ISCC EU 205

GREENHOUSE GAS EMISSIONS

Document Title: ISCC EU 205 Greenhouse Gas Emissions

Version 4.0

Valid from: 1st July 2021

Note: From 1st July 2021, only the version 4.0 of this ISCC document is applicable. This version of the document has been submitted to the European Commission in the framework of the recognition process of ISCC EU under the legal requirements of the Renewable Energy Directive (EU) 2018/2001 (RED II). The recognition of ISCC EU in the framework of the RED II is pending. This ISCC document may be subject to change depending on further legislation and further requirements of the European Commission.

Content

Summary of Changes

The following is a summary of the mainchanges to the previous version of the document (ISCC EU System Document 205 v 3.0). The revision of the document is a major review in the framework of the rerecognition of ISCC under the Directive (EU) 2018/2001 (recast) (RED II). Minor amendments, e.g. corrections of phrasings and spelling mistakes, are not listed.

Summary of changes made in version 4.0	Chapter
General: All reference with regard to the RED refer to the Renewable Energy Directive (EU) 2018/2001 (recast) (also referred to as RED II)	
General: Amendments of chapter structure: • Deletion of chapter 4.3.6: "e_{ee} – emissions from excess electricity", in GHG formula and respectively in all other relevant parts of this document • Deletion of chapter 5 "Switching between different options of GHG information" • Division of chapter in 4.3.8 into two separate chapters	

Additions:
• "Following the requirements of the recast Renewable Energy Directive (2018/2001/EC), ISCC requires a minimum level of GHG savings for final biofuels, bioliquids and biomass fuels:
  ○ at least 50% for biofuels, biogas consumed in the transport sector, and bioliquids produced in installations in operation on or before 5 October 2015
  ○ at least 60% for biofuels, biogas consumed in the transport sector, and bioliquids produced in installations starting operation from 6 October 2015 until 31 December 2020
  ○ at least 65% for biofuels, biogas consumed in the transport sector, and bioliquids produced in installations starting operation from 1 January 2021
  ○ at least 70% for electricity, heating and cooling production from biomass fuels used in installations starting operation from 1 January 2021 until 31 December 2025, and 80% for installations starting operation from 1 January 2026.
  ○ The greenhouse gas emissions savings from the use of renewable liquid and gaseous transport fuels of non-biological origin shall be at least 70"
  ○ An installation shall be considered to be in operation once the physical production of fuel, heat or cooling, or electricity has started (i.e. once the production of fuels including biofuels, biogas or bioliquids, or production of heat, cooling or electricity from biomass fuels has started).
• "The document outlines the use of total and disaggregated default values and how the calculation of actual values is embedded in the ISCC system. Every chapter states the relevant requirements applicable to biofuels, bioliquids and biomass fuels."
• "Dependent on the type of fuel and the market in which it is consumed, different GHG calculation formulas apply:
  ○ biomass fuels are gaseous and solid fuels produced from biomass
  ○ bioliquids are liquid fuels produced from biomass which are used for purposes other than transport, such as electricity generation and heating and cooling
  ○ biofuels are liquid fuels used for transport which are produced from biomass.
• "In the following chapters, "feedstock" is defined as the input material and hence can either be a raw material or an intermediate product, depending on the scope of the receiving entity."
	2

Summary of changes made in version 4.0	Chapter
General: • "Greenhouse gas emissions from the production and use of biofuels, bioliquids and biomass fuels before conversion shall be calculated as: $E = e_{ec} + e_l + e_p + e_{td} + e_u – e_{sca} – e_{ccs} – e_{ccr}$" • Several references to bioliquids, biomass fuels and and Annex VI of RED II	3, footnotes
General: • Several inclusions of references to bioliquids and biomass fuels • Inclusion of requirements for biomass fuels • Footnote **Additions** • "The total default value (TDV) for GHG emission savings laid down in part A or B of Annex V and part A of Annex VI of the RED II can only be used if it reflects the production pathway, i.e. the raw material at the beginning of the supply chain and the process of the certified operator and el (emissions from land-use change) calculated according to chapter 4.3.2 of this document must equal to or less than zero. It is possible to use a combination of the DDV for cultivation and an individually calculated value for emissions from land-use change (el)." • "The TDV for palm oil biodiesel (with open effluent ponds) cannot be used, as the default GHG emission saving only accounts 20%. • "The TDV for biodiesel (palm) can be applied for all palm (oil) derivatives as intermediate products." • "Transport of raw material from the farm to the first gathering point (FGP) is included in the DDV element 'emissions from cultivation' (e_{ec})." • "Typical values published in the RED II cannot be used for certification"	3.1
General: • Inclusion of requirements for bioliquids and biomass fuels • Inclusion of formula element "e_u" in paragraph • Amendments in wording and updated references in paragraph of NUTS2 values **Additions:** • "It is not possible to calculate actual values retrospectively for elements of the upstream supply chain." • "In the absence of relevant information of NUTS2 values in non-EU country reports or information on disaggregated default values for cultivation emissions of agricultural biomass in the RED II Annex V and VI it is allowed to calculate averages based on local farming practices based for instance on data of a group of farms, as an alternative to using actual values." • "Estimates of emissions from cultivation and harvesting of forestry biomass may be derived from the use of averages for cultivation and harvesting emissions calculated for geographical areas at national level, as an alternative to using actual values." • "A switch between different GHG information approaches is only possible if all relevant information and data can be verified by the auditor. Therefore, conducting an individual calculation for upstream processes at a later stage of the supply chain is not permitted, because the relevant input data would not be verifiable. Switching to a disaggregated default value or a total default value is possible as long as the relevant information has been delivered by certified economic operators and a default value is provided in the RED II." • "(*) For e_{sca} a bonus of 45 g CO_2eq/MJ manure shall be attributed for improved agricultural and manure management in the case animal manure is used as a substrate for the production of biogas and biomethane."	3.2, footnotes
Additions:	

Summary of changes made in version 4.0	Chapter
• "(in case of agricultural crops the growing season must be included)" • "In cases of exceptional maintenance measures and unstable production conditions a shorter period (for inputs and respective outputs) may be considered if it better reflects the relevant timeframe. This can also be the case if within one year two crops are cultivated of which only one is unambiguously supplied in the biofuel sector." • "Overview of Standard Calculation Values" table provided by the European Commission" • "Whenever available, the EC standard calculation values shall be used." • "(…) or the supplier of the EF/LHV is ISCC/ISO certified" • Footnote	4.1
General: • ISCC Document 203 instead of 206 • Inclusion of reference to forestry biomass • Specification of requirements for GHG calculation and verification under group certification • Inclusion of moisture content calculation (previously chapter 4.3.1) **Additions:** • "The moisture contents of suppliers and recipients of sustainable material need to be consistent (e.g. between a farm/plantation and oil mill). If this is not measured after delivery, industry-wide accepted values e.g. derived from scientific databases can be applied as an alternative."	4.2
General: Change of sub chapters structure **Additions:** • (e.g. straw, crude glycerine)	4.3.1
General: • Specifications to calculate N2O field emission • Footnote **Additions:** • "The GHG emission formula for extraction or cultivation of raw materials e_{ec} includes all emissions (EM) from the extraction or cultivation process itself; including emissions from the collection, drying and storage of raw materials, from waste and leakages, and from the production of chemicals or products used in extraction or cultivation. The capture of CO_2 in the cultivation of raw materials is excluded" • "(…) an adapted EF for the type of renewable electricity may be used if that plant is not connected to the electricity grid. In the case that an electricity production plant is connected to the grid (e.g. a waste incineration plant), using the average emission value for electricity from that individual electricity production plant in the biofuel production process is permitted if it is guaranteed that there is a direct connection between the biofuel plant and the individual electricity production plant and that it is possible to validate the amount of electricity used with a suitable meter." • "N_2O emissions have to be calculated and included for both mineral and organic soils (if any)." • "As for Annex V of the RED II, for the purposes of calculating CO_2 equivalence, 1 g N_2O is equal to 298 g CO_2eq." • "For further guidance on the calculation of the N_2O emissions from the cultivation of the crop using IPCC Tier 1, System Users can use the BioGrace calculation tool. It provides details on the calculation of the N_2O emissions from the cultivation of the crop using IPCC Tier 1. It is also possible to make use of the Global Nitrous Oxide Calculator (GNOC) developed by the Joint Research Center for the biomass types not included in the BioGrace calculator."	4.3.1.1,

Summary of changes made in version 4.0	Chapter
• “When calculating GHG emissions on cultivation level also emissions from replanting activities and from activities on immature areas must be taken into account.”	

General: “raw material” instead of “product”
Additions:
• “For the calculation of N_2O-field emissions specifically:
  ○ Amount of N_2O-N produced from atmospheric deposition of N (ATD)
  ○ Amount N_2O-N produced from leaching, runoff of N (L)”
• “If case biomass is dried and stored in an external warehouse, these emissions also need to be taken into account.”
	4.3.1.2

General: • Formula for calculation including potential deduction of the bonus from restored degraded land “-eB” and respective new paragraph for requirements	4.3.2
General: • Inclusion of requirements for biomass fuels • Detailed specifications on the calculation and verification of e_{sca}	4.3.3
Addition: • “Emissions from transport and distribution, e_{td}, shall include emissions from the transport of raw and semi-finished materials and from the storage and distribution of finished materials.”	4.3.4
General: • Adaption of second formula to calculate transport emissions and clarification of application **Addition**: • “This approach needs to be replicated for each amount of material transferred via a different transport type. If all material is forwarded via one transport type, then amount of transported material in transport type is equal to the amount of all material transported”	4.3.4.1
General: • Inclusion of requirements for biomass fuels • Footnote	4.3.4.2
Addition: • “Emissions from processing, e_p shall include emissions from the processing itself; from waste and leakages; and from the production of chemicals or products used in processing including the CO_2 emissions corresponding to the carbon contents of fossil inputs, whether or not actually combusted in the process. Emissions from processing shall include emissions from drying of interim products and materials where relevant.“	4.3.5
General: • Inclusion of requirements for biomass fuels • Footnote	4.3.5.1
General: Inclusion of requirements for bioliquids and biomass fuels **Additions:** • “Combustion emissions of fossil methanol or other process catalysts containing methanol (e.g. potassium methylate) must also be taken into account and need to be reflected in the relevant emission factor and must be verified by the Certification Body.” • “Biogas plants must have a gas-tight digestate storage tank and a dosing unit with a weighing system.”	4.3.5.2,

Summary of changes made in version 4.0	Chapter
Additions: • "was effectively captured and safely stored in compliance with Directive 2009/31/EC" • "Emissions related to capturing and processing of CO_2 have to be taken into account in the calculation applying the appropriate emission factors for the energy consumed and the inputs used." • "e_{ccr}: Quantity of biogenic CO_2 captured for replacement of fossil CO_2 during the biofuel, bioliquid and biomass fuel production process" • "e_{ccs} : Quantity of CO_2 captured and stored for storage during the biofuel, bioliquid and biomass fuel production process"	4.3.6 (previously 4.3.7)
General: • "Biofuel feedstock factor "to "fuel feedstock factor"	4.3.7 (previously 4.3.8)
General: • Re-structuring of chapter and formulas • "Biofuel allocation factor"to "fuel allocation factor" • "Feedstock" instead of "input material" • Emission savings like e_{sca}, e_{ccr} and e_{ccs} need to be allocated to co-products • Inclusion of requirements for biomass fuels • Footnote	4.3.8,
General: • Adapted formulas to calculate savings for different markets and types of fuels • New fossil reference values • Inclusion of requirements for bioliquids and biomass fuels • Footnote **Additions:** • "A biofuel, bioliquid and biomass fuel is considered to be final, if no further processing of the material takes place" • "Should the exact distance for downstream transport and distribution not be known to the final processing unit, conservative assumptions must be made (e.g. transport distance to Europe and throughout Europe)." • "Disaggregated default values for transport and distribution are provided in sections D and E of Annex V and Annex VI of the RED II for certain final fuels. If a final fuel is produced for which no such values are available a conservative approach can be used and the highest value of the most logical choice from these tables can be used."	4.3.9,
General: • Re-structuring of chapter • Detailed specification of verification requirements for both default and actual GHG emission calculations	5
General: Update of emission factors **Addition:** • The following overview can be updated by ISCC when respective databases (e.g. BioGrace) provide new published values	Annex I

1. Introduction

Intention, Applicability. Legal background

The purpose of the document "Greenhouse Gas Emissions" is to explain the options for stating greenhouse gas (GHG) emission values along the supply chain and to provide the methodology, rules and guidelines for calculating and verifying GHG emissions and emission reductions.

The ISCC requirements regarding GHG emissions apply to all relevant supply chain elements from raw material production to the distribution of the final product, including cultivation or extraction, all processing steps, and the transport and distribution of intermediate and final products.

2 Scope and Normative References

GHG emission saving targets

Following the requirements of the recast Renewable Energy Directive (2018/2001/EC)[1], ISCC requires a minimum level of GHG savings for final biofuels, bioliquids and biomass fuels:

- at least 50% for biofuels, biogas consumed in the transport sector, and bioliquids produced in installations in operation on or before 5 October 2015
- at least 60% for biofuels, biogas consumed in the transport sector, and bioliquids produced in installations starting operation from 6 October 2015 until 31 December 2020
- at least 65% for biofuels, biogas consumed in the transport sector, and bioliquids produced in installations starting operation from 1 January 2021
- at least 70% for electricity, heating and cooling production from biomass fuels used in installations starting operation from 1 January 2021 until 31 December 2025, and 80% for installations starting operation from 1 January 2026
- The greenhouse gas emissions savings from the use of renewable liquid and gaseous transport fuels of non-biological origin shall be at least 70%

An installation shall be considered to be in operation once the physical production of fuel, heat or cooling, or electricity has started (i.e. once the production of fuels including biofuels, biogas or bioliquids, or production of heat, cooling or electricity from biomass fuels has started).

Relevant supply chain elements

For the following elements in the supply chain, information on GHG emissions must be provided:

a) Raw material production (extraction or cultivation)

[1] *In the following referred to as the RED II*

b) Processing units (companies that process raw materials/intermediate products and thereby change the physical or chemical properties of the input material)

c) Transport and distribution

The requirements for the calculation of GHG emissions throughout the supply chain and the verification requirements for auditors are explained in this document. The document outlines the use of total and disaggregated default values and how the calculation of actual values is embedded in the ISCC system. Every chapter states the relevant requirements applicable to biofuels, bioliquids and biomass fuels.

Types of fuels

Depending on the type of fuel and the market in which it is consumed, different GHG calculation formulas apply:

> *biomass fuels* are gaseous and solid fuels produced from biomass

> *bioliquids* are liquid fuels produced from biomass which are used for purposes other than transport, such as electricity generation and heating and cooling

> *biofuels* are liquid fuels used for transport which are produced from biomass.

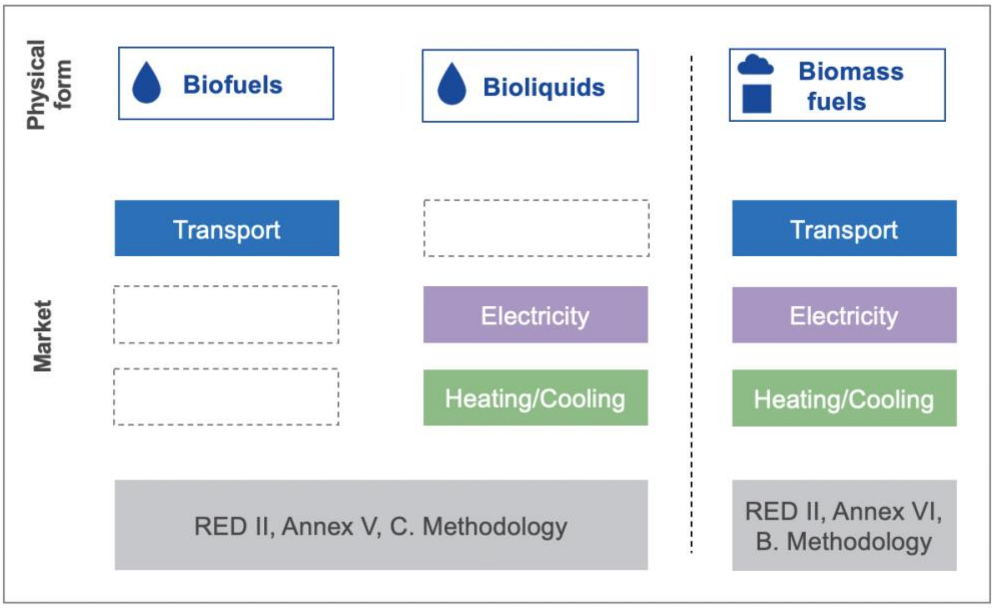

Figure 1: Overview of GHG calculation methodologies for different types of fuels and markets

Definition of feedstock

Figure 1 provides an overview on when which of both GHG calculation methodologies needs to be applied. This depends on the market the final fuel. Should be supplied in as well as the aggregate condition of the fuel. In the following chapters, "feedstock" is defined as the input material that is processed and hence can either be a raw material or an intermediate product, depending on the scope of the receiving entity.

As a basic principle, all relevant ISCC documents are valid for the scope of the application. The normative references display the documents to which the contents are linked and have to be considered.

3 Options for the provision of GHG information

The RED II[2] allows economic operators to calculate actual GHG emission values, to use total default values or to use a combination of disaggregated default values and calculated actual values.

Within ISCC there are different options for GHG information provision:

3.1. Use of total default values (TDV) OR

Use of disaggregated default values (DDV; which allow a combination of default values and actual values);

3.2. Use of actual values (individually calculated values).

GHG calculation formula

Greenhouse gas emissions from the production and use of biofuels, bioliquids and biomass fuels shall be calculated as[3] :

$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr}$

where

E *total emissions from the use of the fuel,*

e_{ec} *emissions from the extraction or cultivation of raw materials,*

e_l *annualised emissions from carbon stock changes caused by land-use change,*

e_p *emissions from processing,*

e_{td} *emissions from transport and distribution,*

e_u *emissions from the fuel in use*,

e_{sca} *emission savings from soil carbon accumulation via improved agricultural management,*

e_{ccs} *emission savings from CO_2 capture and geological storage,*

e_{ccr} *emission savings from CO_2 capture and replacement*

Emissions from the manufacture of machinery and equipment shall not be taken into account.

[2] *Annex V and VI of RED II*

[3] *Before conversion of bioliquids and biomass fuels into electricity or for heating/cooling, Annex V, C. Methodology, RED II*

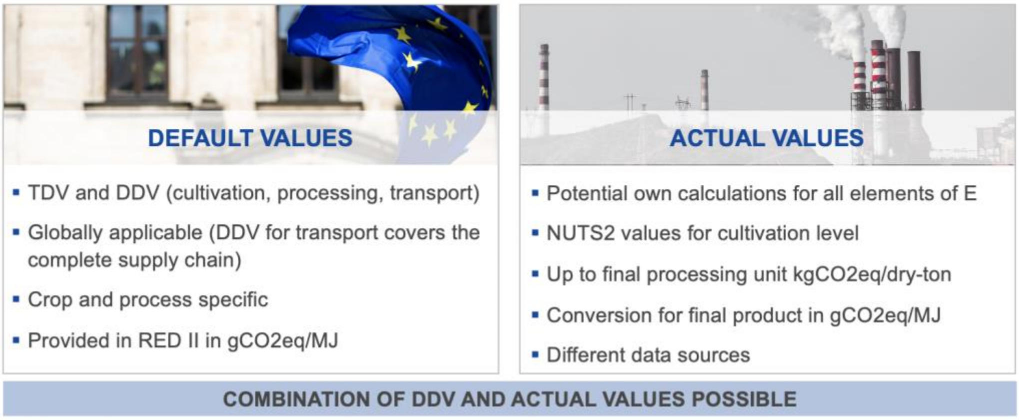

Figure 2: Overview of options to forward GHG values

Figure 2 reflects four options for forwarding GHG information through certified supply chains. The following chapter explains the different approaches in more detail, including practical implications.

3.1 Use of default values

Source of default values

Total default values and disaggregated default values are provided by the RED II in Annex V and Annex VI[4].
These default values reflect standardised biofuel, bioliquid and biomass fuel supply chains and processes, and are conservative estimates. Disaggregated default values are available for cultivation (e_{ec}), processing (e_p), and transport and distribution (e_{td}). Default values listed in Annex V and Annex VI can be applied only if the process technology and raw material used for the production of the biofuel match the respective scope of the default value. Certified economic operators can only use (disaggregated) default values if the following criteria are met:

Restrictions for the use of default values

> The total default value (TDV) for GHG emission savings laid down in part A or B of Annex V and part A of Annex VI of the RED II can only be used if it reflects the production pathway, i.e. the raw material at the beginning of the supply chain and the process of the certified operator and e_l (emissions from land-use change) calculated according to chapter 4.3.2 of this document must equal to or less than zero. It is possible to use a combination of the DDV for cultivation and an individually calculated value for emissions from land-use change (e_l).

Minimum level

> The TDV can only be used if the minimum level of GHG emission savings can be reached (see *chapter 2*), e.g. the total default value for palm oil biodiesel (with open effluent ponds) cannot be used, as the default GHG emission saving is only 20%.

---

[4] *The Corrigendum to Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources published on 25 September 2020 provides updated default values for some pathways.*

> The TDV for biodiesel (palm) can be applied for all palm (oil) derivatives as intermediate products.

> Transport of raw material from the farm to the first gathering point (FGP) is included in the DDV element 'emissions from cultivation' (e_{ec}).

> Typical values published in the RED II cannot be used for certification.

Forwarding total default values

If the *TDV* is applied, certified economic operators up to the final processing unit do not provide actual numbers for the GHG value but state "Use of total default value" on their Sustainability Declarations. The producer of the biofuel/bioliquid/biomass fuel states the TDV as provided in RED II in g CO_2eq per MJ of biofuel, the GHG emission savings in % and the start date of biofuel operations on the final sustainability declaration (=proof of sustainability "PoS"). The information on GHG emissions can be reported as an aggregate.

During the certification audit, the auditor needs to verify the suitability of the input material and process as well as the correct application of the total default value.

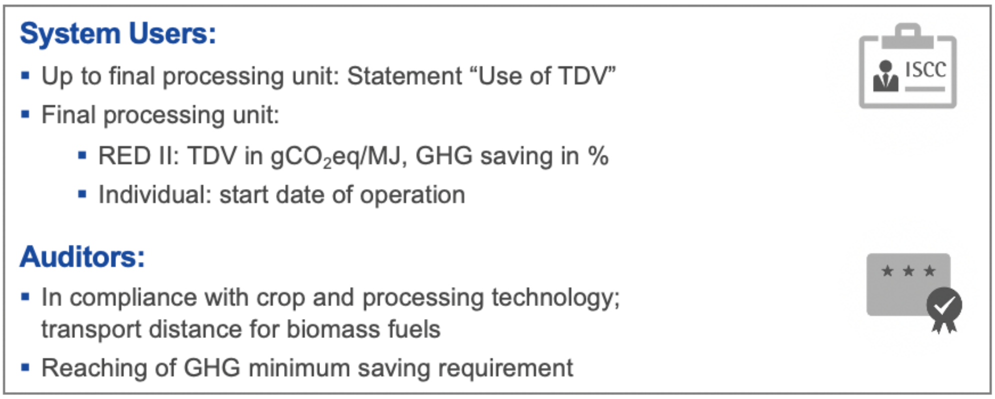

Figure 3: Application of total default values

If an economic operator in the supply chain cannot use the total default value, e.g. because one of the criteria referred to in the above figure 3 is not fulfilled, it may be possible under certain conditions to use individual calculation or disaggregated default values.

Use of disaggregated default values

The *disaggregated default values* are only provided for emissions from cultivation (e_{ec}), processing (e_p) and transport and distribution (e_{td})[5]. Using these values provides the possibility to combine disaggregated default values with actual values from individual GHG calculations. One example would be to use the disaggregated default value for the incoming raw material and calculate an individual GHG value for emissions from processing at the operational unit (assuming that the entity is either the first processing unit or an actual GHG value for earlier processing steps has been received). Another

[5] *In sections D and E of Annex V, as well as Section C of Annex VI of the RED II different disaggregated default values for biofuels, bioliquids and biomass fuels are provided*

option would be to combine an individual calculation for processing but apply the disaggregated default value for GHG emissions from transport & distribution.

Forwarding disaggregated default values

When using disaggregated default values for one or more elements of the calculation formula, certified economic operators up to the final processing unit have to state "Use of disaggregated default value" on their Sustainability Declarations. Figure 4 below shows key points to take into account when dealing with disaggregated default values.

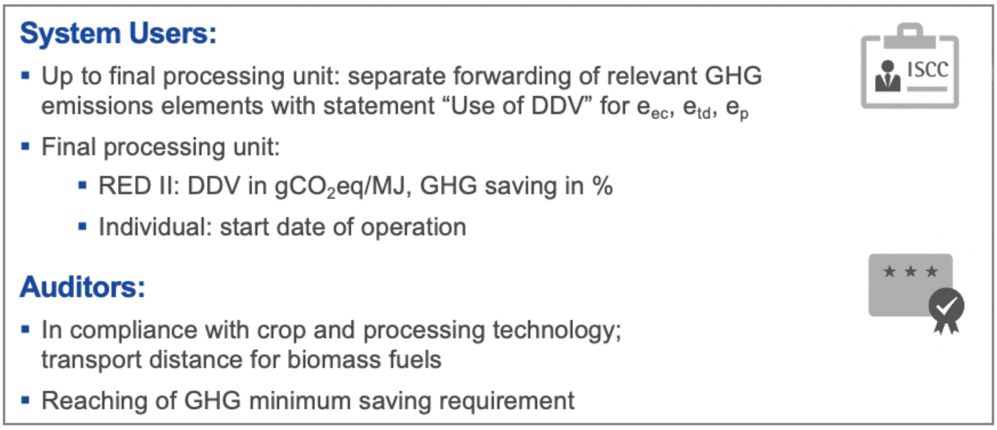

Figure 4: Application of disaggregated default values

Specific requirements for biomass fuels:

The operator can only apply default values for the production of the biomass fuel if the feedstock used, process technology as well as the transport distance reflect the pathway given in RED II.

Where biomethane is used as compressed biomethane as a transport fuel, a value of 4.6 gCO_2q/MJ biomethane needs to be added to the default values included in RED II, Annex VI.Use of actual values

3.2 Use of actual values

Individual calculation of GHG emissions

Individually calculated GHG values or *"actual values"* are calculated based on the RED II methodology (according to the methodology laid down in part C of Annex V and as well as part B of Annex VI) and ISCC's specifications as described in this document. Individual calculations of emissions must always be conducted at the point in the supply chain where they originate (e.g. emissions from cultivation can only be determined at the farm/plantation or the central office or the FGP of a group of farmers if all data is available there). It is not possible to calculate actual values retrospectively for elements of the upstream supply chain. For the calculation of "actual values" all relevant inputs of an economic operator must be considered.

Forwarding actual values

Certified economic operators who conduct an individual GHG calculation must always state the GHG values calculated for raw materials and intermediate products in kg CO_2eq/dry-ton of output on Sustainability Declarations[6]. The RED II requires information on actual GHG emission values to be provided for all relevant elements of the GHG emission calculation formula. It is therefore required that e_{ec}, e_l, e_p, e_{td}, e_u, e_{sca}, e_{ccs} and e_{ccr} are reported separately. Figure 5 summarizes the methodology how to forward actual valus in the supply chain.

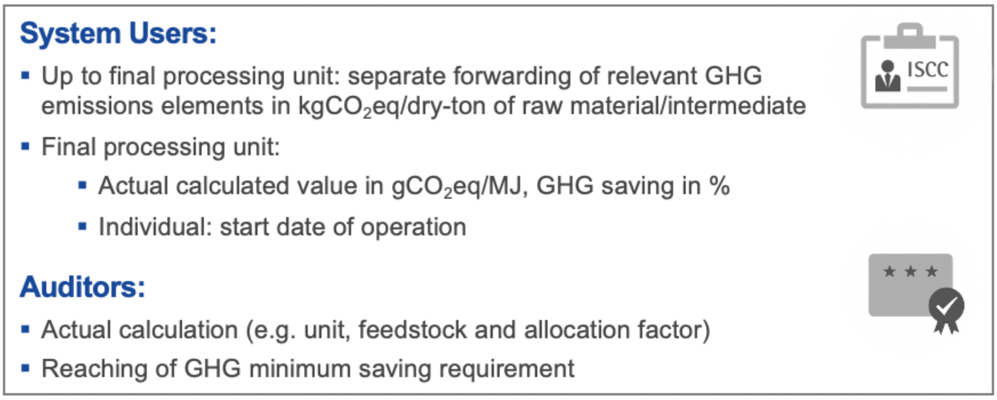

Figure 5: Application of actual values

Use of NUTS2 GHG values

For agricultural production, Member States or the competent authorities in third countries may have submitted reports to the Commission including data on typical emissions from the cultivation of feedstocks calculated on a regional level (NUTS2 or NUTS2 consistent region for non-EU countries). As laid out under Article 31(2) of the RED II, values from the "NUTS 2" reports submitted to the Commission by the Member States in accordance with Regulation (EC) No 1059/2003 of the European Parliament and of the Council can be used. Once the calculation of these values has been scrutinised by the Commission and approved by the EC through an Implementing Act, ISCC system users are allowed to apply these values as an alternative to actual values. Values need to be applied in the unit kg CO_2eq/dry-ton of feedstock. Any updates to the NUTS2 values by Member States which have not been included in the reports published before 2015 (pre-ILUC Directive), or the submission of new “NUTS2 equivalent values” for third countries, requires recognition by the EC. It is possible to use either the respective GHG value for the specific NUTS2 region (or the region in the third country) from which the raw material originates or to use the highest emission value from the Member State’s NUTS2 report (or the third country report) for specific raw material coming from that country.

Forwarding of NUTS2 values

Companies (farmers or FGPs/Central offices) using the emission values for cultivation provided in Member State Reports must provide the specific value in kg CO_2eq/dry-ton of raw material on their Sustainability Declarations as available on the Commission website.

[6] *Please see chapter 4.3.9 for specific requirements of final biofuel/bioliquid/biomass fuel producers*

Use of average GHG values

In the absence of relevant information on NUTS2 values in non-EU country reports[7] or information on disaggregated default values for cultivation emissions of agricultural biomass in the RED II Annex V and VI, it is permitted to calculate averages based on local farming practices based on, for example, data from a group of farms, as an alternative to using actual values.

Calculation and data

Estimates of emissions from cultivation and harvesting of forestry biomass may be derived from the use of averages for cultivation and harvesting emissions calculated for geographical areas at national level, as an alternative to using actual values. The methodology for calculating average GHG values can be the same as described in the chapter 4 “Requirements for individual GHG emission calculations”. The data should be updated over time unless there is no significant variability in the data over time. For emissions from agrochemical use, the typical type and quantity of agrochemical product used for the raw material in the region concerned may be utilised. Emissions from the production of agrochemicals should either be based on measured values or on the technical specifications of the production facility. When the range of emissions values for a group[8] of agrochemicals production facilities to which the facility concerned belongs is available, the most conservative emission number (highest) of that group shall be used. When a measured value for yields is used (as opposed to an aggregated value) for the calculations, a measured value for agrochemical input must also be used and vice versa.

Switching GHG information

A switch between different GHG information approaches is only possible if all relevant information and data can be verified by the auditor. Therefore, conducting an individual calculation for upstream processes at a later stage of the supply chain is not permitted, because the relevant input data would not be verifiable. Switching to a disaggregated default value or a total default value is possible as long as the relevant information has been delivered by certified economic operators and a default value is provided in the RED II.

Other recognised certification schemes

Options other than those described are not accepted under the RED II. All deliveries, including those from other recognised voluntary certification schemes, must comply with these requirements, otherwise they cannot be accepted.

---

[7] *Reports referred to in the RED II Article, 31(4) or information on disaggregated default values for cultivation emissions in the RED II Annex V,*

[8] *It refers to for example a situation where an economic operator knows that a certain company in a certain country produced the fertiliser. That company has a number of fertiliser production facilities in that country for which the range of processing emissions are known; an economic operator can claim the most conservative number of emissions from those group of fertiliser production facilities.*

Specific requirements for biomass fuels:

RED II, Annex VI, part c outlines the methodology market operators need to apply in the case of co-digestion of n substrates in a biogas plant for the production of electricity or biomethane. Actual greenhouse gas emissions of biogas and biomethane are calculated as follows:

GHG calculation methodology for biomass fuels

$$E = \sum_{l}^{n} S_n \cdot (e_{ec,n} + e_{td,feedstock,n} + e_{l,n} - e_{sca,n}) + e_p + e_{td,product} + e_u - e_{ccs} - e_{ccr}$$

where

E = *total emissions from the production of the biogas or biomethane before energy conversion;*

S_n = *Share of feedstock n, as a fraction of input to digester;*

$e_{ec,n}$ = *emissions from the extraction or cultivation of feedstock n;*

$e_{td,feedstock,n}$ = *emissions from transport of feedstock n to the digester;*

$e_{l,n}$ = *annualised emissions from carbon stock changes caused by land-use change, for feedstock n;*

e_{sca} = *emission savings from improved agricultural management of feedstock n (*);*

e_p = *emissions from processing;*

$e_{td,product}$ = *emissions from transport and distribution of biogas and/or biomethane;*

e_u = *emissions from the fuel in use, that is greenhouse gases emitted during combustion*

e_{ccs} = *emission saving from CO_2 capture and geological storage;*

e_{ccr} = *emission savings from CO_2 capture and replacement*

(*) For e^{sca} a bonus of 45 g CO_2eq/MJ manure shall be attributed for improved agricultural and manure management in the case animal manure is used as a substrate for the production of biogas and biomethane.

Emissions from the manufacture of machinery and equipment shall not be taken into account.

Specific requirements for bioliquids and biomass fuels:

Energy installations delivering heat/electricity

Greenhouse gas emissions from the production and use of **bioliquids** shall be calculated in the same way as for biofuels (E), but with an extension necessary for including the energy conversion to electricity and/or for use for heating and cooling. Hence, energy installations using bioliquids to deliver only heat, only electricity, or (useful) heat together with electricity and/or mechanical energy need to apply the methodology provided in the RED II, Annex V, C. Methodology, point b in addition to the formula stated above (E).

Greenhouse gas emissions from the use of **biomass fuels** for producing electricity, or used for heating and cooling, including the energy conversion to electricity and/or for use for heating or cooling shall be calculated according to the methodology as provided in the RED II, Annex VI, B. Methodology, point d.

For energy installations delivering **only heat**:

$EC_h = \frac{E}{\eta_h}$ For energy installations delivering only electricity:

For energy installations delivering **only electricity**:

$$EC_{el} = \frac{E}{\eta_{el}}$$

For the electricity or mechanical energy coming from energy installations delivering useful heat together with electricity and/or mechanical energy:

$$EC_{el} = \frac{E}{\eta_{el}} \left(\frac{C_{el} \cdot \eta_{el}}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right)$$

For the useful heat coming from energy installations delivering heat together with electricity and/or mechanical energy:

$$EC_h = \frac{E}{\eta_h} \left(\frac{C_h \cdot \eta_h}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right)$$

where:

$EC_{h,el}$ = *Total greenhouse gas emissions from the final energy commodity*

E = *Total greenhouse gas emissions of the fuel before end-conversion*

η_{el} = *The electrical efficiency, defined as the annual electricity produced divided by the annual energy input, based on its energy content*

η_h = *The heat efficiency, defined as the annual useful heat output divided by the annual energy input, based on its energy content*

C_{el} = *Fraction of exergy in the electricity, and/or mechanical energy, set to 100 % (C_{el}= 1)*

C_h = *Carnot efficiency (fraction of exergy in the useful heat)*

The Carnot efficiency, C_h , for useful heat at different temperatures is defined as:

$$C_h = \frac{T_h - T_0}{T_h}$$

where:

T_h = *Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery*

T_0 = *Temperature of surroundings, set at 273,15 kelvin (equal to 0 °C)*

If the excess heat is exported for heating of buildings, at a temperature below 150 °C (423,15 kelvin), C_h can alternatively be defined as follows:

C_h = *Carnot efficiency in heat at 150 °C (423,15 kelvin), which is: 0,3546*

For the purposes of that calculation, the following definitions apply.

> *cogeneration* shall mean the simultaneous generation in one process of thermal energy and electricity and / or mechanical energy;

> *useful heat* shall mean heat generated to satisfy an economical justifiable demand for heat, for heating or cooling purposes;

> *economical justifiable demand* shall mean the demand that does not exceed the needs for heat or cooling, and which would otherwise be satisfied at market conditions.

4 Requirements for individual GHG emission calculation

The following chapters describe how an individual calculation shall be conducted in the different steps of the supply chain. Chapter 4.1 describes the general requirements for data gathering and the type of data to be used in an individual calculation. Chapter 4.2 defines the relevant supply chain elements for an individual GHG calculation. In chapter 4.3 the calculation methodologies for the following elements are introduced in detail:

4.3.1: Emissions from the extraction or cultivation of raw materials (e_{ec})

4.3.2: Emissions from carbon stock changes caused by land-use change (e_l)

4.1 Data gathering

The GHG calculation methodology for individual calculations differentiates between the different elements in the supply chains, i.e. between agricultural producers (cultivation) and processing units. The calculation formula consists of actual data gathered from the individual (to be) certified company and data gathered from databases and literature.

Audit data gathering for individual calculation

Certification audit data gathering is relevant for actual input data, e.g. electricity or heat consumption, chemicals or fertilisers and for output data like wastewater production. Actual data measured and gathered at the system user must be documented and provided to the auditor for the verification. This can include field record systems, production reports, production information systems, delivery notes, weighbridge protocols, contracts, invoices and others. The calculation period should cover a full twelve-month period (in case of agricultural crops the growing season must be included). It must be as up to date as possible. As an alternative, it must cover the previous calendar or financial year. In cases of exceptional maintenance measures and unstable production conditions a shorter period (for inputs and respective outputs) may be considered if it better reflects the relevant timeframe. This can also be the case if within one year two crops are cultivated of which only one is unambiguously supplied in the biofuel sector. The respective period for data gathering and thus for the calculation of GHG emissions must be transparently displayed in the calculation. If, at the initial certification audit, no actual data is available (i.e. at the beginning of the production), “design data” can be used to conduct the individual calculation. Six months after the date of certificate issuance, certified economic operators must prove to their Certification Bodies that the values based on design data are appropriate. In case of deviations, new actual GHG values must be calculated, verified and used. After one year, the company has to switch from design data to actual data. This change is subject to the general recertification audit.

Inputs with little or no effect

If an input has little or no effect for the emission element of the calculation formula, it can be excluded from the emission calculation. Inputs with little or no effect are those that have an impact on the overall emissions of the respective calculation formula element (e.g. cultivation e_{ec}) that is lower than 0.5%.

Data sources for EF and LHVs

Published data includes the emission factors (EF), with which the respective input data are multiplied, and lower heating values. These have to be gathered from official sources, like the "Overview of Standard Calculation Values" table provided by the European Commission or Annex of this document I "List of emission factors and lower heating values (LHVs)".Whenever available, the EC standard calculation values[9] shall be used. Alternative values may be used but must be duly justified and flagged in the calculation documentation in order to facilitate verification by auditors. They can be based on Ecoinvent, BioGrace (recognised version) or individually calculated or measured (e.g. LHV could be measured through laboratory analyses) as long as the methodology for the GHG calculation complies with the methodology set in the RED II and is verifiable during the audit or the supplier of the EF/LHV is ISCC/ISO certified. If not available, other scientifically peer-reviewed literature or official statistical data from government bodies can be used. All data gathered from databases or literature shall be based on the most recent available sources and shall be updated over time. The source and the date of data collection shall be documented. Emission factors chosen or calculated shall also reflect the specific situation and set-up, e.g. if a process-specific input was produced in Europe then the emission factor for this input shall also reflect the European situation. It is the responsibility of the CB to confirm that alternative sources can be used by the System User.

4.2 Supply chain elements

System boundaries

An individual GHG emission calculation is not performed for the whole supply chain but only within the system boundary of a certified supply chain element. The following figure shows the supply chain elements responsible for calculating the individual elements of the calculation formula. Figure 6 shows at which step in the supply chain what kind of emissions can arise at the example of an agricultural supply chain:

> For agricultural supply chains the minmum requirements to be forwarded up to the final biofuel processor are eec, el (in case emissions from land use change in compliance with ISCC requirements took place), ep and etd

> For waste/residue supply chains the minmum requirements to be forwarded up to the final biofuel processor are ep and etd

> esca, eccr and eccs are voluntary additional savings and can only be forwarded if they are actually implemented and verified at the respective supply chain element

[9] *As published on the website of the European Commission*

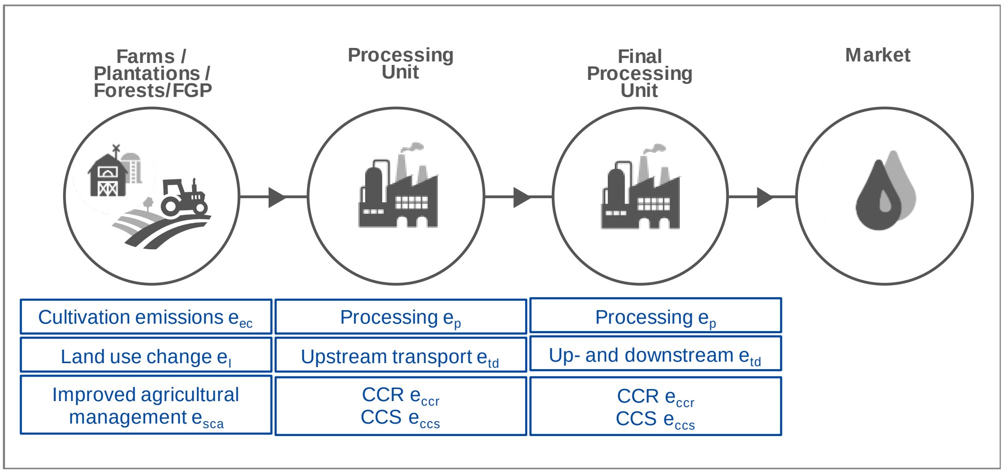

Figure 6: Relevant supply chain elements for an individual calculation for biofuels of the different elements of the calculation formula in an agricultural supply chain

Individual calculation for cultivation

Actual values of emissions from the extraction or cultivation of raw materials e_{ec} can only be determined at the origin of the chain of custody on the farm/ plantation level and for forestry biomass at the forest sourcing area level. Farmers and agricultural producers or FGPs/groups' central offices (on behalf of the farmers belonging to the group) can conduct an individual GHG emission calculation for e_{ec}. If, additionally, land-use change (e_l) has occured (that did not violate ISCC Principle I) or improved agricultural management (e_{sca}) is applied, these emissions (or savings in the case of e_{sca}) also need to be calculated at this step. If farms or plantations belong to a group, they can either conduct an individual GHG emission calculation for each farmer or one GHG emission calculation for the whole group. As highlighted in the EC Communication 2010/C160/01, group certification for the purpose of calculating GHG emissions is acceptable if the units have similar production systems and products.[10] The data basis for an individual calculation of a group is based on a sample of relevant individual input data. Data is gathered from the square root of all farms/plantations belonging to a group. The data gathering samples must take into account the different crops cultivated, regional specifics and the size of the individual farms. Sampling for the purpose of individual calculations must also be risk-based. This means that farms applying an individual calculation for GHG emissions need to be represented accordingly in the sample. The highest GHG emission value can be used for the whole group. Using the average of different GHG emission values is not permitted.

If during the validity of a certificate and prior recertification:

- further farmers are added to the supply base, the already calculated highest actual value can be used for the complete supply base. It is the responsibility of the FGP in the framework of the self assessment and internal audit to ensure that individual calculations comply with

[10] *For all requirements on on group certification see ISCC EU System Document 203 "Traceability and Chain of Custody"*

ISCC requirements. Samples of the individual calculations need to be verified latest in the upcoming recertification audit. The CB is responsible to choose farmers that become part of this sample (for more guidance please see the requirements as outlined in ISCC EU System Documents 203 "Traceability and Chain of Custody" and 204 "Risk Management").

- farmers would like to switch from a group certification setup the highest value is applied for all farmers to individual farm calculations it is the responsibility of the CB to decide if a respective switch can be allowed (i.e. because relevant GHG documentation is established, clear and traceable). It is the responsibility of the CB to decide if an on-site visit is necessary to verify compliance with ISCC requirements.
- in case all group members use the default value and would like to switch to an actual calculation, relevant requirements for group certification of this chapter need to be applied.
- any changes in the GHG methodology must be clearly documented by the economic operator and must be reported to the certification body before the adjustment.

Above stated adaptions should be reflected in the risk assessment of the System User and the CB, i.e. potentially leading to a higher risk in the next audit.

Individual calculation for processing units

If the certified economic operator is a processing unit, the emissions from processing (e_p) may be calculated. Actual values of emissions from processing can only be determined if emissions from all processing steps are recorded and transmitted through the chain of custody. During this step further emission savings such as CO_2 capture and geological storage (e_{ccs}) or CO_2 capture and replacement (e_{ccr}) are calculated if applicable.

Individual calculation for transport

Actual values of emissions from transport and distribution (e_{td}) can only be determined if emissions from all transport steps are recorded and transmitted through the chain of custody. Any recipient of physical material has to determine the upstream transport emissions (e_{td}) and has to transmit these values to the recipient of the material. The final processing unit also has to determine the downstream transport and distribution emissions to the final market (including the filling station).

Moisture factor

All elements need to provide emissions in $kgCO_2eq$/dry-ton throughout the supply chain up to the final biofuel producer. Therefore, the emissions are either divided by the amount of dry feedstock or they are calculated by applying a moisture factor:

$$e\ \ feedstock\left[\frac{kg\ CO_2eq}{ton_{dry}}\right] = \frac{e\ \ feedstock\left[\frac{kg\ CO_2eq}{ton_{moist}}\right]}{(1 - moisture\ content)}$$

The moisture content should be the value measured after delivery, or, if this is not known, the maximum value allowed by the delivery contract. The moisture contents of suppliers and recipients of sustainable material need to be consistent (e.g. between a farm/plantation and oil mill). If this is not measured after delivery, industry-wide accepted values e.g. derived from scientific databases can be applied as an alternative.

If at any point of the chain of custody emissions have occurred and are not recorded, so that the calculation of an actual value is no longer feasible for operators downstream in the chain of custody, this must be clearly indicated in the Sustainability Declarations.

4.3 Calculation methodology

4.3.1 Emissions from the extraction or cultivation of raw materials (e_{ec})

Applicability of e_{ec}

Emissions from the extraction or cultivation of raw materials apply to all agricultural raw materials, such as rapeseed/canola, palm, soybean, wheat, corn/maize and sugarcane. If wastes or residues (e.g. straw, crude glycerine) are used as a raw material in a process, the GHG emissions of extraction or cultivation of the raw material are considered to be zero and emissions at the point of origin of the waste or residue are zero.

4.3.1.1 Calculation formula for extraction or cultivation of raw materials

Sum of emissions from cultivation or extraction

The GHG emission formula for extraction or cultivation of raw materials e_{ec} includes all emissions (EM) from the extraction or cultivation process itself; including emissions from the collection, drying and storage of raw materials, from waste and leakages, and from the production of chemicals or products used in extraction or cultivation. The capture of CO_2 in the cultivation of raw materials is excluded:

$$e_{ec}\left[\frac{kg\ CO_2eq}{ton}\right] = \frac{\left(EM_{fertiliser} + EM_{N2O} + EM_{inputs} + EM_{diesel} + EM_{electricity}\right)\left[\frac{kg\ CO_2eq}{ha * yr}\right]}{yield\ raw\ material\ \left[\frac{ton}{ha * yr}\right]}$$

Division by yield

The sum of GHG emissions from fertilisers, plant protection products, seeds, diesel and electricity (EM, here in kg CO_2eq per ha and year) is divided by the yield of raw material in tons per ha and year in order to receive the specific GHG emission per ton of raw material. For all types of raw materials, the yield shall refer to the dry matter content. If not calculated per dry ton directly a correction is required (please find the formula in chapter 4.2).

Emissions of individual inputs (EM)

The emissions of the different inputs (EM) are calculated by multiplying the input data with the respective emission factors. Care must be taken that units of on-site gathered data and data used from recognised sources are the same.

$$EM_{diesel} = diesel\ consumption\ \left[\frac{l}{ha * yr}\right] * EF_{diesel}\left[\frac{kg\ CO_2eq}{l}\right]$$

For calculating EM_{diesel} the diesel consumption of all activities during field-preparation, cultivation, harvest or further processing of the raw material must be determined and multiplied with the emission factor (EF) for diesel.

EM_{diesel}

$$EM_{electricity} = electricity\ consumption\left[\frac{kWh}{ha * yr}\right] * EF_{electricity}\left[\frac{kg\ CO_2eq}{kWh}\right]$$

If electricity is consumed from the grid, the emission factor of the regional electricity mix ($EF_{electricity}$) shall be used. In the case of the EU the most logical choice is the whole EU. If electricity from renewable energies is directly consumed (i.e. not supplied from the grid), an adapted EF for the type of renewable electricity may be used if that plant is not connected to the electricity grid. In the case that an electricity production plant is connected to the grid (e.g. a waste incineration plant), using the average emission value for electricity from that individual electricity production plant in the biofuel production process is permitted if it is guaranteed that there is a direct connection between the biofuel plant and the individual electricity production plant and that it is possible to validate the amount of electricity used with a suitable meter.

$EM_{electricity}$

$$EM_{input} = input\left[\frac{kg}{ha * yr}\right] * EF_{input}\left[\frac{kg\ CO_2eq}{kg}\right]$$

EM_{input} refers to seed and plant protection products. The unit for EM_{input} is always kg active ingredient of the plant protection product.

EM_{input}

$$EM_{fertiliser} = fertiliser\ input\left[\frac{kg\ nutrient}{ha * yr}\right] * EF_{production}\left[\frac{kg\ CO_2eq}{kg\ nutrient}\right]$$

The amount of fertiliser used always refers to the main nutrient/active ingredient (e.g. nitrogen).

$EM_{fertiliser}$

- For *synthetic fertilisers* (e.g. P_2O_5, K_2O, CaO) $EF_{production}$ is relevant and must be applied.
- For *synthetic nitrogen fertilisers*, in addition to $EF_{production}$, N_2O-field emissions have to be calculated.

$$EM_{N2O}\left(\frac{kgCO2eq}{ha}\right) = \left[E_{N2O-direct}\left(\frac{kg\ N2O}{ha}\right) + E_{N2O-indirect}\left(\frac{kgN2O}{ha}\right)\right] * 298$$

For *organic nitrogen fertilisers* and *crop residues* left on the field **N_2O-field emissions** must be calculated. The IPCC methodology must be applied to ensure that N_2O emissions from soils are taken into account, including what are described as both “direct” and “indirect” N_2O emissions of synthetic and organic nitrogen fertilisers and crop residues.[11] All three IPCC Tiers can be used by economic operators. For the calculation of the N_2O-field emissions

N_2O-field emissions

[11] *IPCC guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11, http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf and “2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories”*

according to IPCC Tier 1 methodology, the “Annotated example of a GHG calculation using the EU Renewable Energy Directive methodology” provides further practical guidance.[12] N_2O emissions have to be calculated and included for both mineral and organic soils (if any).

The following approaches can be applied to calculate N_2O-field emissions:

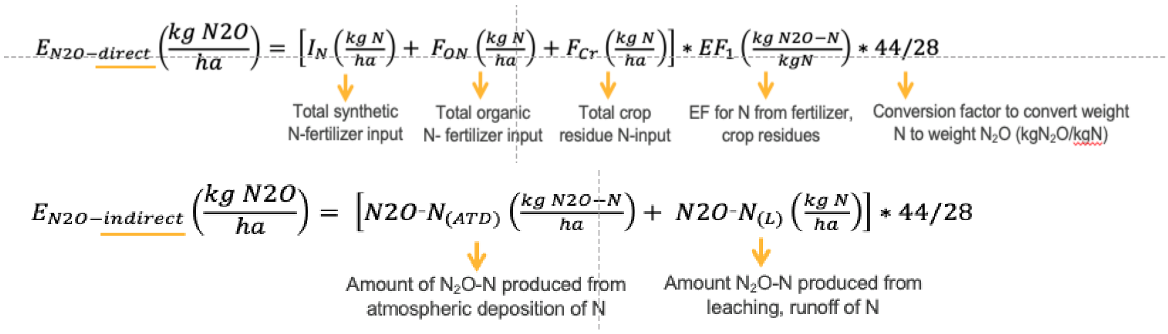

Figure 7: Overview of calculation of direct and indirect N_2O field-emissions based on IPCC Tier 1 calculation

As stated in Annex V of the RED II, 1 g N_2O is equal to 298 g CO_2eq for the purposes of calculating CO_2 equivalence.

For further guidance on the calculation of N_2O emissions from the cultivation of crops using IPCC Tier 1, System Users can use the BioGrace calculation tool. It is also possible to make use of the Global Nitrous Oxide Calculator (GNOC) developed by the Joint Research Center for types of biomass not included in the BioGrace calculator.

Replanting activities

When calculating GHG emissions on cultivation level emissions from replanting activities and from activities on immature areas must also be taken into account.

4.3.1.2 Data basis

On-site data gathering

Relevant input data for cultivation

The following data for the calculation of GHG emissions from cultivation must be gathered on-site. They will form the basis for the calculation of GHG emissions for an individual crop. All input values must be gathered for the same reference area and time period. In the example below the time period of 1 year (yr) and the reference area of 1 hectare (ha) are used.

> Amount of seeds in kg seeds per ha and yr

> Amount of plant protection products (PPP) in kg active ingredient per ha and year (e.g. kg glyphosate/(ha*yr))

> Amount of synthetic fertilisers: phosphorus (P_2O_5), potassium (K_2O), lime (CaO), and nitrogen (N) fertiliser in kg nutrient per ha and year (e.g. kg nitrogen/(ha*yr))

[12] https://ec.europa.eu/energy/sites/ener/files/2010_bsc_example_ghg_calculation.pdf

> Amount of organic nitrogen (N) fertilisers in kg N/(ha*yr)

> Amount of crop residues in kg N /(ha*yr)

> For the calculation of N_2O-field emissions specifically:

   - Amount of N_2O-N produced from atmospheric deposition of N (ATD)
   - Amount N_2O-N produced from leaching, runoff of N (L)

> Diesel consumption, electricity consumption and other energy consumption (for any work related to the cultivation and drying of biomass).

> If biomass is dried and stored in an external warehouse, these emissions also need to be taken into account.

> Yield of the raw material in ton/(ha*yr) moist and moisture content to determine yield of dry matter. If moisture content or yield of dry matter are not known, emissions can be calculated based on moist yield and adapted by applying a moisture factor (see 4.2). Therefore, the moisture content should be measured after delivery to the first gathering point or be based on the maximum value allowed by the delivery contract with the first gathering point

In the case that further emission-relevant inputs are used during cultivation, the relevant amounts per ha and time period must be documented and included in the calculation.

Published data

Relevant emission factors

The following data for the calculation of GHG emissions are normally gathered from literature or other officially recognised or certified sources:

> Emission factors (EF) for seed in kg CO_2eq/kg seed

> Emission factors for plant protection products in kg CO_2eq/kg active ingredient

> Emission factors for synthetic fertilisers reflecting the emissions of production, extraction and processing of the fertilisers in kg CO_2eq/kg nutrient (to be applied for P_2O_5, K_2O, CaO, and synthetic N fertiliser)

> Emission factor for field emissions of all nitrogen fertilisers including synthetic and organic N fertiliser and crop residues in kg CO_2eq/kg N (EF_{field})

> Emission factors for diesel, electricity or other energy source in kg CO_2eq per unit of energy used

Forwarding of e_{ec}

After calculating the GHG emissions per dry-ton of raw material, the certified agricultural producers or FGPs/Central offices (on behalf of the farmers belonging to the group) forward the GHG information for e_{ec} in kg CO_2eq/dry-ton raw material together with the agricultural raw material itself to the recipient.

4.3.2 Emissions from carbon stock changes caused by land-use change (e_l)

Definition and reference year land use change

Land-use change is a change from one of the following IPCC land cover categories: forest land, grassland, wetlands, settlements, or other land, to cropland or perennial cropland[13]. 'Cropland' and 'perennial cropland' (specified as palm and short rotation coppice) shall be regarded as one land use. GHG emissions from land-use change (e_l) between the five land categories to cropland or perennial cropland taking place after the cut-off date of 1 January 2008 and in compliance with ISCC sustainability principle 1 (see ISCC EU System Document 202-1 “Agricultural Biomass – ISCC Principle 1”) must be taken into account. A change in cropland structure, management activities, tillage practices, or manure input practices is not considered land-use change.

For calculating emissions in kg CO_2eq/dry-ton of raw material, the carbon stock of the actual land use (CS_A) is subtracted from the carbon stock of the reference land use (prior to the land-use change) (CS_R). The result is divided by the yield of raw material (which is measured as dry matter or by adapting the emissions value by applying a moisture factor (see 4.2)) and annualised over 20 years. In order to convert the carbon (C) to CO_2eq-emissions, the conversion factor of 3.664 must be applied. The following formula needs to be applied:

Formula for e_l

$$e_l\left[\frac{kg\ CO_2eq}{ton}\right] = \left(\frac{CS_R\left[\frac{kg\ C}{ha}\right] - CS_A\left[\frac{kg\ C}{ha}\right]}{yield\ raw\ material\left[\frac{ton}{ha * yr}\right] * 20\ [yr]} * 3.664\right) - eB$$

As the total carbon stock change is annualised over 20 years, the GHG emissions from land-use change must be considered for a period of 20 years after the land-use change took place. The reference land use (CS_R) and the actual land use (CS_A) are defined by the mass of carbon in the soil and vegetation per unit of land:

CS_R= The carbon stock per unit area associated with the reference land use (land carbon stock before conversion into agricultural land) measured as mass (tons) of carbon per unit area, including both soil and vegetation. The reference land use shall be the land use in January 2008 or 20 years before the raw material was obtained, whichever is more recent;

CS_A= the carbon stock per unit area associated with the actual land use (carbon stock per unit of land after conversion into agricultural land)

[13] *Perennial crops are defined as multi-annual crops, the stem of which is usually not annually harvested such as short rotation coppice and oil palm.*

measured as mass (tons) of carbon per unit area, including both soil and vegetation. In cases where the carbon stock accumulates over more than one year, the value attributed to CS_A shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever is earlier;

The carbon stock (CS) of land use i (reference or actual) per unit area takes into account the soil organic carbon as well as the carbon of the vegetation:

Formula for CS

$$CS_i = \left(SOC + C_{veg}\right) * A$$

A is referring to the converted area (is 1 if whole area is subject to conversion).

C_{veg} is zero fro cropland

C_{veg} is the above and below ground carbon stock of the vegetation. The vegetation value for cropland is zero[14]. The soil organic carbon (SOC) consists of four factors, which depend on climate, soil type, management practice and C-input practice: the standard soil organic carbon in the 0-30 cm topsoil layer (SOC_{ST}), the land use factor (F_{LU}), the management factor (F_{MG}) and the input factor (F_i):

Formula for SOC

$$SOC = (SOC_{ST} * F_{LU} * F_{MG} * F_i)$$

Forwarding of e_l

Together with the batch of the respective agricultural raw material, the supplier forwards the actual GHG value for land-use change e_l in kg CO_2eq/dry-ton raw material to the recipient.

The RED II also provides the option for a GHG bonus if degraded land is restored:

Bonus "severely degraded land"

e_B= bonus of 29 g CO_2eq/MJ for biofuel, bioliquid, biomass fuel if biomass is obtained from restored degraded land

The bonus of 29 g CO_2eq/MJ can only be applied and attributed if evidence is provided that the land:

> was not in use for agriculture or any other activity in January 2008; and

> is severely degraded land, including land that was formerly in agricultural use.

The bonus of 29 g CO_2eq/MJ shall apply for a period of up to 20 years from the date of conversion of the land to agricultural use, provided that a steady increase in carbon stocks as well as a sizable reduction in erosion phenomena for land falling under severely degraded land are ensured. *Severely degraded land* means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded (e.g. characterised by soil erosion, significant loss of soil quality or biodiversity).

[14] *EC Communication 2010/C160/02 from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels. Brussels.*

Forwarding of e_b

Auditors need to verify on farm/plantation level during the farm audit if the requirements stated above are fulfilled so that the bonus can be applied. If a farm/plantation is compliant with these requirements, the respective information needs to be forwarded through the supply chain via Sustainability Declarations and the final biofuel producer can deduct the bonus from the total GHG value of the final product in the final biofuel proof of sustainability (PoS).

4.3.3 Emission saving from soil carbon accumulation via improved agricultural management (e_{sca})

The RED II allows the use of emissions savings, e_{sca}, due to carbon accumulation in soil driven by the adoption of improved agricultural management. According to the "*Communication from the Commission on the practical implementation of EU Biofuels and bioliquids sustainability scheme and on counting rules of biofuels (COMM 2010/C 160/02)",* improved agricultural management refers to practices that may increase carbon content in soil, such as:

> Shifting to reduced or zero-tillage.

> Improved crop rotations and/or cover crops, including crop residues management.

> Improved fertiliser or manure management (e.g. use of organic fertilisers).

> Use of soil improver (e.g. compost, manure fermentation digestate).

How to calculate e_{sca}

According to the Annex II of the Communication[15], e_{sca} has to be calculated as follows:

$$e_{sca}\left[\frac{kg\ CO_2eq}{dry - ton}\right] = \frac{CS_R\left[\frac{kg\ C}{ha}\right] - CS_A\left[\frac{kg\ C}{ha}\right]}{yield\ raw\ material\ \left[\frac{dry - ton}{ha * yr}\right] * \mathrm{n}\ [yr]} * 3.664$$

CS_R and CS_A refer to the carbon stock of the reference land use (R) and the actual land use (A). They are calculated as shown in the chapter 4.3.2 "Land use change". As an alternative to calculate SOC with standard values, it is also possible "to use other appropriate methods […] to determine *SOC*. As far as such methods are not based on measurements, they shall take into account climate, soil type, land cover, land management and inputs".[13] The result is divided by the yield of the raw material (either refers to dry matter or emissions must be adapted by applying a moisture factor (see 2nd formula in 4.3.1.2) and annualised over the period of cultivation of the raw material (n). In case the IPCC methodology is applied, n is 20.

[15] *COMM 2010/C 160/02*

The three following options can be applied for the calculation:

Three options

> IPCC methodology, as defined in 2006 guidelines. The adoption of improved agricultural management practices must be addressed under the IPCC "cropland remaining cropland" framework

> Field measurements

> Field measurements combined with crop and soil modelling

General provisions must be taken into account for either option applied:

Restrictions on use of esca

> Emission savings from such improvements can be taken into account if evidence is provided that the above-mentioned practices were adopted **after January 2008**.

> The actual values for e_{sca} have to be calculated at individual farm level, i.e. it is not allowed to use a regional approach. This can result **in different e_{sca} values per farmer.** In case of non-homogenous soil, climate or management practice(s), soil organic carbon values have to be estimated for each single field the farmer owns or rents and e_{sca} has to be calculated at farm level.

> **Solid and verifiable evidence for each individual farmer who claims e_{sca}** must be provided that soil carbon has increased or that they are implemented in best practice so that an increase in soil carbon can be expected over the period in which the raw materials concerned were cultivated.

> **Increased use of agrochemicals for pest control (e.g. herbicides), due to the application of improved agricultural practices must be considered** in terms of overall GHG emissions from cultivation. For example, shifting from conventional to no-tillage prevents the mechanical control of weeds through tillage. Also, leaving crop residue in the field, without post-harvest incorporation in soil, may significantly increase the risk of spreading plant diseases to the next crop in rotation. To avoid such problems, the switch to no-tillage practices will most likely result into an increase in agro-chemicals input that must be accounted. Additionally, for organic fertilizers N_2O emissions must be calculated.

> The Improved agricultural management practices must be applied **continuously** for at least three years successively if the economic operators would like to account for e_{sca}. This means that it is not allowed to switch every year management practices when e_{sca} is claimed.

> If farmer rotates the improved agricultural management practices among fields, e_{sca} can be claimed **only to fields where the cultivation of bioenergy crop takes place on that year**.

- If two or more crops are grown in the same field over the same year/agricultural season, e_{sca} savings has to be divided among all crops that could dedicated to bioenergy production within the same year/agricultural season, e.g. soybeans, wheat, corn. This applies only to the harvested part of the crops, not to hay nor residues.
- **Averaging** of emission values from farmers applying e_{sca} and farmers not applying e_{sca} **is not allowed**, and only those farmers who apply e_{sca} measures are allowed to forward respective values together with the batch of sustainable material.
- Only changes in SOC are taken into account, hence reference and actual carbon stocks (CS_R and CS_A) are expressed as reference and actual soil organic carbon, SOC_R and SOC_A respectively. Therefore, CS and SOC are used synonymously in this chapter.
- SOC_R must be set before the improved agriculture management is applied. In absence of that, changes in soil organic carbon (and their magnitude) cannot be detected.
- In the case of the **IPCC method**, SOC_R and SOC_A are defined by the standard values. For field measurements and combined field measurements and modelling methods, the first field measurement defines SOC_R, then SOC_A is measured periodically.
- In contrast to a direct avoidance of GHG emissions, the increase of SOC as a climate protection measure is only effective if carbon storage is long-term and the corresponding amount of CO_2 is thus removed from the atmosphere for the foreseeable future. Changes in the agricultural practices can completely reverse the positive effect of the SOC build-up. Hence, **a long-term commitment of the farmer is encouraged.** ISCC reserves the right to reject certain improved agricultural practices if scientific evidence shows that these practices will not sequester the SOC in the long run.

Forwarding of e_{sca}

Together with the batch of the respective agricultural raw material, the supplier forwards the actual GHG value for soil carbon accumulation via improved agricultural management e_{sca} in kg CO_2eq/dry-ton raw material to the recipient.

Specific requirements for biomass fuels:

For e_{sca} a bonus of 45 g CO_2eq/MJ manure shall be attributed for improved agricultural and manure management in the case animal manure is used as a substrate for the production of biogas and biomethane. Auditors need to verify during the audit at the biogas plant if the bonus can be applied. In case of compliance, respective information needs to be forwarded throughout the supply chain via Sustainability Declarations and the final biofuel producer can deduct the bonus in the final biofuel proof of sustainability (PoS). Auditors need to verify at the processing unit if the above stated requirement is fulfilled so that the bonus can be applied. In case of compliance, respective information needs to be forwarded throughout the supply chain via Sustainability Declarations and the final biofuel producer can deduct the bonus in the final biofuel proof of sustainability (PoS) from the total GHG value of the final product.

4.3.4 Emissions from transport and distribution (e_{td})

Emissions from transport and distribution, e_{td}, shall include emissions from the transport of raw and semi-finished materials and from the storage and distribution of finished materials.

4.3.4.1 Calculation formula for transport emissions

GHG emissions from upstream transport of the feedstock or downstream transport of the product e_{td} can be calculated based on the following formula:

Formula for e_{td}

$$e_{td}\left[\frac{kg\ CO_2eq}{ton}\right] = \frac{T_{needed} * \left(d_{loaded}[km] * K_{loaded}\left[\frac{l}{km}\right] + d_{empty}[km] * K_{empty}\left[\frac{l}{km}\right]\right) * EF_{fuel}\left[\frac{kg\ CO_2eq}{l}\right]}{amount\ transported\ material\ [ton]}$$

In order to find out how often a transport system was used for the transported amount, T_{needed} must be calculated. If e.g. amount is received in wet-ton, this value is calculated by dividing the amount of transported goods (wet) by the loading weight of the transport system used, e.g. if 100 tons of input material is transported by trucks which can carry 20 tons, 5 trucks (T_{needed} = 5) would be needed to transport all the feedstock. The sum of the fuel consumption of loaded transport and empty transport (if applicable) is multiplied with the number of times this transport system is being used and the emission factor of the fuel. Afterwards emissions are adapated to dry-matter.

As an alternative, the methodology for ton-km may also be used:

Alternative formula for e_{td}

$$e_{td}\left[\frac{kg\ CO_2eq}{ton}\right] = \frac{(amount_{transported\ material\ in\ transport\ type}[ton] * distance_{transported}[km]) * EF_{transport\ type}\left[\frac{kg\ CO_2eq}{tkm}\right]}{amount\ transported\ material\ in\ transport\ type\ [ton]}$$

The amount of transported feedstock is multiplied by the total distance and an emission factor in ton-km for the transport type. This approach needs to be replicated for each amount of material transferred via a different transport type. If all material is forwarded via one transport type, then amount of transported material in transport type is equal to the amount of all material transported.

Upstream and downstream transport

As processing units calculate upstream transport emissions in kg CO_2eq/dry-ton feedstock but have to provide GHG values in terms of the output they deliver as sustainable, emissions need to be adapted to determine kg CO_2eq/dry-ton of product by applying the feedstock factor. In chapter 4.3.7

and 4.3.8 the methodologies for converting and allocating upstream emissions are described.

4.3.4.2 Data basis

On site data gathering

Relevant input data for transport

For the calculation of e_{td} the following information needs to be provided through on-site data gathering. All input values must be gathered for the same time period.

> Transport distance (d) loaded/empty respectively (return transports that are empty do not need to be taken into account),

> Mode of transport (e.g. diesel truck, 40t) and,

> Amount of product transported.

Published data

Relevant published data

The following factors must be drawn from the "ISCC list of emission factors" (see Annex 1 of this document) or from another recognised/certified source:

> Fuel consumption of the respective mode of transport per km when loaded K_{loaded} in l per km,

> Fuel consumption of the respective mode of transport per km when empty K_{empty} in l per km,

> Emission factor fuel (EF_{fuel}) in kg CO_2eq per l fuel,

> As an alternative, an emission factor based on ton-km transported can also be used and multiplied with the amount transported and the distance [kg CO_2eq/t-km].

> As an alternative to using fuel consumption data from literature, fuel consumption can also be measured by the logistics providers and provided to the economic operator who is in charge of calculating emissions from transport. The reports from the logistics provider must be verified.

Forwarding of e_{td}

Together with the batch of the respective material, the supplier forwards the actual GHG value for transport and distribution e_{td} in kg CO_2eq/dry-ton product to the recipient.

Specific requirements for biomass fuels:

Gas losses occurring from the transport of gas in the transmission and distribution infrastructure (gas grid) must be included in the scope of the GHG emissions savings calculation. A standard industry factor can be applied for this purpose. System Users can use examples as published by MarcoGaz[16] or the DBFZ[17] or alternative factors.

4.3.5 Emissions from processing (e_p)

Emissions from processing, e_p, shall include emissions from the processing itself, from waste and leakages, and from the production of chemicals or products used in processing, including the CO_2 emissions corresponding to the carbon content of fossil inputs, whether or not actually combusted in the process. Emissions from processing shall include emissions from drying of interim products and materials where relevant.

4.3.5.1 Calculation formula for processing emissions

Sum of emissions from processing

The calculation must be based on the following formula:

$$e_p \left[\frac{kg\ CO_2eq}{ton}\right] = \frac{\left(EM_{electricity} + EM_{heat} + EM_{inputs} + EM_{wastewater}\right)\left[\frac{kg\ CO_2eq}{yr}\right]}{\text{yield product}\left[\frac{ton}{yr}\right]}$$

For all types of products, the yield shall refer to the dry matter content. If not calculated per dry ton directly a correction needs to take place (please find the formula in chapter 4.2).

Emissions of individual inputs (EM)

The emissions of the different inputs (EM) must be calculated according to the formulas below and divided by the yield of the main product.

Formula components for calculating EM are:

$$EM_{electricity} = electricity\ consumption \left[\frac{kWh}{yr}\right] * EF_{regional\ electricity\ mix}\left[\frac{kg\ CO_2eq}{kWh}\right]$$

$EM_{electricity}$

If electricity is sourced externally from the grid, the emission factor for electricity from the regional electricity mix shall be used (average emission intensity for a defined region, $EF_{regional\ electricity\ mix}$). In the case of the EU the most logical choice is the whole EU. If electricity from renewable energies is directly consumed (i.e. not connected and supplied from the grid), an adapted EF for the type of renewable electricity may be used (please see chapter 4.3.1.1 for further information).

EM_{heat}

For calculating the emissions from heat production, two different formulas can be used, based on the available units of the provided heat:

$$EM_{heat} = fuel\ consumption \left[\frac{kg\ or\ l}{yr}\right] * EF_{fuel}\left[\frac{kg\ CO_2eq}{kg\ or\ l}\right]$$ or

$$EM_{heat} = heat\ produced\ from\ fuel \left[\frac{MJ}{yr}\right] * EF_{fuel/heat\ system}\left[\frac{kg\ CO_2eq}{MJ}\right]$$

---

16 MarcoGaz, Methane emissions in the European Natural Gas midstream sector, WG-ME-17-31, 22/11/2017

17 DBFZ, Technische und methodische Grundlagen der THG-Bianzieruung von Biomethan, 2015

As the emission factors for heat production differ for the fuel and the heating system, both data must be documented. For calculating EM_{heat} the consumed heat or the fuel consumption for producing the heat for all activities during processing must be determined and multiplied with the respective emission factor (EF). If heat and electricity are consumed from a combined heat and power system (CHP), two emission factors exist, one for the produced heat and the other for the produced electricity. One can either determine the total fuel consumed in the CHP and multiply that with the emission factor for the fuel or determine electricity and heat production and apply the different emission factors for heat and electricity.

EM_{inputs}

$$EM_{inputs} = inputs\ consumption\ \left[\frac{kg\ or\ l}{yr}\right] * EF_{inputs}\left[\frac{kg\ CO_2eq}{kg\ or\ l}\right]$$

EM_{inputs} refers to all other types of inputs required as e.g. consumed chemicals (e.g. hydrogen), other production goods, process water, or diesel or other fuel used in the production process (e.g. natural gas).

$EM_{wastewater}$

$$EM_{wastewater} = wastewater\ \left[\frac{cbm}{yr}\right] * EF_{wastewater}\left[\frac{kg\ CO_2eq}{cbm}\right]$$

All wastewater that is generated during the activities of processing must be documented and multiplied with the respective emission factor.

Specific requirements for biomass fuels:

Emissions during storage of digestate

Biogas plants must consider emissions occurring during the storage of the digestate for the GHG calculation.

Diffuse methane emissions

At the biomethane plant, diffuse methane emissions from the fermentation process must be taken into account when calculating GHG emissions. Methane emissions of 1% of the biomethane quantity produced are assumed. Lower values must be proven by corresponding measurements.

4.3.5.2 Data basis

System boundaries

Every processing unit in the supply chain must guarantee that all GHG emissions from processing, GHG emissions from wastes (wastewater), and from process-specific inputs are included in the emissions calculation. Annual average figures can be used.

Emissions allocation to different products

Emissions from processing need to be allocated to main products and co-products. The methodology for doing so is described in chapter 4.3.7 “Working with incoming emission values” and 4.3.8 “Allocation of emissions to main products and co-products”.

For the calculation of GHG emissions from processing (e_p) as a minimum, the following data shall be determined i.e. the respective quantities must be extracted from respective operating documents for the previous year and must be verified by the auditors.

On-site data gathering

On-site data always needs to be gathered for the whole process and not purely for biofuel-relevant processes. The following data for the calculation of GHG emissions must be gathered on-site. All input values must be gathered for the same time period.

Relevant input data for processing

> Amount of main product and co-products in tons per year. Either refers to dry matter or emissions must be adapted by applying a moisture factor (see formula in 4.2)
> Amount of process-specific inputs used (e.g. methanol, NaOH, HCl, H2SO4, hexane, citric acid, fuller's earth, alkali, process water, diesel or other fuel) in kg per year or litres per year
> Combustion emissions of fossil methanol or other process catalysts containing methanol (e.g. potassium methylate) must also be taken into account and need to be reflected in the relevant emission factor and must be verified by the Certification Body

Combustion emissions

> Electricity consumption in kWh/yr and source of electricity (e.g. grid)
> Heat consumption in MJ/yr, fuel for heat production (e.g. natural gas) and type of heating system (e.g. boiler or combined heat and power system)
> Amount of wastes (e.g. palm oil mill effluent (POME), wastewater) in kg/yr
> Biogas plants must have a gas-tight digestate storage tank and a dosing unit with a weighing system.

Published data

Relevant published data

The following data for the calculation of GHG emissions can be gathered from recognised/certified sources:

> Emission factors for process specific inputs in kg CO_2eq/kg and fuels used in kg CO_2eq/l
> Emission factors for electricity consumption based on the source of electricity in kg CO_2eq/kWh
> Emission factors for heat consumption based on the fuel and the type of heating system in kg CO_2eq/MJ.

Forwarding of e_p

The actual GHG value for an intermediate product must be provided to the recipient of the product in the unit kg CO_2eq/dry-ton product. The total GHG emissions are calculated per dry-unit mass of the main product (e.g. kg CO_2eq-emissions/dry-ton of sunflower oil). If a processing unit has received actual values and also conducts an individual calculation, emissions produced at the processing unit have to be added by applying a feedstock and allocation factor (see chapter 4.3.7 and 4.3.8).

Specific requirements for bioliquids and biomass fuels:

Allocation to substrate quantities

For the individual calculation of GHG emissions for biogas and biomethane plants the substrate quantities documented in the operations journal and the assigned GHG values must be taken into account for the calculation. The total biogas and/or biomethane yield will be allocated to the individual substrates. An exact allocation of substrate quantity and gas yield is not possible. Therefore, the allocation of gas yields is done via literature values such as methane yields (in m3 per ton of fresh mass) that can be found for instance in the German Biomass Ordinance (BiomasseV) or in scientific documents (e.g. KTBL values “Typical values for agriculture”).

Cogeneration units

Where a cogeneration unit which provides heat and/or electricity to a fuel production proess for which emissions are being calculated, produces excess electricity and/or excess useful heat, the GHG emissions shall be divided between the electricity and the useful heat according to the temperature of the heat (which reflects the usefulness (utility)) of the heat.

<u>The following methodologies need to be applied:</u>

> For bioliquids: RED II Annex V, C.Methodology, point 16

> For biomass fuels: RED II Annex VI, B.Methodology, point 16

The greenhouse gas intensity of excess useful heat or excess electricity is the same as the greenhouse gas intensity of heat or electricity delivered to the fuel production process and is determined by calculating the greenhouse gas intensity of all inputs and emissions, including the feedstock and CH4 and N_2O emissions, to and from the cogeneration unit, boiler or other apparatus delivering heat or electricity to the biomass fuel production process. In the case of cogeneration of electricity and heat, the calculation is performed following the two above stated references[18].

4.3.6 Emission savings from CO_2 capture and replacement (e_{ccr}) and CO_2 capture and geological storage (e_{ccs})

“CO_2 Replacement”

<u>Emission savings from CO_2 capture and replacement (e_{ccr}):</u>

The RED II sets out that emission savings from carbon capture and replacement, e_{ccr}, shall be limited to emissions avoided through the capture of CO_2 of which the carbon originates from biomass. e_{ccr} can only be taken into account if it can be proven that the CO_2 replaces fossil-derived CO_2 which is used in the production of commercial products and services. Therefore, the recipient should provide information on how the CO_2 that is replaced was generated previously and declare, in writing, that due to the replacement, emissions are avoided. The auditor is responsible for deciding whether the

[18] *For biofuels and bioliquids: RED II Annex V, C. Methodology, point 16; For biomass fuels: RED II Annex VI, B.Methodology, point 16*

requirements of the RED II are met on a case by case basis, including deciding whether emissions are actually avoided. It is not required to conduct audits on the premises of the recipient as the recipient of the CO_2 is not part of the chain of custody related to the biofuel production.

"CO_2 Storage"

Emission savings from CO_2 capture and geological storage (e_{ccs}):

e_{ccs} can only be taken into account if the emissions have not already been accounted for in e_p. Valid evidence needs to be provided that CO_2 was effectively captured and safely stored in compliance with Directive 2009/31/EC. If the CO_2 is directly stored it should be verified whether the storage is in good condition, that there are no leakages, and that the existing storage guarantees that the leakage does not exceed the current state of technology. If the CO_2 is sold for storage, one option for proving storage is to provide contracts and invoices from a professional, recognised storage company.

The following formula shall be used to calculate e_{ccr} and e_{ccs} (in g CO_2eq per MJ fuel):

$$e_{ccr/ccs}\left[\frac{g\ CO_2eq}{MJ}\right] = \frac{\left(produced\ CO_2[kg] - energy\ consumed\ [MWh] * EF\left[\frac{kg\ CO_2eq}{MWh}\right] - input\ materials\ [kg] * EF\left[\frac{kg\ CO_2eq}{kg}\right]\right) * 1000}{produced\ quantity\ of\ biofuel\ [t] * 1000 * lower\ heating\ value\ biofuel\left[\frac{MJ}{kg}\right]}$$

System boundaries

For both elements, the emissions saved must relate directly to the production of the biofuel or its intermediates that they are attributed to. All biofuels/intermediates originating from the same process must be treated equally, i.e. the allocation of arbitrarily different amounts of savings to biofuels obtained from the same process is not permitted. If the CO_2 is not captured continuously, it might be appropriate to deviate from this approach and to attribute different amounts of savings to biofuel obtained from the same process. However, in no case should a higher amount of savings be allocated to a given batch of biofuel than the average amount of CO_2 captured per MJ of biofuel in a hypothetical process where the entire CO_2 stemming from the production process is captured. Emissions related to the capture and processing of CO_2 have to be taken into account in the calculation by applying the appropriate emission factors for the energy consumed and the inputs used.

On-site data gathering

Relevant input data for CO_2 capture

For the calculation of e_{ccr} and e_{ccs} the following information needs to be gathered on-site:

> Amount of biofuel, bioliquid and biomass fuel produced

> e_{ccr}: Quantity of biogenic CO_2 captured for replacement of fossil CO_2 during the biofuel, bioliquid and biomass fuel production process

> e_{ccs} : Quantity of CO_2 captured and stored for storage during the biofuel, bioliquid and biomass fuel production process

> Origin of the (biogenic) CO_2 (extraction, transport, processing and distribution of fuel)

> Quantity of energy consumed for the capturing and the processing of CO_2 (e.g. compression and liquefaction)

> Other input materials consumed in the process of CO_2 capture and processing

Published data

Relevant published data

The following information needs to be gathered from recognised/certified sources:

> GHG emission factors for all inputs and their sources (e.g. for input materials, energy consumption etc.)

> Lower heating value of the main product in MJ per kg

4.3.7 Working with incoming emission values

As referred to in chapter 3.1, "Use of default values" and 3.2, "Use of actual values" certified economic operators must state the calculated GHG value or DDV for all relevant elements of the calculation formula on the Sustainability Declaration of their product if the TDV is not applied.

Aggregation of different input values

If an ISCC System User receives different GHG values, the aggregation of GHG values from incoming input materials is only possible if the product identities and GHG values are the same. As an alternative to using single values for each incoming batch, the highest GHG value (of the least performing batch) can also be used for all incoming batches of the same kind of input material.

Requirements for incoming and own GHG values

Incoming GHG emission values need to be adjusted from kg CO_2eq/dry-ton of feedstock to kg CO_2eq/ton of product. In order to do so, emissions of input materials are multiplied by a fuel **feedstock factor (FF)**. For some of the received actual GHG values, like processing emissions or transport emissions, actual values need to be added at each step of the chain of custody by the respective operational unit.

4.3.7.1 Feedstock factor for intermediates

A feedstock factor (FF) needs to be applied for all incoming emissions (e_{ec}, e_{sca}, e_l, e_p, e_{td}, e_{ccr} and e_{ccs}) as they are expressed in terms of the input material and need to be converted to the respective outgoing product of the certified unit. Hence, the FF represents the ratio of dry input material required to make one ton of dry output. For intermediate products the FF is *mass-based* and is calculated by dividing the total amount of feedstock (in this case raw material) by the total amount of the intermediate main product. The following formula must be applied when processing intermediate products:

Feedstock factor for intermediates

$$FF = Ratio\ of\ X\ ton\ dry\ feedstock\ required\ to\ make\ 1\ ton\ dry\ intermediate\ product$$

$$= \frac{Total\ amount\ of\ feedstock\ (ton_{dry})}{Total\ amount\ of\ output\ (ton_{dry})}$$

The formula below shows an example how the feedstock factor has to be applied when a company has received a GHG value for emissions from cultivation for its input material (e_{ec} of feedstock a), processes the material into an intermediate product (e.g. vegetable oil) and needs to forward an adapted individual value for emissions from cultivation on the outgoing Sustainability Declaration (for the certified vegetable oil):

$$e_{ec} interm.\, product_a \left[\frac{kg\ CO_2eq}{ton_{dry}}\right] = e_{ec} feedstock_a \left[\frac{kg\ CO_2eq}{ton_{dry}}\right] * Fuel\ feedstock\ factor_a$$

Adding own emissions

After converting the GHG emissions of the incoming input material to the GHG emissions of the intermediate product, the additional emissions of the recipient need to be added to the emissions accordingly. For instance, in figure 7, processing unit P2 has to add its actual GHG values for upstream e_{td} and apply the FF. While incoming emissions of e_p will also be multiplied by the FF, the processing unit's own processing emissions will not, but will only be added to the calculated value of e_p.

4.3.7.2 Feedstock factor for final fuels

As for intermediates, the FF also needs to be applied for all incoming emissions (e_{ec}, e_{sca}, e_{l}, e_p, e_{td}, e_{ccr} and e_{ccs}) for final products as they are expressed in terms of the feedstock (in this case a raw material or an intermediate product depending on the type of plant) and need to be converted to the respective outgoing product of the certified unit. An example would be when a final biofuel producer, which has received a GHG value for emissions from extraction and cultivation together with the delivery of the feedstock (e_{ec} of vegetable oil), processes the material into a final product (e.g. biodiesel) and needs to forward an adapted individual value for emissions from cultivation on the outgoing Sustainability Declaration for the biodiesel. For final biofuels the FF is calculated on an *energetic basis* by dividing the total energy content of the feedstock by the total energy content of the final biofuel main-product. The following formula must be applied when processing final biofuels:

Feedstock factor for final fuels

$$Final\ fuel\ feedstock\ factor = [Ratio\ of\ X\ MJ\ feedstock\ required\ to\ make\ 1\ MJ\ final\ fuel]$$

$$FF = \frac{Total\ energy\ content\ of\ feedstock\ (MJ)}{Total\ energy\ content\ of output\ (MJ)}$$

The energy content is calculated based on the lower heating value (LHV) of the materials. Please note that for the calculation of the *feedstock factor* the LHV per *dry* ton needs to be applied while for the calculation of the *allocation* *factor* LHV values for *wet* biomass[19] need to be used as this approach was also applied for the calculation of the default values.

4.3.8 Allocation of emissions to main- and co-products

General requirements

Only emissions up to and including the production of the intermediate product and co-products can be included in the allocation via an allocation factor (AF). Downstream processing or transport and distribution emissions of an intermediate product cannot be added prior to allocation, as those emissions are not related to the co-products. The allocation of GHG emissions to any products that are considered a waste or residue (including agricultural residues like straw) is not permitted. The emissions to be divided are e_{ec} + e_l + e_{sca} + those fractions of e_p, e_{td}, e_{ccs}, and e_{ccr} that take place up to and including the process step at which a co-product is produced.

Relevant data

Yields of intermediates/final fuels and co-products shall be measured on-site, while relevant lower heating values can come from published sources. Co-products that have a negative energy content shall be considered to have an energy content of zero for the purpose of the calculation.

Forwarding of GHG information

After applying the FF and AF, the certified company passes on the GHG emission information in kg CO_2eq/dry ton intermediate product or g CO_2eq/MJ final biofuel together with the product itself on the Sustainability Declaration.

4.3.8.1 Allocation factor for intermediates

Allocation of intermediates

Allocation is done based on the AF, which reflects the relation of the total energy content of the intermediate main product to the total energy content of all products. The energy content is calculated from the lower heating value and the yield of the respective product. The lower heating value shall always refer to the moisture content of the material. The following formula must be applied to all emissions from received materials and emissions produced at the respective certified unit (e_{ec} + e_l + e_{sca},e_p, e_u $e_{td,}$ e_{ccr} and e_{ccs}) when calculating the AF:

$$AF\ intermediate\ product = \frac{Energy\ content_{interm.product}[MJ]}{Total\ energy\ content\ \left(energy\ content_{interm.product}[MJ] + energy\ content_{co-product}[MJ]\right)}$$

with

$$Energy\ content_{\ interm.product}[MJ] = \ yield_{\ interm.product}\left[\frac{kg_{dry}}{year}\right] * LHV_{\ \mathrm{inter.}product}\left[\frac{MJ}{kg}\right]$$

and

[19] For the purposes of allocation only, the ‘wet definition LHV’ is used. This subtracts the energy needed to evaporate the water in the wet material from the LHV of the dry matter. Products with a negative energy content are treated at this point as having zero energy, and no allocation is made. See also RED II, Annex V, part C, point 18

$$Energy\ content_{co-product}[MJ] = yield_{co-product}\left[\frac{kg_{dry}}{year}\right] * LHV_{co-product}\left[\frac{MJ}{kg}\right]$$

The following formula is used for the calculation of allocated emissions when processing intermediate products:

AF formula applied

$$e_{ec}interm.product_a\ allocated\left[\frac{kg\ CO_2eq}{ton_{dry}}\right] = e_{ec}interm.product_a\ non-allocated\left[\frac{kg\ CO_2eq}{ton_{dry}}\right] * Allocation\ factor\ interm.product_a$$

4.3.8.2 Allocation factor for final fuels

Allocation is done based on the AF, which reflects the relation of the total energy content of the final biofuel main product to the total energy content of all products. The energy content is calculated from the lower heating value (wet) and the yield of the respective product. The following formula needs to be applied when calculating the AF:

Allocation factor final fuels

$$AF\ fuel = \frac{Energy\ content_{biofuel}[MJ]}{Total\ energy\ content\ (energy\ content_{ibiofuel}[MJ] + energy\ content_{co-product}[MJ])}$$

with

$$Energy\ content_{biofuel}[MJ] = yield_{biofuel}\left[\frac{kg_{dry}}{year}\right] * LHV_{fuel}\left[\frac{MJ}{kg}\right]$$

and

$$Energy\ content_{co-product}[MJ] = yield_{co-product}\left[\frac{kg_{dry}}{year}\right] * LHV_{co-product}\left[\frac{MJ}{kg}\right]$$

For final fuels the following formula is applicable for the relevant elements in the calculation methodology (shown for the example of $e_{ec,}$ but all other values need to be similarly adjusted):

AF formula applied

$$e_{ec}fuel_a\left[\frac{g\ CO_2eq}{MJ\ biofuel}\right]_{ec} = \frac{e_{ec}feedstock_a\left[\frac{g\ CO_2eq}{kg_{dry}}\right]}{LHV_a\left[\frac{MJ\ feedstock}{kg\ dry\ feedstock}\right]} * fuel\ feedstock\ factor_a * Allocation\ factor\ fuel_a$$

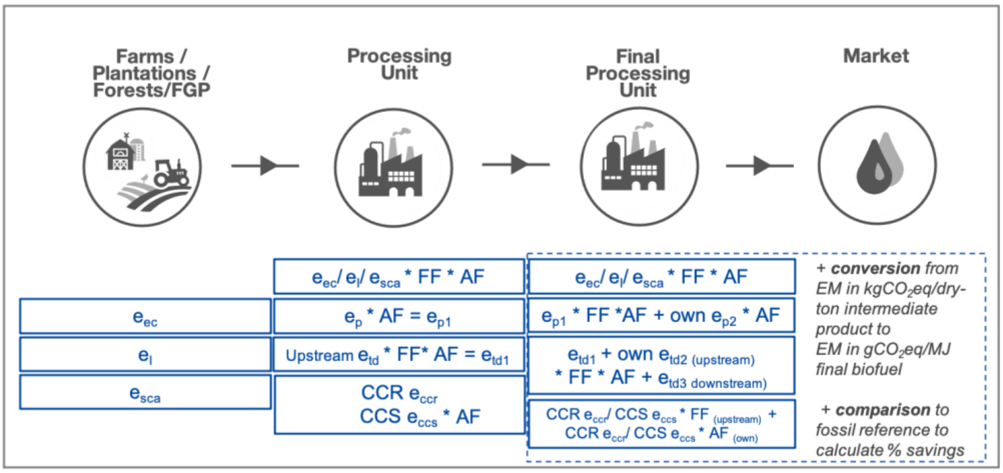

Figure 8: Summary of steps required for incoming and own emissions with actual values in an agricultural supply chain for a biofuel

Emissions delivered with the incoming feedstock and the upstream transport emissions, which are given in kg CO_2eq/dry-ton feedstock must be multiplied by the feedstock factor (FF) in order to calculate the emissions in kg CO_2eq /dry- ton of output product. In a second step, for incoming and own emissions the allocation factor (AF) need to be applied (except for downstream transport).

Specific requirements for biomass fuels:

In the case of biogas and biomethane, all co-products shall be taken into account for the purposes of that calculation.

4.3.9 Further requirements for the producers of final biofuels, bioliquids and biomass fuels

Downstream transport and distribution

A biofuel, bioliquid or biomass fuel is considered to be final if no further processing of the material takes place. The producers of final biofuels, bioliquids and biomass fuels (hereafter called final processing units) must also include emissions from the downstream transport and distribution (up to and including the filling station). Should the exact distance for downstream transport and distribution not be known to the final processing unit, conservative assumptions must be made (e.g. transport distance to Europe and throughout Europe). As those emissions relate only to the biofuel transport, no allocation is possible.

Disaggregated default values for transport and distribution are provided in sections D and E of Annex V and Annex VI of the RED II for certain final fuels. If a final fuel is produced for which no such values are available a conservative approach can be used and the highest value of the most logical choice from these tables can be used.

Calculating emissions in g CO_2eq/MJ fuel

Additionally, the final processing unit must calculate the GHG emissions of all elements of the calculation formula in g CO_2eq/MJ biofuel and the GHG saving potential of the final fuel. After the conversion (via feedstock factor) and allocation of all GHG emissions, as referred to in chapter 4.3.7 “Working with incoming emission values” and 4.3.8 “Allocation of emissions to main- and co-products”, the final GHG emissions (of e.g. cultivation/extraction of the raw material, processing and transport & distribution) are displayed in kg CO_2eq/dry-ton of biofuel. In order to determine the GHG emissions per MJ biofuel, the respective lower heating value of the biofuel has to be used.

Sum emissions biofuel

For comparing the emissions to the fossil reference, the sum of all emissions has to be build based on the formula:

GHG emissions biofuel = $e_{ec} + e_l + e_p + eu + e_{td} - e_{sca} - e_{ccs} - e_{ccr}$

GHG saving formulas for transport market

The GHG saving potential **for transport fuels** compared to the fossil reference is calculated according to the following formula:

Biofuels:

$$\text{GHG saving potential}[\%] = \frac{\textit{GHG emission from fossil fuel comparator for transport} - \textit{GHG emission from biofuel}}{\textit{GHG emission from fossil fuel comparator for transport}} * 100$$

Biomass fuels:

$$\text{GHG saving potential}[\%] = \frac{\textit{GHG emission from fossil fuel comparator for transport} - \textit{GHG emission from biomass fuel used in transport}}{\textit{GHG emission from fossil fuel comparator for transport}} * 100$$

GHG saving formula for heating/cooling/ electricity markets

The GHG saving potential generated **from heating and cooling**, **and electricity** compared to the fossil reference is calculated according to the following formula:

Bioliquids and biomass fuels:

$$\text{GHG saving potential}[\%] = \frac{\textit{GHG emission fossil from fossil fuel comparator for uselful heat or electricity} - \textit{GHG emission from heat or electricity}}{\textit{GHG emission fossil from fossil fuel comparator for uselful heat or electricity}} * 100$$

Fossil references

The following emission values shall be used for fossil references:

> Biofuels for transport[20]: 94 g CO_2eq/MJ fossil fuel[21],

> Bioliquids used for electricity, and production of energy for heating and/or cooling: 183 g CO_2eq/MJ fossil fuel,

[20] *Including biomass fuels used as transport fuels*

- Bioliquids used for the production of useful heat, as well as for the production of energy for heating and/or cooling: 80 g CO_2eq/MJ
- For biomass fuels used for the production of electricity the fossil fuel comparator shall be 183 g CO_2eq/MJ electricity or 212 g CO_2eq/MJ electricity for the outermost regions[22]
- For biomass fuels used for the production of useful heat, as well as for the production of energy for heating and/or cooling the fossil fuel comparator shall be 80 g CO_2eq/MJ heat
- For biomass fuels used for the production of useful heat, in which a direct physical substitution of coal can be demonstrated, the fossil fuel comparator shall be 124 g CO_2eq/MJ heat

Forwarding of GHG emissions for final fuels

After applying the FF and AF, the certified company passes on the GHG emission information in g CO_2eq/MJ final fuel product together with the information on GHG savings as well as the start date of biofuel/ bioliquid/ biomass fuel production on the Sustainability Declaration.

Specific requirements for bioliquids and biomass fuels

Fuel in use

The final producer also needs to take into account the emissions from the fuel in use (e_u). Emissions of CO_2 from fuel in use, e_u, are given as zero for biofuels, bioliquids and biomass fuels, but emissions of non-CO_2 greenhouse gases (CH_4 and N_2O) from the fuel in use shall be included in the e_u factor for bioliquids and biomass fuels. RED II, Annex VI outlines default value information on "non-CO_2 emissions from the fuel in use" for some biomass fuels. For all other biomass fuels and bioliquids which are not mentioned there but for which this additional information needs to be provided, System Users can use a conservative approach and apply the highest value given for e_u from the reference table mentioned above or values from recognised published literature[23] can be applied. The information on emissions from "e_u" needs to be forwarded together with the batch of sustainable material on the Sustainability Declaration.

5 Documentation and verification requirements

Depending on the type of GHG information an economic operator is using, different evidence must be kept for audit verification.

Verification in case a methane capture device is installed:

[22] *Outermost regions according to Article 349 TFEU are Guadeloupe, French Guiana, Martinique, Mayotte, Réunion and Saint Martin (France), the Canary Islands (Spain) and the Azores and Madeira (Portugal)*

[23] *E.g. JRC Science for Policy Report "Solid and gaseous bioenergy pathways: input values and GHG emissions: Calculated according to methodology set in COM(2016) 767: Version 2"*

Verification of methane capture devices at palm oil mills

> If a methane capture device that can guarantee actual methane capture is operated by the unit, e.g. for pre-treatment of wastewater, the following aspects need to be checked and fulfilled:

> The methane capture technology at the palm oil mill must ensure that the methane is captured in an efficient manner similar to what has been assumed in the calculation of the default values.

> Absorption of all wastewater in a closed system (only short-term storage of fresh wastewater) and supply to a methane capture device,

> Use of the biogas produced for energy purposes or, in the worst case, flaring of the biogas and

> The methane capture device is in good condition, leakages are non-existent, and the producer provides a guarantee about the maximum methane leakage that does not exceed the current state of the technology.

Verification of total or disaggregated default values:

Verification of default values

> If the upstream supply chain fulfils the requirements for using (disaggregated) default values. This can be verified by checking the Sustainability Declarations of the incoming input material.

> If the economic operator fulfils the requirements for using (disaggregated) default values. This can be verified by checking the heating system (especially relevant for ethanol plants) or the palm oil mill's methane capture technology, etc.

Verification of individually calculated values:

The following verification approach is required for all individual calculations:

Verification approach of actual values

> Every Certification Body that verifies individual GHG emission calculations needs to have at least one GHG expert auditor who is responsible for verifying the methodology and the input data prior to the audit. In order to become a GHG expert, the auditor has to participate in an ISCC GHG training[24]

> The ISCC System User has to make the GHG emission calculation of the planned audit available to the Certification Body (e.g. in Excel)

> The GHG expert checks information (e.g. methodology, emission factors, lower heating values, other standard values etc.) prior to the on-site certification audit. If they have any questions and/or require any corrections, the CB can contact the client directly for clarification

[24] *Please also see ISCC EU System Document 103 "Requirements for Certification Bodies and Auditors"*

> During the on-site certification audit, the auditor verifies all relevant information concerning the calculation of actual GHG values (e.g. type of heat, types of inputs, consumption amounts etc.)

> The auditor has to document emissions occurring at the audited site (for all relevant elements) and, if relevant, the savings achieved in the audit report. If the emissions deviate significantly from typical values then the report must also include information that explains the deviation

> If the Certification Body requests any corrections, System Users must provide an updated file to the CB so that a final confirmation can take place

> ISCC System Users are only allowed to use the actual value after the CB has explicitly confirmed that it is correct

> Additionally, CBs need to provide GHG calculations together with other certification documents to ISCC. This is in order to facilitate a prompt investigation by ISCC in case of alleged non-compliance of actual GHG emission values. These documents (preferably in Excel) must be complete, transparent and include the methodology, formulas, input values, emission factors and respective sources

> The procedure above also applies if a System User would like to switch from default to individually calculated values

> If an actual calculation which has already been verified is updated, the System User must contact the CB. It is the responsibility of the CB to decide if an on-site audit is necessary to verify compliance with ISCC requirements

> In any case, the CB needs to provide ISCC with updated certification documents (annex, audit procedures, GHG calculations)

> System Users need to send the first three Sustainability Declarations issued after the recertification audit to their CB so that the auditor responsible can verify that the correct default value or, in case of actual values, the approved GHG value is used and applied correctly.

If an individual calculation was conducted, the economic operator has to keep records and evidence of the following data which will be verified during the audit:

Data to be provided

> Evidence of all data for all relevant in- and outputs and feedstock factors of the production process (e.g. production reports, Sustainability Declarations, invoices)

> Sources of emission factors (standard values list of European Commission, ISCC list of emission factors or other scientifically peer-reviewed literature/databases) including the year of

publication and their applicability (with respect to time period and region)

> For external suppliers (e.g. of steam), individual emission factors must be provided. It must be possible to verify the emission factor and the data/methodology used for the calculation within the scope of the audit or the emission factor must be certified under ISCC

> Sources for the used lower heating values for main- and co-products (e.g. RED II, ISCC list of emission factors and lower heating values (LHVs), scientifically peer-reviewed literature/ databases, documents from laboratory test results)

> The methodology used for the individual calculation and the calculation itself must be transparent. The calculation itself must be done in a way that allows the auditor to verify the calculation

> For CO_2 Capture and Replacement (CCR), the auditor has to check if the emission saving from CCR is limited to emissions of which the carbon originates from biomass, and which is used to replace fossil-derived CO_2. This requires access to information such as a declaration from the recipient of the CO_2, in writing, that fossil-derived CO_2 is avoided due to the CO_2 coming from CCR. The declaration should include information on the purpose for which the captured CO_2 is used

> For CO_2 Capture and Storage (CCS), the auditor has to check if the emission saving from CCS are limited to emissions avoided through the capture and sequestration of emitted CO_2 and directly relate to the extraction, transport, processing and distribution of the fuel. Valid evidence that CO_2 was effectively captured and safely stored in compliance with Directive 2009/31/EC needs to be provided.

Annex I

List of emission factors and lower heating values (LHVs)

The choice of emission and energy factors has an impact on the results of the GHG emissions calculation.

Relevant parts of emission factors

Emission factors describe the relationship between the amount of released GHG emissions and the amount of input material. They are needed in order to calculate the CO_2eq emissions related to a specific input material. Emission factors for energy supply must include direct and indirect effects. Direct effects are air emissions from combustion, waste, effluents and electricity use. They mainly depend on the carbon content of the fuel. Indirect effects are the upstream emissions of a material. They include e.g. emissions from extraction or processing steps. Both factors – direct and indirect – must be considered in the emission factor used.

Lower heating values are needed for the calculation of feedstock factors (FF) and allocation factors.

Possible sources

The variance of individual emission factors may be large and for some inputs emission factors might not be available or just an approximation can be used. However, to avoid cherry picking and to support objective, transparent and verifiable Individual calculations and audits, ISCC has developed a list of emission factors. The list is mainly based on the list of standard calculation values published on the Commission website, Biograce and Ecoinvent (version 3.7, Allocation cut-off; IPCC 2013; GWP 100a). Alternative values might be used but must be duly justified and flagged in the documentation of the calculations in order to facilitate the verification by auditors (see chapter 4).

The following overview can be updated by ISCC on a continuous base as soon as databases (e.g. BioGrace) provide new published values.

Table 1: List of emission factors, lower heating values (LHVs) and their respective sources

Input	Unit	Standard factor	Source, description
A) Emission factors for cultivation			
Fertilizer			
Ammonium nitrate	kg CO_2eq/kg N	3.45	European Commission: Standard values for emission factors, v 1.0. 2015

Input	Unit	Standard factor	Source, description
Ammonium nitrate phosphate	kg CO_2eq/kg N	RER: 1.4972 RoW: 1.9082	Ecoinvent v. 3.7, 2020: ammonium nitrate phosphate production, as N
Ammonium sulphate	kg CO_2eq/kg N	2.724	European Commission: Standard values for emission factors, v 1.0. 2015
Calcium ammonium nitrate	kg CO_2eq/kg N	3.67	European Commission: Standard values for emission factors, v 1.0. 2015
CaO-fertiliser	kg CO_2eq/kg CaO	0.13	European Commission: Standard values for emission factors, v 1.0. 2015
Diammonium phosphate	kg CO_2eq/ kg N	RER: 1.444 RoW: 1.6423	Ecoinvent v. 3.7, 2020 diammonium phosphate production
Glyphosate	kg CO_2eq/kg	11.522	Ecoinvent v. 3.7, 2020: market for glyphosate (GLO)
K_2O-fertiliser	kg CO_2eq/kg K_2O	0.576	European Commission: Standard values for emission factors, v 1.0. 2015
Monoammonium phosphate	kg CO_2eq/kg N	RER: 0.88649 RoW: 0.9101	Ecoinvent v. 3.7, 2020: monoammonium phosphate production
N-fertiliser	kg CO_2eq/kg N[25]	5.881	European Commission: Standard values for emission factors, v 1.0. 2015
Pesticides	kg CO_2eq/kg a.i.[26]	10.97	European Commission: Standard values for emission factors, v 1.0. 2015

[25] *For all N-fertilisers the emission factor refers to the amount of nitrogen in the fertiliser.*
[26] *Active ingredient*

Input	Unit	Standard factor	Source, description
P_2O_5-fertiliser	kg CO_2eq/kg P_2O_5	1.011	European Commission: Standard values for emission factors, v 1.0. 2015
Rock phosphate	kg CO_2eq/kg P_2O_5	0.095	European Commission: Standard values for emission factors, v 1.0. 2015: 21% P_2O_5, 23% SO_3
Triple superphosphate (TSP)	kg CO_2eq/kg P_2O_5	0.517	European Commission: Standard values for emission factors, v 1.0. 2015
Urea	kg CO_2eq/kg N	1.92	Biograce v 4d, 2014
Urea ammonium nitrate	kg CO_2eq/kg N	2.68	Biograce v 4d, 2014
Seeds			
Seeds corn	kg CO_2eq/kg seed	1.9794	Ecoinvent v. 3.7, 2020: maize seed production, for sowing, max. water content of 12% (GLO)
Seeds corn	kg CO_2eq/kg seed	0.35	European Commission: Standard values for emission factors, v 1.0. 2015, Non-GMO
Seeds rapeseed	kg CO_2eq/kg seed	0.73	European Commission: Standard values for emission factors, v 1.0. 2015
Seeds rye	kg CO_2eq/kg seed	0.72224	Ecoinvent v. 3.7, 2020: rye seed production, for sowing, max. water content of 15% (GLO)
Seeds soybean	kg CO_2eq/kg seed	2.8088	Ecoinvent v. 3.7, 2020: market for soybean seed, for sowing (GLO)

Input	Unit	Standard factor	Source, description
Seeds soybean	kg CO_2eq/kg seed	0.40	European Commission: Standard values for emission factors, v 1.0. 2015, Non-GMO
Seeds sugarbeet	kg CO_2eq/kg seed	3.54	European Commission: Standard values for emission factors, v 1.0. 2015
Seeds sugarcane	kg CO_2eq/kg seed	0.0016	European Commission: Standard values for emission factors, v 1.0. 2015
Seeds sunflower	kg CO_2eq/kg seed	0.73	European Commission: Standard values for emission factors, v 1.0. 2015
Seeds wheat	kg CO_2eq/kg seed	0.276	European Commission: Standard values for emission factors, v 1.0. 2015
B) Emission factors for processing			
Process inputs			
Ammonia	kg CO_2eq/kg	2.66	European Commission: Standard values for emission factors, v 1.0. 2015
Citric acid	kg CO_2eq/kg	0.96	European Commission: Standard values for emission factors, v 1.0. 2015
Cycle-hexane	kg CO_2eq/kg	0.723	European Commission: Standard values for emission factors, v 1.0. 2015
Deionised water	kg CO_2eq/kg	Europe without CH: 0.00044202 RoW: 0.00047459	Ecoinvent v. 3.7, 2020: market for water, deionised

Input	Unit	Standard factor	Source, description
Fuller's earth	kg CO_2eq/kg	0.20	European Commission: Standard values for emission factors, v 1.0. 2015
Hydrochloric acid	kg CO_2eq/kg	0.75	European Commission: Standard values for emission factors, v 1.0. 2015
Hydrogen	kg CO_2eq/kg	RER: 2.1157 RoW: 2.3789	Ecoinvent v. 3.7, 2020: market for hydrogen, liquid
Lubricants	kg CO_2eq/kg	0.95	European Commission: Standard values for emission factors, v 1.0. 2015
Magnesium oxide	kg CO_2eq/kg	1.1791	Ecoinvent v. 3.7, 2020: market for magnesium oxide (GLO)
Methanol	kg CO_2eq/kg	1.98	Calculated from Biograce v 4d, 2014.
Methanol (without downstream EM → not applicable)	kg CO_2eq/kg	0.65878	Ecoinvent v. 3.7, 2020: market for methanol (GLO)
Nitrogen	kg CO_2eq/kg	0.43	European Commission: Standard values for emission factors, v 1.0. 2015
Phosphoric acid	kg CO_2eq/kg	3.01	European Commission: Standard values for emission factors, v 1.0. 2015
Potassium hydroxide	kg CO_2eq/kg	1.934	European Commission: Standard values for emission factors, v 1.0. 2015
Process water	kg CO_2eq/kg	Europe without CH: 0.0003418 RoW: 0.00107	Ecoinvent v. 3.7, 2020: market for tap water

Input	Unit	Standard factor	Source, description
Pure CaO for processes	kg CO_2eq/kg	1.03	European Commission: Standard values for emission factors, v 1.0. 2015
Sodium hydroxide	kg CO_2eq/kg	0.469	European Commission: Standard values for emission factors, v 1.0. 2015
Sodium methylate	kg CO_2eq/kg	4.88	Biograce v 4d, 2014
Electricity consumption from grid (electricity mix)			
EU	kg CO_2eq/kWh$_{el}$	0.383	JEC Well-to-Tank report v5, 2020
Argentina	kg CO_2eq/kWh$_{el}$	0.51	Biograce v 4d, 2014
Brazil	kg CO_2eq/kWh$_{el}$	0.11	Biograce v 4d, 2014
Indonesia	kg CO_2eq/kWh$_{el}$	1.05	Biograce v 4d, 2014
Malaysia	kg CO_2eq/kWh$_{el}$	0.88	Biograce v 4d, 2014
Energy consumption from internal production			
Diesel	kg CO_2eq/kg	0.56265	Ecoinvent v. 3.7, 2019: market for diesel, low-sulfur (RoW)
Heat/electricity from CHP (biogas)	kg CO_2eq/MJ	0.0876	European Commission: Standard values for emission factors, v 1.0. 2015
Heat/electricity from CHP (diesel)	kg CO_2eq/MJ kg CO_2eq/kWh	heat: 0.032855 electricity: 0.72185	Ecoinvent v. 3.7, 2020: Heat and power co-generation, diesel, 200kW electrical, SCR-NOx reduction (RoW)

Input	Unit	Standard factor	Source, description
Heat/electricity from CHP (NG)	kg CO_2eq/MJ kg CO_2eq/kWh kg CO_2eq/MJ kg CO_2eq/kWh	RoW heat: 0.02782 RoW electricity: 0.59025 Europe without CH heat: 0.027506 Europe without CH electricity: 0.58358	Ecoinvent v. 3.7, 2020: Heat and power co-generation, natural gas, 1MW electrical, lean burn
Heat from boiler (hard coal)	kg CO_2eq/MJ_{th}	0.13549	Ecoinvent v. 3.7, 2020: heat production, at hard coal industrial furnace 1-10MW (Europe without CH)
Heat from boiler (light fuel oil)	kg CO_2eq/MJ_{th}	0.091476	Ecoinvent v. 3.7, 2020: heat production, light fuel oil, at industrial furnace 1MW (RoW)
Heat from boiler (lignite)	kg CO_2eq/MJ_{th}	0.20577	Ecoinvent v. 3.7, 2020: heat production, lignite briquette, at stove 5-15kW (Europe without CH)
Heat from boiler (NG)	kg CO_2eq/MJ_{th}	Europe without CH: 0.069501 RoW: 0.075764	Ecoinvent v. 3.7, 2020: heat production, natural gas, at industrial furnace >100kW
Liquefied petroleum gas (LPG)	kg CO_2eq/kg	Europe without CH: 0.63676 RoW: 0.61361	Ecoinvent v. 3.7, 2020: market for liquefied petroleum gas
Natural gas	kg CO_2eq/MJ	4000 km, Russian quality: 0.066 4000 km, EU Mix quality: 0.0676	European Commission: Standard values for emission factors, v 1.0. 2015

Input	Unit	Standard factor	Source, description
Solar electricity	kg CO_2eq/kWh_{el}	0.07195	Ecoinvent v. 3.7, 2020: Electricity production, photovoltaic, 3kWp flat-roof install. multi-Si (RoW)
Waste wood	kg CO_2eq/kg	0.045248	Ecoinvent v. 3.7, 2020: treatment of waste wood, post-consumer, sorting and shredding (RoW)
Wind electricity	kg CO_2eq/kWh_{el}	0.012824	Ecoinvent v. 3.7, 2020: Electricity production, wind, 1-3MW turbine, onshore (RoW)
Electricity production in conventional power plants			
Electricity (heavy fuel oil)	kg CO_2eq/kWh_{el}	0.91415	Ecoinvent v. 3.7, 2020: electricity production, oil (RoW)
Lignite in Steam Turbine	kg CO_2eq/kWh_{el}	1.03	Biograce v 4d, 2014. Conversion factor 1 MJ = 0.28 kWh
NG in Combined Cycle Gas Turbine	kg CO_2eq/kWh_{el}	0.44	Biograce v 4d, 2014. Conversion factor 1 MJ = 0.28 kWh
Straw in Steam Turbine	kg CO_2eq/kWh_{el}	0.02	Biograce v 4d, 2014. Conversion factor 1 MJ = 0.28 kWh
Waste treatment			
EFB burning	kg CO_2eq/kg EFB	0	Biogenic CO_2 set to zero
EFB and POME Co-composting	kg CO_2eq/kg CPO	0.03	Stichnothe et al. 2010
	kg CO_2eq/kg POME	0.01	
POME[27] treatment in open ponds	kg CO_2eq/kg CPO[28]	0.51	BLE, 2010, Guideline Sustainable Biomass Production
	kg CO_2eq/kg POME	0.16	BLE, 2010, Guideline Sustainable Biomass Production. 3.25 kg POME per kg CPO

[27] *POME: Palm Oil Mill Effluent*
[28] *CPO: Crude Palm Oil*

Input	Unit	Standard factor	Source, description
POME treatment in closed ponds and flaring of emissions	kg CO_2eq/kg CPO	0	Biogenic CO_2 set to zero, No CH4, N_2O if pond appropriately covered without any leakages, methane is properly captured
POME treatment in open ponds with belt press	kgCO2eq/kg CPO	EF open ponds (kg CO_2eq/kg CPO) – (Carbon belt press cake (kg C//kg belt press cake) * Annual average belt press cake production (kg) * 30.59 (kgCO_2eq)/ Annual average CPO production (kg))	Enström et al., 2018
Wastewater treatment	kg CO_2eq/cbm	Europe without CH: 0.48077 RoW: 0.54675	Ecoinvent v. 3.7, 2020: market for wastewater, average
C) Emission factors for transport & distribution			
Barge tanker	kg CO_2eq/ton-km	RER: 0.043458 RoW: 0.04435	Ecoinvent v. 3.7, 2020: market for transport, freight, inland waterways, barge tanker
Diesel	kg CO_2eq/litre	3.14	Biograce v 4d, 2014
Diesel consumption truck (loaded)	litre/km	0.49	BLE, 2010, Guideline Sustainable Biomass Production
Diesel consumption: truck (unloaded)	litre/km	0.25	BLE, 2010, Guideline Sustainable Biomass Production
Electricity consumption train (electricity)	kWh/ton-km	0.06	Biograce v 4d, 2014. Conversion factor 1 MJ = 0.28 kWh
Emissions at filling station from energy consumption	g CO_2eq/MJ biofuel	0.44	Biograce v 4d, 2014
Freight, lorry	kg CO_2eq/ton-km	RER: 0.13098 RoW: 0.13637	Ecoinvent v. 3.7, 2020: market for transport, freight, lorry, unspecified

Input	Unit	Standard factor	Source, description
Freight train	kg CO_2eq/ton-km	Europe without CH: 0.045569 RoW: 0.048276	Ecoinvent v. 3.7, 2020: market for transport, freight train
Heavy fuel oil (HFO)	kg CO_2eq/litre kg CO_2eq/MJ	3.42 0.085	Biograce v 4d, 2014 European Commission:Standard values for emission factors
HFO for maritime transport	kg CO_2eq/MJ	0.087	European Commission: Standard values for emission factors, v 1.0. 2015
Pipeline (oil, liquids) onshore	kg CO_2eq/ton-km	0.02	Biograce v 4d, 2014
Pipeline natural gas (long distance, offshore)	kg CO_2eq/ton-km	RER: 0.057028 RoW: 0.10296	Ecoinvent v. 3.7, 2020: market for transport, pipeline, offshore, long distance, natural gas
Transoceanic tanker	kg CO_2eq/ton-km	0.0060571	Ecoinvent v. 3.7, 2020: market for transport, freight, sea, tanker for petroleum, GLO
D) Lower Heating Values (at 0% water, unless otherwise stated)			
BioOil (co-product FAME from waste oil)	MJ/kg	21.8	European Commission: Standard values for emission factors, v 1.0. 2015
Corn	MJ/kg	18.5	European Commission: Standard values for emission factors, v 1.0. 2015
DDGS (10 wt% moisture)	MJ/kg	16.0	European Commission: Standard values for emission factors, v 1.0. 2015

Input	Unit	Standard factor	Source, description
FFB	MJ/kg	24.0	European Commission: Standard values for emission factors, v 1.0. 2015
Glycerol	MJ/kg	16.0	European Commission: Standard values for emission factors, v 1.0. 2015
Palm kernel meal	MJ/kg	17.0	European Commission: Standard values for emission factors, v 1.0. 2015
Palm oil	MJ/kg	37.0	European Commission: Standard values for emission factors, v 1.0. 2015
Rapeseed	MJ/kg	26.4	European Commission: Standard values for emission factors, v 1.0. 2015
Rapeseed meal	MJ/kg	18.7	European Commission: Standard values for emission factors, v 1.0. 2015
Refined vegetable oil	MJ/kg	37.0	European Commission: Standard values for emission factors, v 1.0. 2015
Soybeans	MJ/kg	23.5	European Commission: Standard values for emission factors, v 1.0. 2015
Sugar beet	MJ/kg	16.3	European Commission: Standard values for emission factors, v 1.0. 2015

Input	Unit	Standard factor	Source, description
Sugar beet pulp	MJ/kg	15.6	European Commission: Standard values for emission factors, v 1.0. 2015
Sugar beet slops	MJ/kg	15.6	European Commission: Standard values for emission factors, v 1.0. 2015
Sugar cane	MJ/kg	19.6	European Commission: Standard values for emission factors, v 1.0. 2015
Sunflower seed	MJ/kg	26.4	European Commission: Standard values for emission factors, v 1.0. 2015
Waste vegetable / animal oil	MJ/kg	37.1	European Commission: Standard values for emission factors, v 1.0. 2015
Wheat	MJ/kg	17.0	European Commission: Standard values for emission factors, v 1.0. 2015
Wheat straw	MJ/kg	17.2	European Commission: Standard values for emission factors, v 1.0. 2015