end of life of the organisms. In that sense, petroleum deposits formed hundreds of million years ago will have nearly no carbon-14 present in it. Whereas fresh biomass (feedstock) shall contain significant amount of carbon-14 that can be detected using radiocarbon dating. Therefore, determining the amount of carbon-14 through radiocarbon dating (^{14}C analysis) can help to ensure the bio-content of a co-processed fuel. Accelerator Mass Spectrometry (AMS) and Liquid Scintillation Counting (LSC) are the two recommended radiocarbon dating techniques to determine the bio-content of a co-processed fuel.

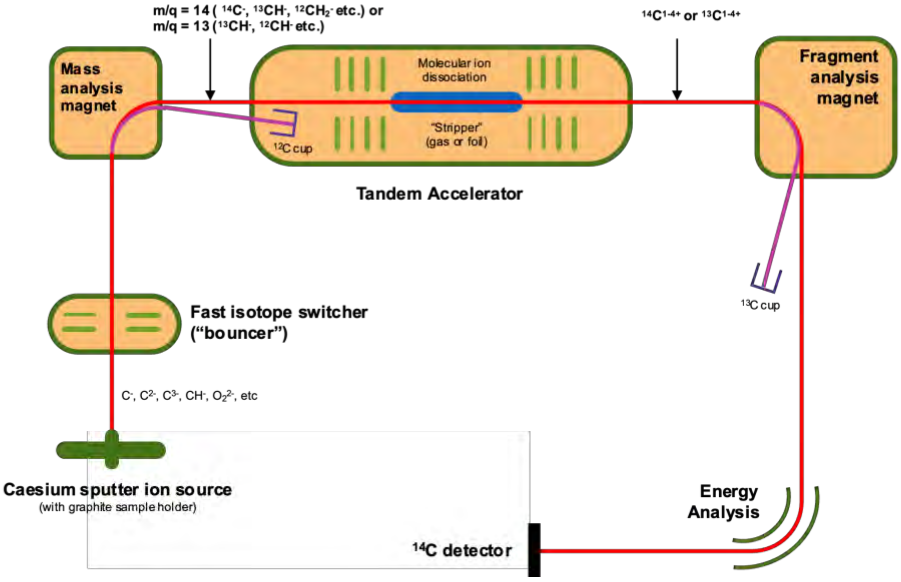

Figure 15 A schematic of a 1-MV AMS 14C analytics measurement system[8]

Accelerator Mass Spectrometry (AMS) separates and measure rare radioisotopes (^{14}C) from stable isotopes (^{12}C and ^{13}C) by converting the atoms in the sample into a beam of fast-moving ions (charged atoms). The mass of these ions is then measured by the application of magnetic and electric fields[7]. First, the sample is pretreated and combusted to produce CO_2 which is then catalytically reduced to graphite. The sample is then bombarded with an ion beam to generate negative elemental or molecular ions of the sample. This step already removes the primary isobaric interference from ^{14}N, as nitrogen does not form a stable negative ion. The ion beam then enters a low energy magnetic analyser where the ^{12}C fraction gets separated from heavier ions and gets measured in a Faraday cup[8]. The remaining fraction of ion beam then enters a tandem accelerator operating at 0.2 to many million volts with two stages operating in

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[6] Beta Analytic. Accelerator Mass Spectrometry (AMS) Dating. 2019. Available online: https://www.radiocarbon.com/about-carbon-dating.htm (accessed in June 2024).

[7] University of Oxford. Oxford Radiocarbon Accelerator Unit. Accelerator Mass Spectrometry (AMS) Measurement. 2019. Available online: https://c14.arch.ox.ac.uk/ams.html (accessed in June 2024).

[8] Lawrence Livermore National Laboratory. Center for Accelerator Mass Spectrometry. Available online: https://cams.llnl.gov/about/what-ams (accessed in June 2024).

tandem to accelerate the particles. The negative ions and the molecules are accelerated to a few hundred KeV energies in the first stage of the tandem accelerator before they pass through a thin stripper medium (gas or thin carbon foil). At this point, molecules will break apart and the impact strips off the negative ion's electrons, converting it to a positive charged ion travelling at several percent of the speed of light. These positive ions leaving accelerator enters the second mass spectrometer where fragments of molecules are separated from the ions of interest using electric and magnetic fields. $^{13}C^{+}$ ions are measured as an ion current in a Faraday cup following the fragment analysis magnet. The $^{14}C^{+}$ ions are further accelerated followed by momentum and energy analysis before being counted using standard particle detectors. The counts of the detectors are then used to determine the amount of ^{14}C present in the co-processed fuel.

Liquid Scintillation counting (LSC) is an analytical technique that measures the radioactivity of a low energy radioisotopes by counting the number of photon emissions generated by the interaction of the beta particle with scintillators.[9] Scintillators are molecules, which when incident with an ionising radiation or particle, can absorb and re-emit absorbed energy in the form of light. The emitted photons are captured by detectors and are quantified.

For efficient counting of the decay, the radioactive sample is suspended in a special cocktail consisting of a) an organic solvent, b) a surfactant and c) a scintillator or fluor.[10] During a radioactive decay, the emitted beta particles from an active sample interact with the solvent molecules and energise them. The energised solvent molecules may further collide with another solvent molecule or a scintillator molecule and eventually transfer the absorbed energy. Upon interaction with the scintillator, it absorbs the energy and gets excited to a higher energy level. The excited scintillator molecule then returns to ground level by reemitting the absorbed energy in the form of photons. The photons are detected by two photo multiplier tubes.

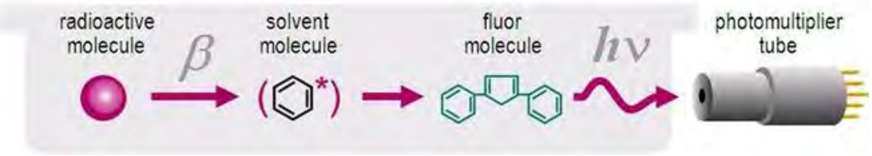

Figure 16 A schematic overview of the Liquid Scintillation Counting (LSC) process[10]

4.3.3 Radiocarbon Test Standards

Standards refer to the analytical response of a well-characterised material whose properties are established or understood clearly. These standards are used as references to calibrate instruments, validate methods and ensure reliability of the analytical results. The different radiocarbon test methods and standards used in AMS and LSC and their precision are listed in Table .4 and Table .5

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[9] Wikipedia, Liquid scintillation counting, Available online: https://en.wikipedia.org/wiki/Liquid_scintillation_counting (accessed in July 2024).
[10] Revvity, Liquid Scintillation Counting, Available online: https://www.revvity.com/de-en/ask/liquid-scintillation-counting (accessed in July 2024)

Table.4 List of different AMS methods used to determine the biocarbon fraction of a co-processed fuel[11]

Testing procedure	Method	Features	Confidence Interval	Source	Bio-feedstock used
General standard for ^{14}C through AMS	ASTM D6866-20 Method B -AMS	Standard Method	±3 wt.% (absolute) in the whole range of the detection limit	ASTM-D6866-21	-
Haverly et al, 2019	ASTM D6866-20 Method B -AMS	Lab-specific blank correction was shown to improve the measurement accuracy across the entire data set by accounting for the site-specific systematic error for each lab	±0.26wt% (absolute) at the 95% confidence level, lower detection limit of 0.40 wt.%.	Biobased carbon content quantification through AMS radiocarbon analysis of liquid fuels	HEFA/Diesel fuel
Oinonen et al, 2010	Simplified AMS method, alternative to ASTM D6866-06a Method D	Faster combustion methods by injecting the AMS sample in a hot oven with controlled conditions (temperature, pressure) and combusting the sample for significantly shorter times	maximum deviation of the measured biobased content (range 0-100%) from the theoretical values was less than 0.5% (abs)	Biofuel proportions in fuels by AMS radiocarbon method	NExBTL renewable diesel
Palstra and Meijer, 2014	AMS method based on a correction using δ13C measure by IRMS, different than ASTM D6866-08	The method proposes to minimise the uncertainty in the calculated biocarbon fraction of gaseous biogenic mixtures by dividing biogases into 4 different groups with different uncertainty ranges.	Uncertainty varies between ±0.5% and ±3.5% (absolute) depending on the type of biogas	Biogenic Carbon Fraction of Biogas and Natural Gas Fuel Mixtures Determined with 14C	Biogas

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[11] Derived from a presentation by the European Commission, Key aspects of certifying Co-processed fuels, 10 July 2024

Table.5 List of different LSC methods used to determine the biocarbon fraction of a co-processed fuel[12]

Testing procedure	Method	Features	Confidence Interval	Source	Bio-feedstock used
General standard for ^{14}C through LSC	ASTM D6866-20 Method C -LSC with benzene as solvent	Standard Method	±3 wt.% (absolute) in the whole range of the detection limit	ASTM-D6866-21	-
Norton and Woodruff, 2012	Simplified LSC approach with different solvents	Unlike the conventional LSC method (i.e., benzene synthesis), the diesel samples were mixed directly with a fluor and then analysed in an LSC without further processing (counting time 180 min).	±0.4% vol. (absolute error) for samples containing 2–20% vol. renewable diesel in fuel blends	Simplified radiocarbon analysis procedure for measuring the renewable diesel concentration in diesel fuel blends.	Renewable diesel blends
Hurt et al, 2021	Simplified LSC approach vs AMS	No sample preparation, 5 h counting.	Detection limit of biocarbon 0.53-0.72%wt for LSC for samples with biocarbon content below 20% (with AMS the range is 0.14-0.3%). For samples with biocarbon >20%, detection limit is 1.33-1.41%.	Liquid Scintillation Counting Method for the Refinery Laboratory-Based Measurements of Fuels to Support Refinery Bio-Feed Co-Processing.	Renewable gasoline, jet, diesel
Bronic et al, 2017	Novel direct-LSC with different solvents	Novel method that uses liquids at different colours to construct modern and background calibration curves	Uncertainty ranges 0.17-1.6% at 5% bio-fraction, and at 50% bio-fraction ranges 0.6	Determination of biogenic component in liquid fuels by the ^{14}C direct LSC method by using quenching properties of modern liquids for calibration.	Pure vegetable oils and ethanol
NESTE (from Stakeholders Meeting)	DIN 51637	Direct count of the number of scintillation flashes (approved by Finnish authorities)	1.4 w% accuracy for bio in diesel and 0.8 w% for bio in gasoline (with lower efficiency at higher level because of the high number of flashes that the instrument can count)	NESTE	diesel samples up to 45 wt.% bio and gasoline up to 25 wt.% bio

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[12] Derived from a presentation by the European Commission, Key aspects of certifying Co-processed fuels, 10 July 2024