



SUSTAINABLE RESOURCES
Verification Scheme GmbH

Technical guidance for greenhouse gas calculation

Version: TG-GHG-en-3.0

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1 Requirements for greenhouse gas emission savings

Article 29 (10) of the Revised Directive (EU) 2018/2001 stipulates requirements for the minimum greenhouse gas (GHG) emission savings that producers of electricity, heating and cooling must demonstrate against their national competent authorities in order to be counted towards the renewable energy- and GHG mitigation targets.

Depending on

- 1) the date of enforcement of national GHG mitigation obligations and
- 2) the start of operation of the plant and
- 3) the total time of operation,

the following GHG emissions savings must be achieved, as long as there are no other requirements defined in the national regulations of the country in which the installation is operated:

- ✓ for electricity, heating and cooling production from biomass fuels used in installations that started operating after 20 November 2023, at least 80%;
- ✓ for electricity, heating and cooling production from biomass fuels used in installations with a total rated thermal input equal to or exceeding 10 MW that started operating between 1 January 2021 and 20 November 2023, at least 70% until 31 December 2029, and at least 80 % from 1 January 2030;
- ✓ for electricity, heating and cooling production from gaseous biomass fuels used in installations with a total rated thermal input equal to or lower than 10 MW that started operating between 1 January 2021 and 20 November 2023, at least 70 % before they have been operating for 15 years, and at least 80 % after they have been in operation for 15 years;
- ✓ for electricity, heating and cooling production from biomass fuels used in installations with a total rated thermal input equal to or exceeding 10 MW that started operating before 1 January 2021, at least 80 % after they have been operating for 15 years, at the earliest from 1 January 2026 and at the latest from 31 December 2029;
- ✓ for electricity, heating and cooling production from gaseous biomass fuels used in installations with a total rated thermal input equal to or lower than 10 MW that started operating before 1 January 2021, at least 80 % after they have been operating for 15 years and at the earliest from 1 January 2026.

The GHG emission savings are the savings of GHG emissions expressed as a percentage from the use of biomass fuels compared to fossil fuels for the production of electricity or heat.¹

An installation is deemed to be operational if it generates electricity and/or heat for the first time in accordance with its intended use after technical readiness for operation has been established. The date the installation became operational does not change if the generator or other technical or structural parts are replaced after the initial start-up. An installation is any device that generates electricity and/or heat, including those that temporarily store energy and convert it into electricity and/or heat. It is important in this case to validate whether the installation starts production after the respective cut-off date.

Mitigating greenhouse gases is part of the SURE scheme requirements. The last interface that converts biomass fuels into electricity and/or heat must provide information on the date the installation became operational.

2 Scheme principles for the greenhouse gas calculation

2.1 Methodology for greenhouse gas calculation

The calculation of the total GHG emissions and the greenhouse gas emission saving resulting from the use of biomass fuels must be calculated as specified in Articles 31(1) to 31(3) of Revised Directive (EU) 2018/2001 and Implementing Regulation (EU) 2022/996.² Any updates to these regulations or additional guidance by the European Commission on specific technical aspects regarding the calculation rules will immediately enter into force in the SURE scheme.

GHG emissions from the production of biomass fuels and the production of electricity and/or heat must be calculated as follows³:

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

where:

E = total emissions from the production of the biomass fuel before energy conversion

e_{ec} = emissions from the extraction of raw materials, in particular from the cultivation and harvesting of the biomass used to produce the biomass fuels; CO₂ fixation during cultivation is not taken into account

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 biomass fuel in use*

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

e_{ccs} = *emission savings from CO₂ capture and geological storage*

e_{ccr} = *emission savings from CO₂ capture and replacement*

Greenhouse gas emissions from biomass fuels are expressed as gCO₂eq/MJ (grams of CO₂ equivalent per MJ of biomass fuel); the total greenhouse gas emissions for the final energy commodity (electricity or heat) produced from biomass fuels ($EC_{h,el}$) are expressed as gCO₂eq/MJ (grams of CO₂ equivalent per MJ of electricity or heat). Greenhouse gas emissions from raw materials and intermediate products are expressed in terms of grams of CO₂ equivalent per kilogram of dry matter of raw materials and intermediate products [gCO₂eq/kg]. If heat is produced at the same time as electricity, emissions are divided between heat and electricity, regardless of whether the heat is actually used for heating or cooling.

Emissions from the manufacture of machinery and equipment are not taken into account. CO₂ emissions during combustion of the fuel (e_u) are set to zero for the biomass fuels. Emissions of non-CO₂ greenhouse gases (CH₄ and N₂O) from the fuel in use must be included in the e_u factor.

Economic operators must provide the auditor with all relevant information on the calculation of the actual GHG emissions prior to the planned audit. All data measured and recorded on site that is relevant for the calculation of actual values must be documented and submitted to the auditor for verification. This includes, if applicable, all information on the emission and conversion factors and default values applied and their reference sources, GHG emission calculations and evidence relating to the application of GHG emission saving credits.

GHG emissions data must include accurate data on all relevant elements of the emission calculation formula (if relevant) under Revised Directive (EU) 2018/2001.⁴

The auditor must record the greenhouse gas emissions (after allocation) occurring at the audited site in the audit report or in accompanying documents to show that the calculation has been thoroughly verified and understood.

Where the emissions deviate significantly ($\geq 10\%$) from typical values or calculated actual values of emissions savings are abnormally high (greater than 30% deviation from default values⁵, reasons must be given for the deviation in the audit report. If implausibilities result

in the audit not being passed, SURE must be informed in accordance with the valid scheme principles for the certification process.

Upon request, all information on the calculation of actual GHG emissions, GHG emission savings and the audit report for reporting to the European Commission or the competent national authorities must be provided to SURE immediately.

The GHG emission savings of biomass fuels or electricity and/or heat from biomass fuels must be determined using one of the following alternatives pursuant to Revised Directive (EU) 2018/2001:

- ✓ using the default values (last interface)
- ✓ based on actual values calculated in accordance with the methodology in Revised Directive (EU) 2018/2001 (see the requirements below)
- ✓ using disaggregated default values
- ✓ using a combination of disaggregated and actual values

For every phase in the production and supply chain, the use of (disaggregated) default values and/or all details used to determine the actual values (methodology, measurements, data sources for non-measured values) must be documented.

If actual values are not used, the quantity of GHG emissions should not be transferred between various interfaces in the value chain because it is not possible to know whether this is a default value or an actual value in downstream phases. It is therefore the responsibility of downstream operators to include information about the (disaggregated) default GHG emission values for the final biofuel/bioliquid/biomass fuel when reporting to the member states.

2.2 Calculation using default values

Economic operators may use the default value for the greenhouse gas emission saving to provide proof of compliance with the GHG savings requirement if

- ✓ the production pathway and raw material in Annex VI of Revised Directive (EU) 2018/2001 applies
- ✓ the GHG emissions resulting from carbon-stock changes caused by land-use change (e_l value) are less than or equal to “0”
- ✓ and – if distance-dependent default value classes are used – corresponding transport distances along the supply chain have been specified.

Default values must be taken from Annex VI of Revised Directive (EU) 2018/2001⁶. The European Commission may update the default values. Any updates will immediately enter into force in the SURE-EU system.

If a default value is used, it is determined by the last interface. In this case, it is sufficient for the upstream economic operators to simply indicate “use default value” or similar wording to the downstream economic operator.”

The same applies to disaggregated default values. They only apply to certain elements in the supply chain (e_{ec} , e_p and e_{td}). When economic operators use the disaggregated default values up to the last interface, this must be indicated on their shipping documents, e.g. “Disaggregated default value used for e_{ec} ” or “Disaggregated default value used for e_{td} ” and for the respective transport distance (if relevant).

Data for the individual calculation of greenhouse gas emissions only has to be included in the documentation if actual values are applied.

The default values listed in Annex VI to the Revised Directive can only be applied if the process technology used to produce the biomass fuel is employed, the raw materials used consistent with their description and volume and, in the case of solid biomass, the transport distances correspond. If a specific technology is specified, the default values can only be used if this technology has actually been applied. If necessary, both the process technology and the raw materials used must be specified. In exceptional cases and only after confirmation by SURE, comparable default values may be used for biomass fuels for which no (disaggregated) default values are given in Annex VI if it can be reasonably assumed that the emissions do not differ significantly, e.g. a default value for woodchips from residues of the wood-processing industry for woodchips from wood waste (post-consumer wood).

If (disaggregated) default values are used, the correctness of their application shall be documented by the auditor.

2.3 Calculation using actual values

Actual values can be used for each phase in the value chain custody regardless of whether there is a default value or not.

Economic operators may only make actual GHG values claims after their capability to correctly apply the GHG calculation methodology pursuant to Revised Directive (EU) 2018/2001 Article 31 in conjunction with Annex VI is verified in an audit, for example through appropriate training records or an interview by the auditor.

Actual values of emissions can only be determined at the point when they arise in the value chain (e.g. the actual values of emissions from cultivation (e_{ec}) can only be determined at the beginning of the value chain). Similarly, economic operators can only determine the actual values for transport if emissions from all relevant transport steps are taken into account. Actual emissions for processing can only be determined if the emissions of all processing steps are recorded and passed along through the value chain. Additional emissions from transport and/or processing must be added to e_p or e_{td} respectively.

For emissions from the extraction or cultivation of raw materials (e_{ec}), economic operators may use a value calculated for a NUTS level 2 region or a region at more at a more disaggregated NUTS level⁷, provided that

- ✓ the production of the raw material took place in that region, and
- ✓ a Member State or a third country submitted a report pursuant with Article 31 (2) and (3), and
- ✓ the European Commission by means of implemented acts decided that the report contains accurate data for the purpose of measuring GHG-emissions in that region.

NUTS-2 values are to be indicated in the unit $\text{gCO}_2\text{eq/kg}$ of dry matter along the entire production chain. These values are alternatives to the individually calculated values. They are published on the website of the European Commission and are not default values. Consequently, they can only be considered input values to calculate and adjust individual cultivation emissions of the downstream interfaces. They are not suitable for specifying emissions from the cultivation phase in $\text{gCO}_2\text{eq/MJ}$ of biomass fuel.

If no such NUTS-2 value exists in the region of cultivation, economic operators must either use an actual value or an existing disaggregated default value.

Actual values are to be calculated in accordance with the methodology described in Revised Directive (EU) 2018/2001.

The greenhouse gases to be included in the GHG calculation are CO_2 , N_2O and CH_4 . To calculate the CO_2 equivalence, these gases are weighted as follows in accordance with Annex VI of Revised Directive (EU) 2018/2001:

Greenhouse gas	CO_2 equivalence
CO_2	1
N_2O	265
CH_4	28

Table 1: CO_2 equivalence

If these values or other relevant emission or conversion factors change in Revised Directive (EU) 2018/2001, they apply in the SURE-EU scheme with immediate effect upon publication on the EUROPA website⁸ of the European Commission.

All GHG emissions (if relevant) associated with the incoming feedstock (upstream emissions from e_{ec} , e_l , e_p and e_{td}) must be adjusted to the respective intermediate product using the feedstock factor.

The feedstock factor can be calculated as follows:

$$\text{feedstock factor}_a = \frac{\text{feedstock} \left[\text{kg}_{dry} \right]}{\text{intermediate product}_a \left[\text{kg}_{dry} \right]}$$

In addition to the upstream emissions, the emissions generated at the recipient's premises must also be taken into account.

If co-products result from a processing step, the emissions must be allocated (see section 3.9 "Allocation of greenhouse gas emissions").

An example of how the feedstock factor and the allocation factor for the intermediate product are applied to emissions from cultivation is provided below (e_{ec}).

$$e_{ec} \text{intermediate product}_a \left[\frac{\text{gCO}_2\text{eq}}{\text{kg}_{dry}} \right]_{ec} = e_{ec} \text{feedstock}_a \left[\frac{\text{gCO}_2\text{eq}}{\text{kg}_{dry}} \right] \times \text{feedstock factor intermediate product}_a \times \text{allocation factor intermediate product}_a$$

The upstream emissions for the processing stage from e_{ec} , e_l , e_p and e_{td} and the emissions to be included for the interface (if relevant) must be converted into the unit CO₂eq/MJ of the final biomass fuel using the feedstock factor for biomass fuel, the allocation factor for biomass fuel and the lower calorific value (H_i).

The feedstock factor for biomass fuel in relation to the biomass fuel can be calculated as follows:

$$\text{feedstock factor biomass fuel}_a = \frac{\text{feedstock}_a [\text{MJ}]}{\text{biomass fuel}_a [\text{MJ}]}$$

Ratio from the energy, how many MJ of raw product (feedstock) is required for 1 MJ biomass fuel.

If co-products result from a processing step, the emissions must be allocated (see section 3.9 "Allocation of greenhouse gas emissions").

An example of how the feedstock factor for biomass fuel and the allocation factor for biomass fuel are applied to emissions from cultivation is provided below (e_{ec}).

$$e_{ec} \text{ biomass fuel}_a \left[\frac{\text{gCO}_2\text{eq}}{\text{MJ}_{\text{biomass fuel}}}_{ec} \right] = \frac{e_{ec} \text{ feedstock}_a \left[\frac{\text{gCO}_2\text{eq}}{\text{kg}_{dry}} \right]}{\text{lower calorific value}_a \left[\frac{\text{MJ}_{\text{feedstock}}}{\text{kg}_{\text{feedstock dry}}} \right]} \times \text{feedstock factor biomass fuel}_a \times \text{allocation factor biomass fuel}_a$$

To perform this calculation, feedstock factors must be determined on the basis of installation data. For the calculation of the feedstock factor biomass fuel, the lower calorific value, which relates to the dry matter, must be used, whereas for the calculation of the allocation factor, the lower calorific value for the whole product must be used. This approach was also used to calculate the default values. The lower calorific value in relation to the dry matter therefore does not take into account the energy needed to cause the water in the wet material to evaporate. No emissions are allocated for products with a negative energy content.⁹

Once the last interface has determined the total GHG emissions for all elements (if relevant) of the formula in $\text{gCO}_2\text{eq}/\text{MJ}$ of biomass fuel pursuant to Revised Directive (EU) 2018/2001, Annex VI, Part 5, No 1, further or subsequent emissions for conversion to electricity and/or heat must be included. See section 3.5 “Requirements for the calculation of greenhouse gas emissions from transport and distribution (e_{td})”. For information on the calculation of the greenhouse gas emission saving by the last interface, see section 3.10 “Calculating the greenhouse gas reduction by the last interface”.

It is not necessary to include inputs in the calculation which have little or no effect on the result, e.g. low quantities of chemicals used in processing. Inputs with little or no effects are those with a calculated share of less than 0.5 % of the total emissions of the production unit.

All information on actual GHG emissions must be taken into account in the individual greenhouse gas calculation for all elements of the formula under Revised Directive (EU) 2018/2001¹⁰ and passed on throughout the value chain (if applicable). It is therefore necessary to separately report the greenhouse gas emissions of e_{ec} , e_l , e_{sca} , e_p , e_{td} , e_{ccs} and e_{ccr} where relevant. This also applies to the elements of the formula for which there are no default values e_l , e_{sca} , e_{ccr} and e_{ccs} . If information on greenhouse values of individual formula elements required for greenhouse gas calculation is missing, the corresponding (disaggregated) default values must be used. This must be clearly identified and evident in the report. If emissions are not recorded along the production pathway and the result is that downstream operators can no longer calculate actual emissions consistently, this must be clearly indicated in the delivery documents at the phase where this gap occurred, taking into account the accompanying documents.

The values such as emission factors, calorific values, etc. must be taken from Annex IX of Implementing Regulation (EU) 2022/996 to calculate the actual greenhouse gas emissions.

2.4 Calculation using disaggregated default values and actual values

Revised Directive (EU) 2018/2001 also provides disaggregated default values in accordance with Parts A, C and D of Annex VI, which can be used in combination with actual values to calculate GHG emissions.

It is important to note here that there are no default values for the component “land-use changes” (e_l). If disaggregated default values are used for cultivation, GHG emissions from land-use changes always have to be added to them (for information on the methodology to calculate greenhouse gas emissions due to land-use change, see section 3.2).

Disaggregated default values are to be taken from Annex VI of Revised Directive (EU) 2018/2001. The list of (disaggregated) default values can be updated by the Commission. Any changes made by the European Commission to the (disaggregated) default values immediately enter into force in the SURE scheme.

The (disaggregated) default values in Annex VI of Revised Directive (EU) 2018/2001 are to be expressed in gCO₂eq/MJ of biomass fuel. The values are based on the background data of the Joint Research Center (JRC).

For every phase in the production and supply chain, the use of (disaggregated) default values and/or all details used to determine the actual values (methodology, measurements, data sources for non-measured values) must be documented.

When information on greenhouse gas emissions is passed on to the downstream interface, only actual values can be transferred, as otherwise it is not possible to determine whether this is a default value or an actual value for downstream phases. If a default value is to be used, this should be indicated by “use default value” or similar wording and the transport distance should be specified (if relevant). It is the responsibility of the last interface to provide information on the (disaggregated) default values for the final biomass fuel or commodity.

3 Requirements for calculating GHG emissions based on actual values

3.1 Requirements for calculating GHG emissions based on actual values (e_{ec})

The GHG emissions from the production of raw materials (e_{ec}) include the GHG emissions resulting from the cultivation and harvesting of the raw materials and the GHG emissions resulting from the production of the chemicals and other relevant substances used in cultivation

To calculate e_{ec} , the following data is collected on site at a minimum, i.e. the respective values are taken from, e.g. company documents:

- ✓ quantity of P_2O_5 , K_2O , CaO , mineral and organic N fertilisers as well as crop residues in case of agricultural biomass [$kg/(ha \cdot year)$] – total quantity used annually (in the year of cultivation)
- ✓ quantity of chemicals (e.g. pesticides) [$kg/(ha \cdot year)$] – total quantity used annually (in the year of cultivation)
- ✓ fuel consumption [$l/(ha \cdot year)$] – total quantity of fuel used annually for, e.g. tractors, harvesters and water pumps per hectare in the year of cultivation – as a measured value or as an estimate based on documented, reliable data (distance, consumption, etc.)
- ✓ electricity consumption [$kWh/(ha \cdot a)$] – total electricity consumption per hectare in the year of cultivation
- ✓ quantity and type of raw materials used [$kg/(ha \cdot year)$] (e.g. seeds)
- ✓ harvest yield [$kg \text{ harvest yield dry}/(ha \cdot year)$] – quantity of the main/co-product in kg of dry matter per hectare in the year of cultivation. If drying took place, the dry matter content of the dried product must be included.

The method for collecting measured data and the measured data for the calculation of the GHG emissions must be documented so that the calculations are also transparent. Actual emissions from cultivation can only be determined if GHG emissions relevant to the interface are recorded and consistently passed along through the production chain.

It must be kept in mind that the requirements above for calculations and formulas are examples. If other emissions are incurred, they must be recorded and included in the calculation. The data has to be placed in the formula in the right place.

The economic operator responsible calculates the GHG emissions for raw material production (e_{ec}) taking into account the GHG emissions from cultivation and harvest of the raw material as well as the GHG emissions from production of chemicals or products used in cultivation by applying actual values to the following formula (EM = emissions):

$$e_{ec} = \frac{(EM_{fertiliser} + EM_{pesticides} + EM_{fuel} + EM_{electricity} + EM_{N_2O} + EM_{seeds} + EM_{aglime}) \frac{kgCO_2eq}{ha \times year}}{yield_{main product} \left[\frac{kg_{yield}}{ha \times year} \right]}$$

specified in mass units in relation to the dry harvest yield or dry main product (kgCO₂eq/kg dry). The harvest yield relates to the dry matter content.

The formula below is to be used to specify the emissions of the dry matter in kg:

$$e_{ec product a} \left[\frac{gCO_2eq}{kg_{dry}} \right] = \frac{e_{ec product a} \left[\frac{gCO_2eq}{kg_{moist}} \right]}{(1 - moisture content)}$$

The moisture content is based on the delivery details. If it is missing or not known, it is based on the maximum value allowed in the supply contract.

$$EM_{fertiliser} \left[\frac{kgCO_2eq}{ha \times year} \right] = fertiliser \left[\frac{kg}{ha \times year} \right] \times \left(Ef_{production fertiliser} \left[\frac{kgCO_2eq}{kg_{fertiliser}} \right] + Ef_{field} \left[\frac{kgCO_2eq}{kg_{fertiliser}} \right] \right)$$

$$EM_{PSM} \left[\frac{kgCO_2eq}{ha \times year} \right] = PSM \left[\frac{kg}{ha \times year} \right] \times Ef_{production PSM} \left[\frac{kgCO_2eq}{kg} \right]$$

$$EM_{fuel} \left[\frac{kgCO_2eq}{ha \times year} \right] = fuel \left[\frac{l}{ha \times year} \right] \times Ef_{fuel} \left[\frac{kgCO_2eq}{l} \right]$$

$$EM_{electricity} \left[\frac{kgCO_2eq}{ha \times year} \right] = electricity \left[\frac{kWh}{ha \times year} \right] \times Ef_{electricity mix} \left[\frac{kgCO_2eq}{kWh} \right]$$

$$EM_{seeds} \left[\frac{kgCO_2eq}{ha \times year} \right] = seeds \left[\frac{kg}{ha \times year} \right] \times Ef_{seed production} \left[\frac{kgCO_2eq}{kg} \right]$$

$$EM_{aglime} \left[\frac{kgCO_2eq}{ha \times year} \right] = aglime \left[\frac{kg}{ha \times year} \right] \times \left(Ef_{aglime production} \left[\frac{kgCO_2eq}{kg_{aglime}} \right] + Ef_{liming} \left[\frac{kgCO_2eq}{kg_{aglime}} \right] \right)$$

Formula components in detail (EM = emissions; Ef = emission factor):

$Ef_{production\ fertiliser}$	=	emission factor fertiliser production [kgCO ₂ eq/kg fertiliser]
Ef_{field}	=	emission factor of nitrous oxide (N ₂ O) [kgCO ₂ eq/kg N fertiliser]
$Ef_{pesticide\ production}$	=	emission factor pesticide production [kgCO ₂ eq/kg pesticides]
Ef_{fuel}	=	emission factor fuel in agricultural or forestry machinery [kgCO ₂ eq/l of fuel]
$Ef_{EU\ electricity\ mix}$	=	emission factor EU electricity mix [kgCO ₂ eq/kWh]
Ef_{seeds}	=	emission factor seeding material production [kgCO ₂ eq/kg seed]
$Ef_{aglime\ production}$	=	emission factor aglime production [kgCO ₂ eq/kg seed]
Ef_{liming}	=	liming emissions from actual lime use [kgCO ₂ eq/kg aglime]

The values (emission factors, heating values, etc.) in the table in Annex IX of the Implementing Regulation (EU) 2022/996 must be used to calculate e_{ec} . If an emission factor is not listed in Annex IX a scientific literature source or scientifically recognised database (e.g. ecoinvent database) can be used. However, if a standard value is included in Annex IX, it *must* be applied.

The data has to be placed in the formula in the right place. The source must be cited (in particular, the author, title, magazine, volume, year) for values taken from scientific literature sources or scientifically recognised databases. The values taken from literature sources or databases must be based on scientific and peer-reviewed work – with the condition that the data used lies within the commonly accepted data range when available.

The life-cycle greenhouse gas emissions of agricultural and forestry waste, harvest residues and production residues including wood from thinning, crown material, non-merchantable wood, so-called forest residues, straw, waste and residues from processing stages in the value chain and all waste and residues included in Annex IX of Revised Directive (EU) 2018/2001, are set to “zero” until such time as these materials are collected. Materials can be classified as waste, residues or co-products using the SURE scheme principles for the production of biomass fuels from waste and residues.

How the above-mentioned formula elements are calculated was clarified with the entry into force of Implementing Regulation (EU) 2022/996 and is described in more detail below.

3.1.1 Emissions from fuel used by farm machinery (EM_{fuel})

The GHG emissions from crop cultivation (field preparation, seeding, fertiliser and pesticide application, harvesting, collection) include all emissions from the use of fuels (such as diesel

oil, gasoline, heavy fuel oil, biofuels or other fuels) in farm machinery. Economic operators must duly document the amount of fuel use in farm machinery.

When determining the emissions of the fuel used by agricultural machinery (EM_{fuel}), appropriate emission factors must be used in accordance with Annex IX of Implementing Regulation (EU) 2022/996. If biofuels are used instead of conventional fuels, the default emission values set out in Revised Directive (EU) 2018/2001 must be used.

3.1.2 Emissions from the production of fertilisers ($EM_{fertilisers}$) and pesticides ($EM_{pesticides}$)

The emissions from the use of chemical fertilisers and pesticides¹¹ for the cultivation of raw materials must include all related emissions from the manufacture of chemical fertilisers and pesticides. Economic operators must duly document the amount of the chemical fertilisers and pesticides, depending on the crop, local conditions and farming practices.

Appropriate emission factors, including upstream emissions, must be used to account for the emissions from the production of chemical fertilisers and pesticides pursuant to Annex IX of Implementing Regulation (EU) 2022/996.

If the economic operator knows the factory producing the fertiliser and it falls under the EU Emissions Trading System (ETS), the economic operator can use the production emissions declared under ETS, adding the upstream emissions for natural gas, etc. Emissions from the transport of the fertilisers or pesticides must be included in the calculation using the emission factors listed in Annex IX to Implementing Regulation (EU) 2022/996. If the economic operator does not know the factory supplying the fertiliser, it should use the standard values provided for in Annex IX.

3.1.3 Emissions from the production of seeding material

The calculation of cultivation emissions from the production of seeding material for crop cultivation is based on actual data on the seeding material used. Emission factors for the production and supply of seeding material can be used to account for emissions associated with the production of seeds as set out in Annex IX to Implementing Regulation (EU) 2022/996. For other seeds for which Annex IX of the implementing Regulation (EU) 2022/996 does not list suitable values, literature values from the following hierarchy must be used:

- 1) Version 5 of JEC-WTW report
- 2) ECONINVENT database

- 3) “official” sources, such as Intergovernmental Panel on Climate Change (IPCC), International Energy Agency (IEA) or governments
- 4) other reviewed sources of data, such as E3 database, GEMIS database
- 5) peer-reviewed publications
- 6) duly documented own estimates

3.1.4 Emissions from neutralisation of fertiliser acidification and the application of aglime

The emissions from the neutralisation of fertiliser acidification and application of aglime account for the CO₂ emissions from neutralisation of acidity from nitrogen fertilisers or from aglime reactions in the soil

1) Emissions from neutralisation of fertiliser acidification

The emissions resulting from acidification caused by nitrogen fertiliser use in the field is accounted for in the emission calculation, based on the amount of nitrogen fertilisers used. For nitrate fertilisers, the emissions from the neutralisation of nitrogen fertilisers in the soil are 0.783 kg CO₂/kg N; for urea fertilisers, the neutralisation emissions are 0.806 kg CO₂/kg N.

2) Soil emissions from the application of aglime

Economic operators must duly document the amount of aglime fertiliser used. Emissions from the use of lime fertiliser must be calculated as follows:

- a) On acid soils, where pH is less than 6.4, aglime is dissolved by soil acids to form predominantly CO₂ rather than bicarbonate, releasing almost all of the CO₂ into the aglime. The emission factor to be used for calculating emissions is 0.44 kg CO₂/kg CaCO₃ equivalent.
- b) If soil pH is greater or equal to 6.4, an emission factor of $0.98/12.44 = 0.079$ kg CO₂/(kg CaCO₃-eq) aglime applied must be taken into account in the calculation, in addition to the emissions due to the neutralisation of acidification caused by the fertiliser.
- c) The liming emissions calculated following the rules in a) and b) above, may be greater than the fertiliser neutralisation emissions if the fertiliser acidification was neutralised by the applied aglime. In such a case, the fertiliser neutralisation emissions may be subtracted from the calculated liming emissions to avoid that its emissions are counted twice.

The emissions from fertiliser acidification may exceed the emissions from the application of aglime. In such a case, the subtraction would result in apparently negative net liming emissions because not all of the fertiliser acidity is neutralised by aglime but also partly by naturally-occurring carbonates. In this case, the net liming emissions from the use of aglime are counted as zero. However, fertiliser acidification emissions that occur anyway must be maintained in line with point 1).

If data on actual aglime use is not available, the aglime use recommended by the Agricultural Lime Association must be assumed. The amount recommended by the Agricultural Lime Association is based on the type of crop, measured soil pH, soil type and type of liming material. The emissions resulting from the use of this amount of aglime must be determined according to the rules defined in a) and b) above. However, the subtraction according to c) is not permissible in this case, as the Recommended Amount of Agricultural Lime does not take into account the lime used to neutralise the fertiliser applied in the same year, so that double counting of emissions from the neutralisation of fertilisers is not possible.

3.1.5 Soil emissions (nitrous oxide N₂O) from crop cultivation (EM_{N₂O})

The N₂O emissions from managed soils are calculated following the IPCC methodology, including the “direct” and “indirect” N₂O emissions described there.¹² Disaggregated crop-specific emission factors for different environmental conditions (corresponding to Tier 2 of the IPCC methodology) must be used to calculate the N₂O emissions resulting from crop cultivation. Specific emission factors for different environmental conditions, soil conditions and different crops are to be taken into account. Economic operators could use validated models to calculate those emission factors provided that the models take these aspects into account. Another way to include these emissions is the Global Nitrous Oxide Calculator (GNOC) developed by the Joint Research Center¹³. This tool is based on the formulas listed below and in the Annex of this document, whereby the naming conventions in the IPCC (2006) guidelines must be followed when it is used.

The total annual N₂O-N emissions produced from managed soils (N₂O_{total}-N) must be calculated as the sum of indirect and direct N₂O-N emissions.

$$N_2O_{\text{total}}\text{-N} = N_2O_{\text{direct}}\text{-N} + N_2O_{\text{indirect}}\text{-N}$$

N₂O_{direct} = *annual direct N₂O-N emissions produced from managed soils [kg N₂O-N/ha·a]*

N₂O_{indirect} = *annual indirect N₂O-N emissions (that is to say, the annual amount of N₂O-N produced from atmospheric deposition of N volatilised from managed soils and annual amount of N₂O-N produced from*

leaching and run-off of N additions to managed soils in regions where leaching/run-off occurs) [kg N₂O-N/ha·a]

Direct N₂O emissions are N₂O emissions that arise due to the cultivation of the field and are emitted directly from the cultivated soil. The calculation of these emissions must be performed depending on the soil type (mineral or organic soil).

Soils are considered organic if they satisfy requirements 1 and 2, or 1 and 3 below:

- ✓ Thickness of 10 cm or more. A horizon less than 20 cm thick must have 12 % or more organic carbon when mixed to a depth of 20 cm;
- ✓ If the soil is never saturated with water for more than a few days, and contains more than 20 % (by weight) organic carbon (about 35 % organic matter);
- ✓ If the soil is subject to water saturation episodes and has either:
 - at least 12 % (by weight) organic carbon (about 20 % organic matter) if it has no clay; or
 - at least 18 % (by weight) organic carbon (about 30 % organic matter) if it has 60 % or more clay; or
 - an intermediate, proportional amount of organic carbon for intermediate amounts of clay.

The direct N₂O emissions are divided into two soil groupings, where the determination of nitrogen emissions is calculated differently. Section a and b describe the specific calculation methods for direct N₂O emissions for the respective soil type.

Calculation of direct N₂O emissions (N₂O_{Direct})

a) Calculation of direct N₂O emissions for mineral soils

$$N_{2O_{Direct}}-N = [(F_{SN} + F_{ON}) \times EF_{1ij}] + [F_{CR} \times EF_1]$$

where:

- F_{SN} = annual synthetic nitrogen fertiliser input [kg N/ha·a]
- F_{ON} = annual animal manure N applied as fertiliser [kg N/ha·a]
- F_{CR} = annual amount of N in crop residues (above ground and below ground) calculated according to the method described in the Annex [kg N/ha·a]

EF_{1ij} = Crop and site-specific emission factors for N_2O emissions from synthetic fertiliser and organic N application to mineral soils [$kg\ N_2O-N/kg\ N_{input}$]

EF_1 = 0,01 [$kg\ N_2O-N/kg\ N_{input}$]

The crop and site-specific emission factor for N_2O emissions from the application of synthetic fertiliser and organic N to mineral soils (EF_{1ij}) is determined based on the following formula:

$$EF_{1ij} = \frac{E_{fert,ij} - E_{unfert,ij}}{N_{appl,ij}}$$

where:

$E_{fert,ij}$ = N_2O emissions (in $kg\ N_2O-N/ha \cdot a$) based on the S&B model (described below), where fertiliser input is the actual nitrogen application rate (mineral fertiliser and slurry) for crop i at site j

$E_{unfert,ij}$ = N_2O emissions of crop i at site j (in $kg\ N_2O-N/ha \cdot a$) based on the S&B model (described below). The N application rate is set to zero, all the other parameters are kept the same.

$N_{appl,ij}$ = N input from mineral fertiliser and manure (in $kg\ N/ha \cdot a$) to crop i at location j

N_2O emissions from soils under agricultural use, in different agricultural fields under different environmental conditions and agricultural land use classes can be determined following the Stehfest and Bouwman (2006) statistical model (referred to as “the S&B model”):

$$E = \exp(c + \sum ev)$$

where:

E = N_2O emissions in $kg\ N_2O-N/h \cdot a$ (for each $E_{fert,ij}$ & $E_{unfert,ij}$)

c = Constant value (see Annex II)

ev = Effect value for different emission drivers. The ev -values can be found in table 2 of the Annex II.

Applying the S&B Model and considering all effect values, following formula results to calculate $E_{fert,ij}$ and $E_{unfert,ij}$ respectively:

$$E_{fert,ij} = \exp\left(c + 0.0038 \times (F_{SN} + F_{ON}) + ev_{soc} + ev_{ph} + ev_{tex} + ev_{clim} + ev_{veg} + ev_{expl}\right)$$

$$E_{\text{unfert},ij} = \exp(c + ev_{\text{soc}} + ev_{\text{pH}} + ev_{\text{tex}} + ev_{\text{clim}} + ev_{\text{veg}} + ev_{\text{expl}})$$

The ev-values can be found in table 2 of the Annex II.

b) Calculation of direct N₂O emissions for organic soils

$$N_2O_{\text{Direct-N}} = [(F_{\text{SN}} + F_{\text{ON}}) \times EF_1] + [F_{\text{CR}} \times EF_1] + [F_{\text{OS,CG,Temp}} \times EF_{2\text{CG,Temp}}] + [F_{\text{CROS,CG,Trop}} \times E_{2\text{CG,Trop}}]$$

where:

F_{SN}	=	annual synthetic nitrogen fertiliser input; [kg N/ha·a]
F_{ON}	=	annual animal manure N applied as fertiliser [kg N/ha·a]
F_{CR}	=	annual amount of N in crop residues (above ground and below ground) calculated according to the method described in Annex II [kg N/ha·a]
$F_{\text{OS,CG,Temp}}$	=	annual area of managed/drained organic soils under cropland in temperate climate [ha/a]
$F_{\text{OS,CG,Trop}}$	=	annual area of managed/drained organic soils under cropland in tropical climate [ha/a]
EF_1	=	0.01 [kg N ₂ O-N/kg N _{input}]
$EF_{2\text{CG,Temp}}$	=	8 [kg N/ha·a] for temperate organic crop and grassland soils
$EF_{2\text{CG,Trop}}$	=	16 [kg N/ha·a] for tropical organic crop and grassland soils

c) Calculation of indirect N₂O emissions (N₂O_{indirect-N})

Indirect N₂O emissions are N₂O emissions resulting from the volatilization or leaching of nitrogen-containing substances from cultivated fields. In contrast to direct emissions, the calculation of indirect N₂O emissions is independent of the managed soil type, and therefore the formula is applicable to any soil type.

$$N_2O_{\text{indirect-N}} = [((F_{\text{SN}} \times \text{Frac}_{\text{GASF}}) + (F_{\text{ON}} \times \text{Frac}_{\text{GASM}})) \times EF_4] + [(F_{\text{SN}} + F_{\text{ON}} + F_{\text{CR}}) \times \text{Frac}_{\text{Leach-(H)}} \times EF_5]$$

where:

F_{SN}	=	annual synthetic nitrogen fertiliser input; [kg N/ha·a]
$\text{Frac}_{\text{GASF}}$	=	0.10 [(kg N NH ₃ -N + NO _x -N)/kg N _{applied}]. Volatilisation from synthetic fertiliser

F_{ON}	=	annual animal manure N applied as fertiliser [kg N/ha·a]
$Frac_{GASM}$	=	0.20 [(kg N NH_3-N + NO_x-N)/kg $N_{applied}$]. Volatilisation from all organic nitrogen fertilisers applied
EF_4	=	0.01 [kg N_2O-N /(kg N NH_3-N + $NO_x-N_{volatilised}$)]
F_{CR}	=	annual amount of N in crop residues (above ground and below ground) [kg N/ha·a]
$Frac_{Leach-(H)}$	=	0.30 [kg N/(kg $N_{additions}$)]. N losses by leaching/run-off for regions where leaching/run-off occurs
EF_5	=	0.0075 [kg N_2O-N /(kg $N_{leaching/run-off}$)]

3.1.6 Emissions from the collection, drying and storage of raw materials

Emissions from the collection, drying and storage of raw materials include all emissions related to fuel use in the collection, drying and storage of raw materials.

1) Emissions from collection

Emissions from the collection of raw materials include all the emissions resulting from the collection of raw materials and their transport to storage. The emissions are calculated using appropriate emission factors for the type of fuel used (diesel oil, gasoline, heavy fuel oil, bio-fuels or other fuels).

2) Emissions from drying biomass

The cultivation emissions include emissions from drying before storage as well as from storage and handling of biomass feedstock. Data on energy use for drying before storage includes actual data on the drying process used to comply with the requirements of storage, depending on the biomass type, particle size, moisture content, weather conditions, etc. Appropriate emission factors in accordance with Annex IX to Implementing Regulation (EU) 2022/996, including upstream emissions, must be used to account for the emissions from the use of fuels to produce heat or electricity used for drying. Emissions for drying include only emissions for the drying process needed to ensure adequate storage of raw materials. The emissions do not include drying of materials during processing.

3) Accounting for emissions from the consumption of electricity in agriculture

When accounting for the consumption of electricity not produced within the biomass plant, the GHG emissions intensity of the produced and distributed electricity is assumed to be equal to the average emission intensity of the produced and distributed electricity in a defined region, which can be at a NUTS-2 region (*if available and recognised by the European*

Commission) or a national level. If national electric emission coefficients are used for the GHG intensity of the produced and distributed electricity, the values from Annex IX of Implementing Regulation (EU) 2022/996 must be used. By way of derogation from this rule, producers may use an average value for an individual electricity production plant for electricity produced by that plant if it is not connected to the electricity grid and sufficient information are available to derive an emission factor.

3.2 Requirements for calculating greenhouse gas emissions resulting from land-use change (e_l)

In the case of land-use changes (converted areas), which have taken place since 1 January 2008 and on which biomass production is permitted under Article 29 of Revised Directive (EU) 2018/2001, the accumulated GHG emissions resulting from the land-use changes must be calculated and added to the other emissions.¹⁴ GHG emissions must be calculated for any land-use change.

The term “land use changes” refers to changes among the six land categories recognised by the IPCC (forest land, grassland, cropland, wetlands, settlements and other land). Cropland and perennial cropland are considered a single land use. Perennial crops are defined as multi-annual crops whose stem is usually not harvested annually such as short rotation coppice and oil palm.

Directive (EU) 2015/1513, Annex I, therefore stipulates that “cropland” and “perennial cropland” must be regarded as one land use. For all land which according to the definition laid down in Article 1 of 1307/2014 (EU) was grassland in January 2008 or has become grassland in the meantime, it needs to be established whether the grassland would remain or cease to be grassland in the absence of human intervention. This can be natural or non-natural highly biodiverse grassland, which may not be used for the production of biomass biofuels (see “Scheme principles for the production of biomass fuels from agricultural biomass”).

This means, for example, that a change from forest land or grassland to cropland is a land-use change, while a change from one crop (e.g. maize) to another (e.g. rapeseed) is not a land-use change. Cropland includes fallow land (i.e. land set at rest for one or several years before being cultivated again). A change of management activities, tillage practice or manure input practice is not considered land-use change.¹⁵ GHG emissions from changes in carbon stocks resulting from land-use change (e_l) are to be calculated in accordance with Revised Directive (EU) 2018/2001 and the Commission Decision 2010/335/EU of 10 June 2010.¹⁶

The Commission Decision provides details on the calculation of emissions from changes in carbon stock resulting from land-use change, which can be accessed online.¹⁷

Annualised GHG emissions from carbon stock changes caused by land-use change (e_l) are calculated by dividing total emissions equally over 20 years.

These emissions are calculated as follows:

$$e_l = (CS_R - CS_A) \times 3,666 \times \frac{1}{20} \times \frac{1}{P} - e_B^{18(*)}$$

(*) The quotient obtained by dividing the molecular weight of CO₂ (44.010 g/mol) by the molecular weight of carbon (12.011 g/mol) is equal to 3.664.

- e_l = *annualised greenhouse gas emissions from carbon stock changes caused by land-use change (measured as mass of CO₂ equivalents per biomass fuel energy unit); cropland and perennial cropland are regarded as one land use*
- CS_R = *the carbon stock per unit area associated with the reference land use (measured as mass (tonnes) 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 was the later*
- CS_A = *the carbon stock per unit area associated with the actual land use (measured as mass (tonnes) 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 CSA shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever is earlier*
- P = *the productivity of the crop (measured as biofuel or bioliquid energy per unit area per year)*
- e_B = *bonus of 29 gCO₂eq/MJ of biomass fuel if the biomass is produced on restored degraded land under the conditions set out in Annex VI, Part B, Number 8*

“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, see also SURE Scheme principles for the production of biomass fuels from agricultural biomass, section 4.4.7 “Abandoned or severely degraded land”.

If e_l is not zero, the annualised greenhouse gas emissions from carbon stock changes due to land use must be transferred to the next economic operator as the value of e_l in gCO₂eq/kg of dry matter biomass. The biomass producer must therefore use the same formulas as above, where the productivity of the plant (P) is expressed in kg dry matter content of biomass per hectare per year for the calculation.

For converted land where cultivation or silvicultural growing is permitted¹⁹, the accumulated GHG emissions resulting from changes in land use must be calculated and added to the other emission values. The land-use category the cultivated land falls into as of 1 January 2008 therefore has to be determined.

If evidence is provided that the cropland was categorised as “cropland” on 1 January 2008, or the forestry as “forest” on the cut-off date 1 January 2008, and no change in land use took place after the cut-off date 1 January 2008, e_l equals “0”.

3.3 Requirements for the use of aggregated and measured values for the management of agricultural and forested areas

Measured or aggregated values (e_{ec} and e_l) for the management of agricultural and forested areas. The following must be kept in mind when using aggregated values:

- ✓ Aggregated GHG values can be calculated for farms operating as a group in a specific region and on the condition that this is done at a more detailed level than at NUTS 2 or similar level.
- ✓ The aggregated values for cultivation must be calculated according to the methodology for e_{ec} as described in section 3.1 “Requirements for calculating greenhouse gas emissions from the production of raw materials (e_{ec})”.
- ✓ Input data should be primarily based on official statistical data from government authorities if available and of good quality. Otherwise, statistical data published by independent agencies can be used. As a third option, the data can also be taken from literary sources or databases based on scientific and peer-reviewed work – with the condition that the data used lies within the commonly accepted data range when available.
- ✓ The informational material must be based on the most recent data available from the sources above. Typically, data should be updated over time unless it does not vary significantly over time.
- ✓ With respect to fertiliser use, the type and quantity of fertiliser typical for the crops in the respective region must be used.
- ✓ If a measurement for yield (and not an aggregated value) is used for the calculations, a measurement also has to be used for the fertiliser input. The reverse is also true.
- ✓ Economic operators must specify the methods and sources used to determine the input data (e.g. average values based on representative yields, fertiliser input, N_2O emissions and changes in the carbon stock).

3.4 Requirements for the calculation of emissions savings as a result of improved agricultural management (e_{sca})

Management practices, accepted for the purpose of achieving emission savings from soil carbon accumulation, are referred to as “improved agricultural management practices” in the context of RED III. These include (examples):

- ✓ shifting to reduced or zero-tillage
- ✓ improved crop rotations and/or cover crops, including crop residue management
- ✓ improved fertiliser or manure management
- ✓ use of organic soil improver (e.g. compost, manure/slurry fermentation digestate)
- ✓ use of biochar

Similarly, the use of manure/slurry as a substrate for the production of biogas and bio-methane is regarded as improved agricultural manure/slurry management, which contributes to emission savings by preventing diffuse field emissions and can therefore be counted with a credit of 45.05 g CO₂eq/MJ manure and 54 kg CO₂eq/t fresh matter according to Implementing Regulation (EU) 2022/996, Annex IX.

Farmers or groups of farmers who want to be credited with emission savings from improved agricultural management practices must register in the SURE registration portal for the scope “7003 Soil carbon accumulation”, specifying the e_{sca} practices they would like to use, and submit a commitment as part of the self-declaration, which constitutes a commitment to use these improved agricultural management practices for a period of at least 10 years.

Emission savings from improved agricultural management practices can only be taken into account if they do not risk to negatively affect biodiversity. Further, solid and verifiable evidence must be provided that more carbon has been sequestered in the soil, or if it can reasonably be assumed that this was the case during the period in which the raw materials in question were cultivated. At the same time, it is necessary to take into account the emissions resulting from the increased use of fertilisers and plant protection products associated with these practices. For this purpose, adequate evidence must be provided (e.g. through the farmer’s field record) on the historic use of fertilisers or herbicide that is to be counted as the average for the three years before the application of the new agricultural practices. The contribution of nitrogen fixation crops used to reduce the need for additional fertilisers can be considered in the calculations

The emission savings from the accumulation of carbon stock in the soil through improved agricultural management practices (e_{sca}) are to be calculated using the following formula:

$$e_{sca} = (CS_A - CS_R) \times 3.664 \times 10^6 \times \frac{1}{n} \times \frac{1}{P} - e_f$$

- CS_R = mass of soil carbon stock per unit area associated with the reference crop management practice in [t/ha]
- CS_A = mass of soil estimated carbon stock per unit area associated with the actual crop management practices after at least 10 years of application in [t/ha]
- 3.664 = the quotient obtained by dividing the molecular weight of CO_2 (44.010 g/mol) by the molecular weight of carbon (12.011 g/mol) in g CO_2eq/g C
- P = the productivity of the crop (measured as biomass fuel energy per unit area per year)
- n = period (in years) of the cultivation of the crop considered
- e_f = emissions from the increased fertilisers or herbicide use

If an economic operator only uses the improved management practices on part of the farm, the GHG emissions savings can only be claimed for the area covered by them. If an economic operator uses different improved management practices on a single farm, a claim of GHG emission savings must be calculated and claimed individually for each e_{sca} practice.

The improved management practice must be applied for a continuous minimum period of 3 years before the emissions saved by the improved agricultural management practice can be credited. The emission savings determined by the end of the third year can be accumulated and credited to the first consignment after crediting is allowed.

The maximum possible total value of the annual claim of emission savings is capped at 45 g CO_2eq/MJ biomass fuel. This maximum value applies if biochar is used as organic soil improver alone or in combination with other eligible e_{sca} practices. If biochar is not used, the maximum annual cap referred to above is 25 g CO_2eq/MJ biomass fuel.

3.4.1 Determining the CS_R and CS_A values

CS_R and CS_A can be determined for an area if the entire area has a similar climate and soil type as well as similar management history in terms of tillage and carbon input to soil. This means that the values can be determined for a specific farm as well as across farms. Fields that have the same soil and climate characteristics, similar management history in terms of tillage and carbon input to soil and that will be subject to the same improved management practice may be grouped, including those fields belonging to different farmers.

The calculation of the CS_R and CS_A values of an area must be based on measurements of soil carbon stocks by a certified laboratory. A list of laboratories with the relevant certification is provided by the European Commission and will be made available by SURE at www.sure-system.org after publication by the European Commission.

The following rules apply for sampling, measuring soil carbon stock and determining soil storage density:

- ✓ Application of representative sampling method:
 - sampling must be carried out for each plot or field
 - At least one grab sample of 15 well distributed sub-samples per every 5 hectares or per field, whichever is smaller must be taken. The heterogeneity of the plot's carbon content must be taken into account.
 - Fields smaller than 5 hectares with same climatic conditions, soil type, reference farming practice and improved agricultural management practice can be grouped together.
 - Sampling must be done either in spring before soil cultivation and fertilisation or in autumn, a minimum of 2 months after harvest.
 - The direct measurements of soil carbon stock changes must be taken for the first 30 cm of soil.
 - Sampling to determine the actual soil carbon content must be carried out at the same points used to measure the baseline of soil carbon content under identical conditions (especially soil moisture).
 - All data relevant for sampling must be documented in the sampling protocol.
- ✓ Measurement of soil carbon content:
 - The sub-samples must first be dried, sieved, and if necessary homogenised (e.g. by grinding)
 - If the combustion method is used, only organic carbon and not inorganic carbon is to be included.
- ✓ Determining dry bulk density:
 - Changes in bulk density over time must be taken into account.
 - If possible, bulk density should be measured using the tapping method, that is to say by mechanically tapping a cylinder into the soil. If the tapping method is not possible, a reliable method must be used instead.
 - The samples must be oven-dried prior to weighing.

Samples obtained according to these rules must be retained for at least 5 years after measurement. The same applies to the documentation of measurements.

The CS_R must be measured at the farm before the management practice changes in order to establish a baseline. After the CS_R baseline has been established, the increase in soil carbon can be determined using the Rothamsted carbon model (RothC)²⁰ or a model of a voluntary certification scheme recognised by the European Commission or determined by representative measurements. If the model of another voluntary certification system recognised by the European Commission is used, this must be documented in the audit report and communicated separately to SURE. However, it is imperative that the CS_A value is measured at regular intervals no later than 5 years apart and no earlier than three years after implementation of the improved agricultural management practice. From the first measurement of the CS_A value, this constitutes the ultimate basis for determining the actual values of the increase in soil carbon stock. However, after further modelling to estimate the annual increase in soil carbon stocks are only permitted if the models used have been calibrated, based on the real CS_A value measured. In order to model the increase in soil carbon using the RothC model, the following data must be documented:

- ✓ Monthly rainfall in millimetres
- ✓ Monthly pan evaporation in millimetres
- ✓ Average monthly mean air temperature in °C
- ✓ Soil clay content in %
- ✓ An estimate of the decomposability of the crop grown (corresponds to the ratio of decomposable plant material to decomposition-resistant plant material). The approach to estimation must be plausible, based on literature data, and must always be conservative.
- ✓ Soil cover (“yes” or “no”)
- ✓ Monthly input of plant residues in (tC ha⁻¹)
- ✓ Monthly input of farmyard manure in (tC ha⁻¹)
- ✓ Depth of the sampled soil layer

The data used for modelling must be retained for the entire duration of the commitment.

The application of the above methodology (measurement and modelling) for determining the e_{sca} value and the calculation of the individual GHG emissions values and all documentation must be duly verified by the auditor during the audit and documented in audit reports.

3.4.2 Penalties in the event of non-fulfilment of the commitment as well as in the event of non-compliance

If a farmer or an economic operator fails to comply with the commitment signed by him, the e_{sca} value of the current year for the farmer or economic operator of SURE is added as emissions to the overall GHG emissions of the energy crop delivered. The farm or economic operator is not permitted to include an e_{sca} value in the GHG calculations for 5 years. This applies regardless of whether the non-compliance took place in the SURE scheme or in another voluntary certification scheme recognised by the European Commission.

If a commitment has been signed in the name of an economic operator on behalf of several farmers and one of these farmers withdraws early, the above-mentioned penalties apply only to the farm that does not comply with the improved farm management practice and not to all the commitments of the economic operator.

If it is determined during an audit or otherwise that the farm or the economic operator reporting emission savings through improved agricultural management practices does not meet the conditions for reporting these emission savings and this results in the withdrawal of the certificate, SURE must be informed of the facts immediately.

All farmers who are prohibited from further crediting e_{sca} savings either due to a certificate withdrawal or due to non-fulfilment of the commitment will be listed on the SURE website and all certification schemes recognised by the European Commission will be informed.

3.4.3 Farms or economic operators that have already implemented improved agricultural management practices

Farms or economic operators who are already engaged in eligible e_{sca} practices and have made respective e_{sca} claims before the entry into force of this Implementing Regulation may apply a cap of 45 g CO₂eq/MJ biomass fuel in a transition period until the first measurement of the CS_A value (at the latest 5 years after the implementation of the improved agricultural management practice). In such a case, after the CS_A value is determined the first time, the measured five-year difference of the soil carbon stock will become a cap for the annual claims to be made in the following period of 5 years.

In the event that the improved agricultural management practice has been applied for a period longer than 5 years prior to the entry into force of Implementing Regulation (EU) 2022/996 and emission savings have been reported, the soil carbon stock must be measured immediately.

If the first measurement of the carbon stock increase at the 5th year shows higher total annual carbon stock increase, compared to the annual claims made, the annual difference can

be claimed in subsequent years to compensate for lower carbon stock increases. If the annual increase in soil carbon stocks and thus the annual emission savings shows a lower total annual soil carbon stock increase compared to the annual claims made, the annual difference has to be deducted accordingly in the subsequent years. Since the measured value of the increase in soil carbon stock corresponds to the increase within five years, it is possible to simplify by distributing the value obtained equally over the years.

If economic operators have implemented agricultural management practices (e_{sca}) consistently in the past but no previous e_{sca} claims were made, annual retroactive e_{sca} claims can be made but for no longer than 3 years prior to certification. Implementation of the improved agricultural management practice must be proven to the auditor during the audit (e.g. proof via the field register). In such a case, the estimate of the CS_R baseline can be based on a comparative measurement of a neighbouring or other field with similar climatic and soil conditions as well as similar field management history. If there is no available data from such a field, the CS_R must be based on modelling and the first CS_A measurement must be done immediately, at the moment of commitment. The five-year measurement frequency described above then applies.

Emission savings from e_{sca} are only applicable if the measure to improve agricultural management was implemented after 1. January 2008.

The European Commission reserves the right to adapt the methodological approach for determining e_{sca} described in the Implementing Regulation (EU) 2022/996 and included in the SURE documents. This can be done both in the context of Revised Directive (EU) 2018/2001 and in future legislation (e.g. the EU Carbon Management Initiative). Any changes will take effect immediately in the SURE scheme.

3.5 Requirements for calculating greenhouse gas emissions from transport and distribution (e_{td})

Emissions from transport and distribution/supply include the emissions from the transport of the biomass and from the storage and distribution of the biomass fuels (e_{td}). Economic operators along the production and supply chain for biomass fuels that receive biomass calculate the GHG emissions from transport using the following formula:

$$e_{td} \left[\frac{\text{gCO}_2\text{eq}}{\text{kg}_{\text{dry}}} \right] = \frac{(d_{\text{loaded}} \times K_{\text{loaded}} + d_{\text{empty}} \times K_{\text{empty}}) \times E_{\text{fuel}}}{m_{\text{product dry}}}$$

specified in mass units in relation to the dry matter content of the transported biomass ($\text{gCO}_2\text{eq/kg dry}$). This formula applies analogously to all biomass transport options and the energy consumed for them.

d_{loaded} = transport distance across which the biomass or biomass fuel was transported in [km]

d_{empty} = transport distance when the transport vehicle was empty (if the transport vehicle is not empty upon return, it does not have to be included) in [km]

means of transport used (e.g. 40 t diesel truck)

$m_{product}$ = measured mass of the transported biomass or biomass fuel in [kg dry]

Ef_{fuel} = emission factor fuel in [gCO₂eq/l]

K_{loaded} = fuel consumption of the means of transport used per km when loaded in [l/km]

K_{empty} = fuel consumption of the transport vehicle used per km when empty in [l/km]

It must be kept in mind that this formula only applies for a single transport step. If there are more transport steps, the corresponding emissions must be calculated individually. Actual transport emissions can only be determined if the information for the transport steps is recorded and consistently passed along through the production chain. If not, the actual value cannot be accepted. The GHG emissions already included for production and cultivation do not have to be included again in the calculation. Other emissions from transport and distribution have to be added to e_{td} .

Alternatively, the following formula can be used to calculate e_{td} :

$$e_{td} \left[\frac{\text{gCO}_2\text{eq}}{\text{kg}_{\text{dry}}} \right] = \frac{m_{\text{load in transport vehicle}} \times d_{\text{transported}} \times Ef_{\text{transport type}}}{m_{\text{load dry in transport vehicle}}}$$

$m_{\text{load in transport vehicle}}$ = measured mass of the transported biomass or biomass fuel in [t]

$m_{\text{load dry in transport vehicle}}$ = measured dry matter of the transported biomass or biomass fuel in [kg dry]

$d_{\text{transported}}$ = transport distance across which the biomass or biomass fuel was transported in [km]

$Ef_{\text{transport type}}$ = Emission factor of the specific transport type in $\left[\frac{\text{gCO}_2\text{eq}}{\text{t} \times \text{km}} \right]$

If loads are used with different transport types, the specific transport emissions must be determined for each transport type.

The values (emission factors, fuel consumption, etc.) in Annex IX of Implementing Regulation (EU) 2022/996 must be used to calculate e_{td} . As the transport efficiencies listed in Annex IX of Implementing Regulation (EU) 2022/996 are based data published by the JRC which already take into account the return voyage (empty), no separate calculation of the return voyage is required when using the alternative formula.

If an emission factor is not listed in Annex IX, a scientific literature source or scientifically recognised database (e.g. ecoinvent database) can be used. However, if a standard value is included in Annex IX, it *must* be applied.

When calculating transport emissions, the actual GHG emissions must be divided by the dry matter of the biomass transported. Treatment plants calculate the respective upstream transport emissions in gCO₂eq/t of the dry matter content of the transported biomass. The upstream transport emissions, linked to the raw product (feedstock), must be adjusted by applying the feedstock factor and allocation factor to the corresponding product (intermediate or final product) (see section 2.3 “Calculation using actual values”). The last interface is responsible for calculating emissions from transport and distribution for biomass fuels.

If biomethane is transported via the European gas grid, the economic operator injecting and transporting biomethane into the European gas grid must take gas losses of *0.01 gCH₄/MJ* into account.

The GHG emissions associated with the storage of biomass fuels must also be taken into account.

3.6 Requirements for calculating greenhouse gas emissions from processing (e_p)

Every processing facility must ensure that all GHG emissions from processing (e_p) are included in the calculation of the GHG emissions. This includes emissions from processing itself, from waste and leakage and from the production of chemicals or products used in processing, CO₂ emissions corresponding to the carbon content of fossil inputs, whether or not actually combusted in the process. The following formula, which only applies for a single processing step, is used:

$$e_p \left[\frac{\text{gCO}_2\text{eq}}{\text{kg}_{\text{dry}}} \right] = \frac{EM_{\text{electricity}} + EM_{\text{heat}} + EM_{\text{inputs production}} + EM_{\text{wastewater}}}{\text{yield}_{\text{main product dry}}}$$

specified in mass units in relation to the dry matter content of the main product (gCO₂eq/kg dry).

Formula components in detail (EM = emissions²¹; Ef = emission factor):

$$EM_{electricity} \left[\frac{gCO_2eq}{year} \right] = electricity\ consumption \left[\frac{kWh}{year} \right] \times Ef_{electricity} \left[\frac{gCO_2eq}{kWh} \right]$$

$$EM_{heat} \left[\frac{gCO_2eq}{year} \right] = fuel\ consumption \left[\frac{kg}{year} \right] \times Ef_{fuel} \left[\frac{gCO_2eq}{kg} \right]$$

$$EM_{inputs\ production} \left[\frac{gCO_2eq}{year} \right] = inputs\ production \left[\frac{kg}{year} \right] \times Ef_{inputs\ production} \left[\frac{gCO_2eq}{kg} \right]$$

$$EM_{wastewater} \left[\frac{gCO_2eq}{year} \right] = wastewater \left[\frac{l}{year} \right] \times Ef_{wastewater} \left[\frac{gCO_2eq}{l} \right]$$

$$yield_{main\ product\ dry} \left[\frac{kg_{dry}}{year} \right] = yield\ of\ the\ main\ product\ in\ kg_{dry}\ per\ year$$

The annual yield of the main product relates to the dry matter content.

Ef_{fuel} [gCO₂eq/kg] = *emission factor fuel*

$Ef_{wastewater}$ [gCO₂eq/l] = *emission factor wastewater*

$Ef_{electricity}$ [gCO₂eq /kWh] = *emission factor national electricity mix*

$Ef_{inputs\ production}$ [gCO₂eq/kg] = *emission factor chemicals or additional inputs used in processing*

The formula below is to be used to specify the emissions of the dry matter in kg:

$$e_{p\ product_a} \left[\frac{gCO_2eq}{kg_{dry}} \right] = \frac{e_{p\ product_a} \left[\frac{gCO_2eq}{kg_{moist}} \right]}{(1 - moisture\ content)}$$

To calculate the GHG emissions from processing (e_p), the following data at a minimum must be collected on site, i.e. the respective values are taken from, e.g. company documents:

- ✓ electricity consumption [kWh/year] – annual total electricity consumption
- ✓ heat production – type of fuel/combustible used to produce steam (e.g. heating oil, gas, harvest residues)

- ✓ fuel consumption [kg/year] – total annual consumption of fuel for heat production, e.g. heating oil [kg], gas [kg], bagasse [kg]
- ✓ production of inputs [kg/a] – quantity of chemicals or additional products (inputs) used in processing
- ✓ wastewater quantity [l/a] – quantity of wastewater per year
- ✓ yield main product [kg/a] – annual harvest of the main product

Input data for calculating the processing emissions in the production chain must be measured or based on technical specifications of the processing facility. If the range of emissions for a group of processing facilities (which the respective facility belongs to) is known, the most conservative emission value (highest) for this group is to be used. Actual emission values for processing can only be determined if all of the information about emissions relevant to the interface is recorded and consistently passed along through the production chain. Other emissions from processing have to be added to e_p .

The values (emission factors, heating values, etc.) in the table in Annex IX of the Implementing Regulation (EU) 2022/996 must be used to calculate e_p . If an emission factor is not listed in Annex IX a scientific literature source or scientifically recognised database (e.g. ecoinvent database) can be used. However, if a standard value is included in Annex IX, it *must* be applied.

The source must be cited for values taken from scientific literature sources or scientifically recognised databases. If there are different values from producers, the most conservative value must be used. It is also important to include the emissions arising from chemicals and energy that are also indirectly linked to the production of biomass fuels.

In accounting for the consumption of electricity not produced within the biomass fuel plant, the GHG emission intensity of the production and distribution of that electricity is to be assumed to be equal to the average emission intensity of the production and distribution of electricity in the country where the processing takes place. The national emission intensities for grid electricity listed in Annex IX of Implementing Regulation (EU) 2022/996 must be used. If the emission intensity for grid electricity is not listed in Annex IX of Implementing Regulation (EU) 2022/996, the average national emission intensity of the country's electricity generation could be the appropriate choice. ²².

If a biomass plant is operated solely with energy generated on site and there is no connection to the public electricity or heat grid (100 % stand-alone solution), the corresponding individual GHG value can be used for the electricity or heat emission factor.

In practice, stand-alone solutions are more the exception than the rule. A grid connection is typically indispensable to ensure the production capability of the renewable energy or heat

generation plant and to supply excess and non-regulated quantities of electricity/heat that could potentially jeopardise the infrastructure. In the case that the renewable energy plant is connected to the electricity or heat grid and the biomass or biofuel plant is operated solely or partially with the renewable energy generated on site, this can be taken into account in the accounting. This requires a suitable metering infrastructure that can clearly document the direction of energy flow and the electricity quantity. If this is a quantity of renewable energy produced, for example, by a wind turbine or a photovoltaic installation, the emission factor for electricity or heat can be set to 0.

An average value may be used for the electricity produced by an individual electricity power plant if that plant is not connected to the electricity grid. Emissions from processing include emissions from drying intermediate products and materials, where appropriate. Guarantees of origin for electricity from renewable energy sources or other certificates are not applicable to reduce greenhouse gas emissions.

3.7 Requirements for calculating the emission saving from CO₂ capture and replacement (e_{ccr})

Emission savings from CO₂ capture and replacement (e_{ccr}) shall be related directly to the production of the biomass fuel to which they are attributed and shall be limited to emissions avoided through the capture of CO₂ of which the carbon originates from biomass and which is used to replace fossil-derived CO₂ in the production of commercial products and services.

Note that the option to credit emission savings by e_{ccr} is only possible if the biogenic CO₂ is used to replace fossil-derived CO₂ in the production of commercial products and services before 1. January 2036. This means that from 1. January 2036, it will no longer be possible to credit e_{ccr} .

Compliance with the requirement that carbon of fossil origin be replaced by carbon from biomass in the production of commercial products and services is assumed to be satisfied if it is common commercial practice to use only carbon of fossil origin in these commercial products and services.

In this case, there is no need for the certifying company to provide evidence of the actual (end) use of the biogenic CO₂ to replace fossil-derived CO₂ on a case-by-case basis. However, verifiable objective evidence on the CO₂ quantities produced from biogenic carbon in defined time periods must be kept, whereby only those quantities can be credited that are actually sold on the market as directly commercially usable CO₂ or are used directly and are of biogenic origin.

The following parameters are to be considered when calculating the emission saving (e_{ccr}):

- ✓ produced quantity of biomass fuel
- ✓ produced quantity of biogenic CO₂

The following are also to be determined in relation to the processing of CO₂ (compression and liquefaction to carbon dioxide):

- ✓ consumed quantity of energy (electricity, heat, etc.)
- ✓ consumed quantity of auxiliary materials
- ✓ other process-specific, energy-related input variables are included here

as well as the respective greenhouse gas emissions values for these consumed quantities

The emission savings e_{ccr} [g CO₂eq/MJ biomass fuel] are calculated as follows:

$$e_{ccr} = \frac{\text{quantity produced CO}_2 \text{ [t]} - \text{energy consumed [MWh]} \times EF \left[\frac{\text{t CO}_2\text{eq}}{\text{MWh}} \right] - \text{auxiliary materials consumed [t]} \times EF \left[\frac{\text{t CO}_2\text{eq}}{\text{t}} \right]}{\text{produced quantity of biomass fuels [t]} \times \text{lower calorific value biomass fuel} \left[\frac{\text{GJ}}{\text{t}} \right]} \times 1000$$

The balancing period of the emissions saving (e_{ccr}) must be linked to the greenhouse gas balancing period of the respective production pathway of the main product (biomass fuel). If the CO₂ is not captured continuously, it may make sense to allocate different quantities of savings to biomass fuel from the same processes.

However, higher savings of CO₂ should never be allocated to a given batch of biomass fuel per MJ than the savings from the average quantities of CO₂ in a hypothetical process which captures the total CO₂ from the process.

For example, it would not be justified to allocate different quantities of savings to different biomass fuels in relation to the same process. All biomass fuels originating from the same process are treated equally in this respect.

All emissions and information related to CO₂ capture and savings must be included in the greenhouse gas calculation and documentation and must be verifiable by the auditor. These include:

- a) the purpose for which the captured CO₂ is used
- b) the origin of the CO₂ that is replaced
- c) the origin of the CO₂ that is captured
- d) information on emissions due to capturing and processing of CO₂

For the purposes of (b), economic operators using captured CO₂ may state how the CO₂ that is replaced was previously generated and declare, in writing, that emissions equivalent to that quantity are avoided as a consequence of the replacement. That evidence is considered sufficient to verify compliance with the requirements of Directive (EU) 2018/2001 and the avoidance of emissions.

If CO₂ is captured for the purposes of producing a renewable liquid and gaseous fuels of non-biological origin, the quantity of CO₂ captured may not be credited under e_{ccr} . This is also inadmissible if the CO₂ verifiably replaces CO₂ from fossil origin in the production of the renewable liquid and gaseous fuels of non-biological origin.

3.8 Requirements for calculating the emission savings from CO₂ capture and geological storage (e_{ccs})

Emission savings from carbon capture and geological storage (e_{ccs}), not already included in e_p is limited to emissions prevented by the *effective* capture and *safe* storage of CO₂ emissions directly linked to the extraction, transport, processing and distribution of biomass fuel as well as the conversion to electricity and/or heat.

The following parameters are to be considered when calculating the emission saving (e_{ccs}):

- ✓ produced quantity of biomass fuel
- ✓ produced quantity of biogenic CO₂

The following are also to be determined in relation to the processing of CO₂ (compression and liquefaction to carbon dioxide):

- ✓ consumed quantity of energy (electricity, heat, etc.)
- ✓ consumed quantity of auxiliary materials
- ✓ other process-specific, energy-related input variables are included here

as well as the respective greenhouse gas emissions values for these consumed quantities

The emissions saving e_{ccs} [gCO₂eq/MJ biomass fuel] is calculated as follows:

$$e_{ccs} = \frac{\text{quantity produced CO}_2 \text{ [t]} - \text{energy consumed [MWh]} \times EF \left[\frac{\text{t CO}_2\text{eq}}{\text{MWh}} \right] - \text{auxiliary materials consumed [t]} \times EF \left[\frac{\text{t CO}_2\text{eq}}{\text{t}} \right]}{\text{produced quantity of biomass fuel [t]} \times \text{lower calorific value biomass fuel} \left[\frac{\text{GJ}}{\text{t}} \right]} \times 1000$$

The emission saving from carbon capture and geological storage (e_{ccs}) can only be taken into account if there is valid evidence and the audit confirms the quantities of CO₂ that have been

effectively captured and safely stored in accordance with the requirements of Directive (EU) 2009/31. Where CO₂ is geologically stored, certification bodies approved by SURE must verify the evidence provided on the integrity of the storage site and the volume of the CO₂ stored. This verification must be part of the audit report that is uploaded to the SURE database. Where a third party carries out the transport or geological storage of CO₂, proof of storage may be provided through the relevant contracts with and invoices of that third party.

Emission savings from carbon capture and geological storage (e_{ccs}) not already included in e_p is limited to emissions prevented by the capture and storage of emitted CO₂ directly associated with the production, transport, processing and distribution of biomass fuel and their conversion to electricity and/or heat, provided that storage complies with Directive (EU) 2009/31 on the geological storage of carbon dioxide.

The balancing period of the emissions saving (e_{ccs}) must be linked to the greenhouse gas balancing period of the respective production pathway of the main product (biomass fuel). If the CO₂ is not continuously captured, see section 3.7. “Requirements for calculating the emission saving from CO₂ capture and replacement (e_{ccr})”.

3.9 Allocation of greenhouse gas emissions

If co-products or excess useful energy are produced during the production of biomass fuels, their greenhouse gas intensity can be deducted from the greenhouse gas intensity of the biomass fuel:

- ✓ In the case of co-products other than electricity and heat, allocated based on their energy content (lower calorific value).
- ✓ In case of excess electricity or excess heat, by determining the greenhouse gas intensity, the amount of heat or electricity delivered to the production process for biomass fuel. This calculated value may be deducted from the greenhouse gas intensity of the biomass fuel.

3.9.1 Allocation of greenhouse gases to co-products

Allocation takes place in every process step that the main product passes through in which a co-product is produced (except electricity or heat). All GHG emissions up to this process step must be distributed to the main and co-product proportional to their energy content. The portion of GHG emissions allocated to the elements of the formula according to Directive (EU) 2018/2001, Annex VI, Part B, No. 1 is to be calculated using the following formula (if applicable):

$$e'_{allocated} = \text{total GHG} \times \text{allocation factor}$$

The variable total GHG in the formula above is the sum of all GHG gas emissions that are produced up to and including the process step in which the co-product is produced. The allocation involves the formula elements $e_{ec} + e_l + e_{sca}$ + the shares of e_p , e_{td} , e_{ccs} and e_{ccr} up to and including the process step where a co-product is produced. If GHG emissions were already allocated to co-products in an earlier process step, the portion of these greenhouse gas emissions that was assigned to the respective intermediate product in the last process step is used for the total (total GHG). To calculate the allocation factor for intermediate products and biomass fuels, the following data is collected at a minimum on site, i.e. the respective values are taken from, e.g. company documents:

- ✓ mass of the intermediate product/biomass fuel [kg dry]
- ✓ mass of the co-product [kg dry]

The formula for calculating the allocation factor for the intermediate product is as follows:

$$\text{allocation factor intermediate product}_a = \left[\frac{\text{Energy in intermediate product}_a}{\text{Energy in intermediate product}_a \text{ and co-product } c_a} \right]$$

The formula for calculating the allocation factor for biomass biofuel is as follows:

$$\text{allocation factor biomass fuel}_a = \left[\frac{\text{Energy in biomass fuel}_a}{\text{Energy in biomass fuel}_a \text{ and co-product}_a} \right]$$

where:

$$\text{energy content}_{\text{intermediate product}} [\text{MJ}] = \text{yield}_{\text{intermediate product}} [\text{kg}_{\text{dry}}] \times \text{lower calorific value}_{\text{main product}} \left[\frac{\text{MJ}}{\text{kg}} \right]$$

$$\text{energy content}_{\text{biomass fuel}} [\text{MJ}] = \text{yield}_{\text{biomass fuel}} [\text{kg}_{\text{dry}}] \times \text{lower calorific value}_{\text{main product}} \left[\frac{\text{MJ}}{\text{kg}} \right]$$

$$\text{energy content}_{\text{co-product}} [\text{MJ}] = \text{yield}_{\text{co-product}} [\text{kg}_{\text{dry}}] \times \text{lower calorific value}_{\text{co-product}} \left[\frac{\text{MJ}}{\text{kg}} \right]$$

The energy content is determined using the lower calorific value and the yield. The lower calorific value used in applying this rule must be that of the entire (co-) product (not the value for the dry part of it only). In many cases, however, notably in relation to nearly-dry products, the latter could give a result that is an adequate approximation. Because heat does not have a lower calorific value, no emissions can be allocated to it on this basis.

No emissions shall be allocated to waste and residues (including forestry residues and agricultural residues) since they are considered to have zero emissions up until they are collected²³.

The allocation should be made immediately after a co-product (a substance that is usually storable or tradable) and a biomass fuel/intermediate product are produced in a process step. This can be a process step within a plant after which further “downstream” processing takes place for either product. However, if downstream processing of the (co-) products concerned is interlinked (by material or energy feedback loops) with any upstream part of the processing, the system is considered a “refinery” and allocation is applied at the points where each product has no further downstream processing that is interlinked by material or energy feedback loops with any upstream part of the processing.

All co-products that have no heating value and therefore do not fall under Annex VI, Point 17 of the Revised Directive (EU) 2018/2001 must be taken into account when determining the allocation factor. The energy content of co-products with negative energy content is set to zero.

3.9.2 Determination of the greenhouse gas intensity of useful excess heat and electricity

Heat and electricity, which are not the main product, are generally excluded from allocation. The defined lower calorific values of both energy forms (1 kWh/kWh) mathematically exclude an allocation based on the lower calorific value. The GHG intensity of excess useful heat and electricity is therefore equal to the GHG intensity of the heat or electricity supplied for the production of biomass fuels.

The greenhouse gas intensity of the supplied quantity of electricity and heat not generated in the biomass plant itself is determined as described in section 3.6 “Requirements for the calculation of greenhouse gas emissions from processing (e_p)”.

If the energy (electricity or heat) supplied for the production of biomass fuels is generated in the production facility itself, the greenhouse gas intensity is determined as described in section 3.10 “Calculating the greenhouse gas emission saving by the last interface”.

3.10 Calculating the greenhouse gas emission saving by the last interface

The last interface determines the GHG emissions “E” caused by the biomass fuel expressed in $\text{gCO}_2\text{eq/MJ}$ of biomass fuel in accordance with the method described in section 2.1

“Methodology for greenhouse gas calculation” and calculates the GHG emissions in gCO₂eq/MJ of final energy commodity (electricity, heat) for heat and/or electricity production from the biomass fuels.

Greenhouse gas emissions, which are available in the unit gCO₂eq/t of dry feedstock, can be converted into the unit gCO₂eq/MJ of biomass fuel using the following formula:

$$e_{ec} \text{ biomass fuel}_a \left[\frac{\text{gCO}_2 \text{eq}}{\text{MJ}_{\text{biomass fuel}}}_{ec} \right] = \frac{e_{ec} \text{ feedstock}_a \left[\frac{\text{gCO}_2 \text{eq}}{\text{t}_{\text{dry}}} \right]}{\text{lower calorific value}_a \left[\frac{\text{MJ}_{\text{feedstock}}}{\text{t}_{\text{feedstock dry}}} \right]} \times \text{feedstock factor biomass fuel.} \times \text{allocation factor biomass fuel.}_a$$

For information on how to calculate GHG emissions of biogas by co-digestion of different substrates to electricity and heat, see section 3.11 “Balancing of GHG emissions from co-digestion in biogas plants”.

The greenhouse gas saving from the use of biomass fuels to produce heat and electricity compared to the respective fossil reference value can be calculated using the following formula:

$$\text{GHG emission savings} = (EC_{F(h\&c, el)} - EC_{B(h\&c, el)}) / EC_{F(h\&c, el)}$$

where:

$EC_{B(h\&c, el)}$ = total emissions from the heat or electricity from biomass fuels

$EC_{F(h\&c, el)}$ = total emissions from the fossil fuel comparator for useful heat or electricity

Greenhouse gas emissions from biomass installations that deliver only heat must be calculated as follows:

$$EC_h = \frac{E}{\eta_h}$$

Greenhouse gas emissions from biomass plants that deliver only electricity must be calculated as follows:

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

$EC_{h, el}$ = 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 fuel input, based on its energy content*
- η_h = *the heat efficiency, defined as the annual useful heat output divided by the annual fuel input, based on its energy content*

For biomass fuels used for useful heat production and for heating and/or cooling, the comparator is fossil fuel:

$$EC_{F(h)} = \frac{80 \text{ gCO}_2 \text{ eq}}{\text{MJ}_{heat}}$$

If it can be clearly demonstrated that coal is directly physically substituted by biomass fuels for useful heat production, the comparator for fossil fuels is:

$$EC_{F(h)} = \frac{124 \text{ gCO}_2 \text{ eq}}{\text{MJ}_{heat}}$$

For biomass fuels used to generate electricity, the comparator is fossil fuel:

$$EC_{F(el)} = \frac{183 \text{ gCO}_2 \text{ eq}}{\text{MJ}_{electricity}}$$

or for the outermost regions

$$EC_{F(el)} = \frac{212 \text{ gCO}_2 \text{ eq}}{\text{MJ}_{electricity}}$$

Outermost regions are those regions defined in the Treaty on the Functioning of the EU (TFEU) whose energy sector is often characterised by isolation, limited supply and dependence on fossil fuels while those regions benefit from significant local renewable sources of energy.

Useful heat means heat generated to satisfy an economical justifiable demand for heat, for heating and cooling or for production processes such as the provision of steam and pressure, as opposed to unused waste heat. “Economically justifiable demand” means the demand that does not exceed the needs for heat or cooling and which would otherwise be satisfied at market conditions.

When heating and cooling are co-generated with electricity in a single process, emissions are allocated between useful heat and generated electricity. GHG emissions for electricity or mechanical energy are calculated as follows:

$$EC_{el} = \frac{E}{\eta_{el}} \left[\frac{C_{el} \times \eta_{el}}{C_{el} \times \eta_{el} + C_h \times \eta_h} \right]$$

The GHG emissions of useful heat produced in co-generation are calculated as follows:

$$EC_h = \frac{E}{\eta_h} \left[\frac{C_h \times \eta_h}{C_{el} \times \eta_{el} + C_h \times \eta_h} \right]$$

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 fuel input, based on its energy content
- η_h = the heat efficiency, defined as the annual useful heat output divided by the annual fuel 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)

Exergy is the fraction of the total energy of a system or material flow that can do work when it is brought into thermodynamic equilibrium with its environment. In the case of the generation of electricity or mechanical energy, the SURE-EU system assumes that the energy share is 100%, i.e. that there is no energy loss during transmission through the grid until electricity is removed from the grid.

The Carnot efficiency is the highest theoretically possible efficiency in converting thermal energy into useful heat. It describes the ratio of useful heat to the amount of heat absorbed and is higher the greater the temperature difference between the useful heat at the point of delivery and its ambient temperature. Since neither absolute zero nor infinitely high temperatures can be reached, a Carnot efficiency of 100% is impossible.

Accordingly, the Carnot efficiency for useful heat is defined as follows:

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

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 (0 °C)

If excess heat is generated in the co-generation process and used to heat buildings, at a temperature below 150 °C, C_h (423.15 kelvin) can be set at 0.3546.

If the reference values for fossil fuels change or are implemented by the European Commission, for example by means of delegated acts, modified values or methods, these also apply in the SURE-EU system with immediate effect.

3.11 Balancing of GHG emissions from co-digestion in biogas plants

The total emissions from the production of the biomass fuel before energy conversion (E) of a biomass fuel resulting from a co-digestion of different substrates must be calculated as a sum taking into account on pro rata the share of the respective inputs and their emission factors. This means that E is to be calculated as a single value for the whole amount of the biogas/biomethane, resulting from the co-digestion.

If the calculation is based on default values, the calculation of E for biomass fuels resulting from co-digestion must be performed as follows:

$$E = \sum_{n=1}^n S_n \times E_n$$

where:

E = greenhouse gas emissions per MJ biogas or biomethane produced from co-digestion of the defined mixture of substrates

S_n = share of feedstock n in energy content

E_n = emission in g CO₂/MJ for pathway n as provided in Part D of Annex VI of Revised Directive (EU) 2018/2001

The share of feedstock n in the energy content is calculated as follows:

$$S_n = \frac{P_n \times W_n}{\sum_{n=1}^n P_n \times W_n}$$

where:

P_n = energy yield [MJ] per kilogram of wet input of feedstock n(*)

W_n = weighting factor of substrate n defined as:

$$W_n = \frac{I_n}{\sum_1^n I_n} \times \left(\frac{1 - AM_n}{1 - SM_n} \right)$$

where:

- I_n = annual input to digester of substrate n [ton_{fresh matter}]
- AM_n = average annual moisture of substrate n [kg water/kg fresh matter]
- SM_n = standard moisture for substrate $n^{(**)}$

(*) The following values for P_n are used to calculate typical and default values:

- P_{maize} = 4.16 [MJ_{biogas}/kg_{wet maize}/kg_{wet maize at 65% moisture}]
- $P_{manure/slurry}$ = 0.50 [MJ_{biogas}/kg_{slurry biogas}/kg_{slurry at 90% moisture}]
- $P_{biowaste}$ = 3.41 [MJ_{biogas}/kg_{wet biowaste at 76% moisture}]

(**) The following values of the standard moisture for substrate SM_n are used:

- SM_{maize} = 0.65 [kg_{water}/kg_{fresh matter}]
- SM_{manure} = 0.90 [kg_{water}/kg_{fresh matter}]
- $SM_{biowaste}$ = 0.76 [kg_{water}/kg_{fresh matter}]

Changes to these values or calculation methods originating from the Revised Directive (EU) 2018/2001, for example due to delegated acts of the European Commission to review and, if necessary, adjust the methods and values of Annex VI of the Revised Directive (EU) 2018/2001, will take effect immediately in the SURE system.

If the calculation is based on actual values, the calculation of E for biomass fuels resulting from co-digestion must be performed as follows:

$$E = \sum_1^n S_n \times (e_{ec,n} + e_{td, feedstock,n} + e_{l,n} - e_{sca,n}) + e_p + e_{td, product} + e_u - e_{ccs} - e_{ccr}$$

- E = total emissions from the production of the biogas or biomethane before energy conversion
- S_n = share of feedstock n , in fraction of input to the 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

$e_{l,n}$	=	<i>annualised emissions from carbon stock changes caused by land-use change, for feedstock n</i>
e_{sca}	=	<i>emission savings from improved agricultural management of feedstock n</i>
e_p	=	<i>emissions from processing</i>
$e_{td,product}$	=	<i>emissions from transport and distribution of biogas and/or bio-methane</i>
e_u	=	<i>emissions from the fuel in use, i.e. greenhouse gases emitted during combustion</i>
e_{ccs}	=	<i>emission savings from CO₂ capture and geological storage</i>
e_{ccr}	=	<i>emission savings from CO₂ capture and replacement</i>

4 Relevant documents

With regard to the documentation (scheme documents) in the SURE-EU system, reference is made here to the document “Scope and basic scheme requirements”.

SURE reserves the right to create and publish additional supplementary scheme principles if necessary.

The legal EU regulations and provisions for sustainable biomass and biofuels including other relevant references that represent the basis of the SURE documentation are published separately on SURE’s website at www.sure-system.org. References to legal regulations always relate to the current version.

5 References

1

Heat or waste heat is also used to generate cooling with absorption chillers. “Heat” in this case therefore also encompasses “cooling” or “refrigeration”, regardless of whether the end use of the heat is actual heating or cooling via absorption machines.

2

I **EUROPEAN COMMISSION (2018): Revised Directive (EU) 2018/2001 to promote the use of energy produced from renewable sources, Article 31 (1) to (3) and Annex VI:** Available at: <https://eur-lex.europa.eu/legal-content/de/TXT/?uri=CELEX:32018L2001>. (last accessed 01.04.2020).

II **EUROPEAN COMMISSION (2022):** Implementing Regulation (EU) 2022/996 on rules to verify sustainability and greenhouse gas emissions saving criteria and low indirect land-use change-risk criteria. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1697522921663&uri=CELEX%3A32022R0996> (last accessed 17.10.2023)

III **EUROPEAN COMMISSION (2010):** Commission Decision 2010/335/EU of 10 June 2010. Available at: <https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32010D0335&qid=1695731326161>. (last accessed 26.09.2020).

Note that Commission Decision 2010/335/EU of 10 June 2010 is due for review (as set out in Annex V, part C, point 10, Annex VI, part B, point 10). Any changes will be directly implemented with immediate effect.

IV **EUROPEAN COMMISSION (2017):** Communication from the Commission “Note on the conducting and verifying actual calculations of GHG emission savings”. Available at: https://ec.europa.eu/energy/sites/ener/files/documents/note_on_ghg_final_update_v2_0.pdf. (last accessed 01.04.2020).

3

according to Revised Directive 2018/2001/EC (for more information see: ²¹).

4

pursuant to Revised Directive 2018/2001/EC Annex VI, Part B, No. 1 (for more information, see: ²¹).

5

pursuant to Annex VI, Parts A, C and D of Revised Directive (EU) 2018/2001 (for more information, see: ²¹).

6

I Consistent with European Commission: Regulation (EC) 1059/2003 of the **European Parliament** and of the Council as level 2 regions of the classification of territorial units for statistics (NUTS) or as more disaggregated NUTS levels Available at: <http://ec.europa.eu/eurostat/de/web/nuts/overview> (last accessed 01.04.2020).

II Country reports under **EUROPEAN COMMISSION**: Energy topics. Available at: <https://ec.europa.eu/energy/en/topics/renewable-energy/biofuels/> (last accessed 01.04.2020).

8

EUROPA website of the European Commission: https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/voluntary-schemes_en#approved-voluntary-schemes-and-national-certification-schemes (last accessed on 17.06.2022).

9

See also Revised Directive (EU) 2018/2001 Annex VI, Part B, No. 18 (for more information, see: ²¹).

10

Revised Directive (EU) 2018/2001, Annex VI, Part B, No. 1 (for more information, see: ²¹).

11

Pesticides includes all plant protection products, herbicides, insecticides, fungicides, etc.

12

See 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, section 11 (https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf)

13

Global Nitrous Oxide Calculator (GNOC) (<https://gnoc.jrc.ec.europa.eu/>)

14

I based on the methodology in Revised Directive (EU) 2018/2001 Annex VI (for more information, see ²¹).

II **European Commission (2010)**: COMMISSION DECISION OF 10 JUNE 2010 ON GUIDELINES FOR THE CALCULATION OF LAND CARBON STOCKS FOR THE PURPOSE OF ANNEX V TO DIRECTIVE 2009/28/EC (2010/335/EU) Available at: https://eur-lex.europa.eu/legal-content/DE/TXT/?uri=uriserv:OJ.L_.2010.151.01.0019.01.DEU (last accessed on 01.04.2020).

15

for more information, see ⁸.

16

EUROPEAN COMMISSION: Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC (notified under document C(2010) 3751) (2010/335/EU) Available at: <https://op.europa.eu/de/publication-detail/-/publication/55f1c6e9-d08a-4678-9ad4-193c06df52ff> (last accessed on 01.04.2020).

Note that Commission Decision 2010/335/EU of 10 June 2010 is due for review (as set out in Annex V, part C, point 10, Annex VI, part B, point 10). Any changes will be directly implemented with immediate effect.

17

EUROPEAN COMMISSION (2010): (2010): Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC (notified under

document C(2010) 3751) (2010/335/EU) Available at: <http://eur-lex.europa.eu/legal-content/DE/TXT/PDF/?uri=CELEX:32010D0335&from=DE> (last accessed in August 2019).

18

You can find an example of the calculation of el in ECOFYS (2010): Annotated example of a land carbon stock calculation using standard values. Available at: https://ec.europa.eu/energy/sites/ener/files/2010_bsc_example_land_carbon_calculation.pdf (last accessed on 01.04.2020).

19

according to Revised Directive (EU) 2018/2001 (for more information, see: 2 I).

20

Rothamsted carbon model <https://www.rothamsted.ac.uk/rothamsted-carbon-model-rothc>

21

The term “EM” = emissions refers to the total emissions and not only to the emissions of the main product.

22

EUROPEAN COMMISSION, DIRECTORATE-GENERAL FOR ENERGY (DG ENER) (2015): Note on the conducting and verifying actual calculations of GHG emission savings. Available at: <https://ec.europa.eu/energy/sites/ener/files/documents/Note%20on%20GHG%20final.pdf> (last accessed on 01.04.2020).

23

Similarly, if these materials are used as raw materials, they start with zero emissions at the collection point.

Annex I: Determining the the annual amount of Nitrogen in above and below ground crop residues

To calculate $N_2O_{\text{direct-N}}$ and $N_2O_{\text{indirect-N}}$ multiple factors must be considered. One of these factors is the nitrogen input from above and below ground crop residues (F_{CR}) remaining on and in the managed soil. The nitrogen input from above and below ground crop residues must be determined crop specific following the systematic described below:

The nitrogen input from above and below ground crops residues must be determined for:

coconut and oil palm plantations by applying a fixed nitrogen input based on literature as IPCC (2006) provides no default calculation method for standard emission factors pursuant to Annex IX;

sugar beet and sugar cane according to IPCC (2006) Vol. 4 Chapter 11 Eq. 11.6, not considering below-ground residues and with the addition of Nitrogen input from vignasse and filter cake in the case of sugar cane using following formulae:

$$F_{\text{CR}} = \text{Yield} \times \text{DRY} \times (1 - \text{Frac}_{\text{Burnt}} \times C_f) \times [R_{\text{AG}} \times N_{\text{AG}} \times (1 - \text{Frac}_{\text{Remove}})] + F_{\text{VF}}$$

where:

Yield	=	<i>annual fresh yield of the crop [kg/ha]</i>
DRY	=	<i>dry matter fraction of harvested product [kg_{dry matter}/(kg_{fresh weight})]</i>
Frac_{Burnt}	=	<i>Fraction of crop area burnt annually [ha/ha]</i>
C_f	=	<i>Combustion factor [dimensionless]</i>
R_{AG}	=	<i>Ratio of above-ground residues, dry matter to harvested dry matter yield, for the crop [kg_{dry matter}/ kg_{dry matter}]</i>
N_{AG}	=	<i>N content of above-ground residues [kg N/kg_{dry matter}]</i>
Frac_{Remove}	=	<i>Fraction of aboveground residues removed from field [kg_{drymatter}/kg_{above ground dry matter}]</i>
F_{VF}	=	<i>Annual amount of N in sugar cane vignasse and filter cake returned to the field [kg N/ha], calculated as Yield·0,000508</i>

for all other crops according to IPCC (2006) Vol. 4 Chapter 11 Eq. 11.7a 11.11, 11.12; the calculation must be performed by using following formula:

$$F_{\text{CR}} = (1 - \text{Frac}_{\text{Burnt}} \times C_f) \times \text{AG}_{\text{DM}} \times N_{\text{AG}} \times (1 - \text{Frac}_{\text{Remove}}) + (\text{AG}_{\text{DM}} + \text{Yield} \times \text{DRY}) \times R_{\text{BG-BIO}} \times N_{\text{BG}}$$

where:

$\text{Frac}_{\text{Burnt}}$	=	<i>Fraction of crop area burnt annually [ha/ha]</i>
C_f	=	<i>Combustion factor [dimensionless]</i>
AG_{DM}	=	<i>Above-ground residue dry matter [$\text{kg}_{\text{dry-matter}}/\text{ha}$]</i>
N_{AG}	=	<i>N content of above-ground residues [$\text{kg N}/\text{kg}_{\text{dry matter}}$]</i>
$\text{Frac}_{\text{Remove}}$	=	<i>Fraction of aboveground residues removed from field [$\text{kg}_{\text{dry matter}}/\text{kg}_{\text{above ground dry matter}}$]</i>
Yield	=	<i>annual fresh yield of the crop [kg/ha]</i>
DRY	=	<i>dry matter fraction of harvested product [$\text{kg}_{\text{dry matter}}/(\text{kg}_{\text{fresh weight}})$]</i>
$R_{\text{BG-BIO}}$	=	<i>Ratio of belowground residues to above-ground biomass [$\text{kg}_{\text{dry matter}}/\text{kg}_{\text{dry matter}}$]</i>
N_{BG}	=	<i>N content of below-ground residues [$\text{kg N}/\text{kg}_{\text{dry matter}}$]</i>

Crop-specific parameters to calculate the nitrogen input from crop residues are listed in table 1 in chapter 2.3.

Annex II: Tabulated values for the calculation of $N_{2O_{total}}-N$

Table 2: Crop-specific parameters to calculate nitrogen input from crop residues

Crop	Calculation method	DRY	LHV	NAG	slope	intercept	RBG_BIO	NBG	Cf	RAG	N in crop residues	Data sources*
Barley	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.865	17	0.007	0.98	0.59	0.22	0.014	0.8			1,2
Cassava	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.302	16.15	0.019	0.1	1.06	0.2	0.014	0.8			1,2
Coconuts	Fixed N from crop residues	0.94	32.07								44	1,3
Cotton	No inform. on crop residues	0.91	22.64									
Maize	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	17.3	0.006	1.03	0.61	0.22	0.007	0.8			1,2
Oil palm fruit	Fixed N from crop residues	0.66	24								159	1,4
Rapeseed	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.91	26.976	0.011	1.5	0	0.19	0.017	0.8			1,5
Rye	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	17.1	0.005	1.09	0.88	0.22	0.011	0.8			1,6
Safflower seed	No inform. on crop residues	0.91	25.9									
Sorghum (grain)	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.89	17.3	0.007	0.88	1.33	0.22	0.006	0.8			1,7
Soybeans	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.87	23	0.008	0.93	1.35	0.19	0.087	0.8			1,8
Sugar beets	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.6	0.25	16.3	0.004					0.8	0.5		1,9
Sugar cane	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.6	0.275	19.6	0.004					0.8	0.43		1,10
Sunflower seed	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.9	26.4	0.007	2.1	0	0.22	0.007	0.8			1,11
Triticale	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.86	16.9	0.006	1.09	0.88	0.22	0.009	0.8			1,2
Wheat	IPCC (2006) Vol. 4 Ch. 11 Eq. 11.7a	0.84	17	0.006	1.51	0.52	0.24	0.009	0.9			1,2

1: References for parameters DRY and LHV see Appendix 1 of the JRC report "Definition of input data to assess GHG default emissions from biofuels in EU legislation", version 1d - 2019, <https://data.europa.eu/doi/10.2760/69179>

2: IPCC (2006) Vol. 4 Chapter 11 Table 11.2 (Factor a=Slope, b=Intercept, N_{AG} , R_{BG-BIO} and N_{BG}) and Chapter 2 Table 2.6 (Factor Cf). For Cassava and Triticale the general values for "Tubers" and "Cereals" respectively, are considered.

3: Magat (2002), Mantiquilla et al. (1994), Koopmans and Koppejan (1998), Bethke (2008) (data compilation by W. Weindorf. Ludwig Boelkew Systemtechnik GmbH, Ottobrunn, Germany)

4: Schmidt (2007) (data compilation by R. Edwards, JRC, Ispra, Italy)

5 N_{AG} and N_{BG} from Trinsoutrot et al. (1999) Table 1. Residue to seed ratio and factor a is based on Scarlat et al. (2010) Table 1. Ratio of belowground residues to above-ground biomass (R_{BG-BIO}) assumed to be the same as for beans and pulses in IPCC (2006) Vol. 4 Chapter 11 Table 11.2.

6 IPCC (2006) Vol. 4 Chapter 11 Table 11.2, value for R_{BG-BIO} assumed to be similar to Grains

7: IPCC (2006) Vol. 4 Chapter 11 Table 11.2, value for R_{BG-BIO} assumed to be similar to Maize

8: IPCC (2006) Vol. 4 Chapter 11 Table 11.2, except N_{BG} which is underestimated in IPCC (2006) according Chudziak and Bauen (2013).

9: Due to lack of information on below-ground residues for sugar beet, a modified method was used which does not take into account the below-ground biomass. The value for R_{AG} and N content of above-ground residues was adopted from the EDGAR database (European Commission Joint Research Centre (JRC) / Netherlands Environmental Assessment Agency (PBL), 2010). However, there is large disagree-

ment between the R_{AG} and N_{AG} values for Sugar beets applied in different countries (see Adolfsson, 2005).

10: Sugarcane is a semi-perennial crop. Sugarcane is typically replanted every six or seven years. For this period the root system remains alive. As IPCC (2006) does not provide default values, a modified method was used which does not take into account the below-ground biomass. The value for R_{AG} and N content of above-ground residues was adopted from the EDGAR database (European Commission Joint Research Centre (JRC) / Netherlands Environmental Assessment Agency (PBL), 2010).

11: Del Pino Machado, A.S. (2005) gives 0.0072 kg N per kg per dry matter of sunflower shoots. Corbeels et al. (2000) report a 0.0067 kg N per kg per dry matter in stalks. For GNOC a value of 0.007 kg N per kg above-ground residues dry matter was applied. Value - a - for the calculations of N input from crop residues according IPCC (2006) is based on the average of the "residue to crop production" values given for sunflower in Table 1 of Scarlat et al. (2010) Ratio of belowground residues to above-ground biomass and N_{BG} assumed to be the same as IPCC (2006) gives for maize.

Table 3: Constant and effect values for calculating N₂O emissions from agricultural field based on the S&B model

Constant value (c)	-1.516	
Parameter	Parameter class or unit	Effect value (ev)
Fertilizer Input		$0.0038 \cdot N_{\text{application rate}} \left[\frac{\text{kg N}}{\text{ha-a}} \right]$
Soil organic C content (soc)	<1 %	0
	1-3 %	0.0526
	>3 %	0.6334
pH (ph)	<5.5	0
	5.5-7.3	-0.0693
	>7.3	-0.4836
Soil texture (tex)	Coarse	0
	Medium	-0.1528
	Fine	0.4312
Climate (clim)	Subtropical climate	0.6117
	Temperate continental climate	0
	Temperate oceanic climate	0.0226
	Tropical climate	-0.3022
Vegetation (veg)	Cereals	0
	Grass	-0.3502
	Legume	0.3783
	None	0.5870
	Other	0.4420
	Wetland rice	-0.8850
Length of experiment (expl)	1 yr	1.9910

Annex III: Revision Information

Revision Information Version 3.0

Section	Change	Date of change
whole document	Version 2.0 updated to 3.0	19.05.2025
whole document	Directive (EU) 2018/2001 resp. RED II changed to: Revised Directive (EU) 2018/2001 resp. RED III	19.05.2025
whole document	deleted: Corrigendum to 2018/2001 (including foot note 6 & 11)	19.05.2025
Section 1	amended: Article 29 (10) of the Revised Directive (EU) 2018/2001 stipulates requirements for the minimum greenhouse gas (GHG) emission savings that producers of electricity, heating and cooling must demonstrate against their national competent authorities in order to be counted towards the renewable energy- and GHG mitigation targets. Depending on the date of enforcement of national GHG mitigation obligations and the start of operation of the plant and the total time of operation, the following GHG emissions savings must be achieved, as long as there are no other requirements defined in the national regulations of the country in which the installation is operated:	19.05.2025
Section 1	The last interface that converts biofuels [...] changed to: The last interface that converts biomass fuels [...]	19.05.2025
Section 2.1	If these emissions deviate significantly from typical values (e.g. more than 10%), reasons [...] changed to: Where the emissions deviate significantly ($\geq 10\%$) from typical values or calculated actual values of emissions savings are abnormally high (greater than 30 % deviation from default values ²⁴ , reasons [...] added: If implausibilities result in the audit not being passed, SURE must be informed in accordance with the valid scheme principles for the certification process. deleted: [...] and SURE informed immediately of the deviation found.	19.05.2025

Section	Change	Date of change
Section 2.1	The greenhouse gas emission saving [...] changed to: The GHG emission savings [...]	19.05.2025
Section 2.1	production chain replaced by: value chain	19.05.2025
Section 2.2	greenhouse has saving replaced by: GHG savings	19.05.2025
Section 2.3	value chain of custody replaced by: value chain custody	19.05.2025
Section 2.3	<p>Economic operators may alternatively use a value for the emissions from the extraction, harvesting or cultivation of raw materials [...]</p> <p>changed to/replaced and added:</p> <p>For emissions from the extraction or cultivation of raw materials (e_{ec}), economic operators may use a value calculated for a NUTS level 2 region or a region at more at a more disaggregated NUTS level, provided that</p> <ul style="list-style-type: none"> - the production of the raw material took place in that region, and - a Member State or a third country submitted a report pursuant with Article 31 (2) and (3), and - the European Commission by means of implemented acts decided that the report contains accurate data for the purpose of measuring GHG-emissions in that region. <p>NUTS-2 values are to be indicated in the unit $\text{gCO}_2\text{eq/kg}$ of dry matter along the entire production chain. These values are alternatives to the individually calculated values. They are published on the website of the European Commission and are not default values. Consequently, they can only be considered input values to calculate and adjust individual cultivation emissions of the downstream interfaces. They are not suitable for specifying emissions from the cultivation phase in $\text{gCO}_2\text{eq/MJ}$ of biomass fuel.</p> <p>If no such NUTS-2 value exists in the region of cultivation, economic operators must either use an actual value or an existing disaggregated default value.</p>	19.05.2025
Section 2.3	table 1 updated to: $\text{CO}_2 \rightarrow 1$ $\text{N}_2\text{O} \rightarrow 265$ $\text{CH}_4 \rightarrow 28$	19.05.2025
Section 2.4	passage replaced in 2.3	19.05.2025

Section	Change	Date of change
Section 3.1	[...] straw, and waste [...] are taken to be “zero” until [...] changed to: [...] straw, waste [...] and all waste and residues included in Annex IX of Revised Directive (EU) 2018/2001, are set to “zero” [...]	19.05.2025
Section 3.1.5	references updated	19.05.2025
Section 3.4	- use of soil improver changed to: - use of organic soil improver	19.05.2025
Section 3.4	45.05 g CO ₂ eq/MJ biogas changed to: 45.05 g CO ₂ eq/MJ manure	19.05.2025
Section 3.4	Emission savings from improved agricultural management practices can be taken into account if reliable and verifiable evidence is provided. changed to: Emission savings from improved agricultural management practices can only be taken into account if they do not risk to negatively affect biodiversity. Further, solid and verifiable evidence must be provided	19.05.2025
Section 3.5	Formulas (e_{td}) updated	19.05.2025
Section 3.5	added: As the transport efficiencies listed in Annex IX of Implementing Regulation (EU) 2022/996 are based data published by the JRC which already take into account the return voyage (empty), no separate calculation of the return voyage is required when using the alternative formula. added: If biomethane is transported via the European gas grid, the economic operator injecting and transporting biomethane into the European gas grid must take gas losses of 0.01 gCH ₄ /MJ into account	19.05.2025
Section 3.6	Formula (e_p) updated Formula (EM_{heat}) updated	19.05.2025

Section	Change	Date of change
Section 3.6	<p>deleted: For gas losses, an emission factor of 0.17 CH₄/MJ bio-methane must be applied.</p> <p>deleted: In accounting for the consumption of electricity not produced in the biogas plant itself, it is assumed that the GHG emission intensity of the production and transmission of this electricity is equal to the average emission intensity of the production and distribution of electricity in a specific, clearly defined region:</p> <ul style="list-style-type: none"> - In case of the EU as defined region, the average EU emission intensity in the reference value - In case of third countries, where grids are often less linked up across borders, the national average, e.g. could be a appropriate choice. <p>changed to: In accounting for the consumption of electricity not produced within the biomass fuel plant, the GHG emission intensity of the production and distribution of that electricity is to be assumed to be equal to the average emission intensity of the production and distribution of electricity in the country where the processing takes place. The national emission intensities for grid electricity listed in Annex IX of Implementing Regulation (EU) 2022/996 must be used. If the emission intensity for grid electricity is not listed in Annex IX of Implementing Regulation (EU) 2022/996, the average national emission intensity of the country's electricity generation could be the appropriate choice.</p>	19.05.2025
Section 3.7	<p>The definition of this emissions saving in accordance with Annex VI Part B No. 15 of Directive (EU) 2018/2001 is "Emission saving from CO₂ capture and replacement [...]"</p> <p>changed to: Emission savings from CO₂ capture and replacement (e_{ccr}) shall be related directly to the production of the biomass fuel to which they are attributed and shall be limited to emissions avoided through the capture of CO₂ of which the carbon originates from biomass and which is used to replace fossil-derived CO₂ in the production of commercial products and services. Note that the option to credit emission savings by e_{ccr} is only possible if the biogenic CO₂ is used to replace fossil-derived CO₂ in the production of commercial products and services before 1. January 2036. This means that from 1. January 2036, it will no longer be possible to credit e_{ccr}</p>	19.05.2025

Section	Change	Date of change
Section 3.7	liquid and gaseous transport fuel changed to: liquid and gaseous fuels	19.05.2025
Section 3.9.1	added: All co-products that have no heating value and therefore do not fall under Annex VI, Point 17 of the Revised Directive (EU) 2018/2001 must be taken into account when determining the allocation factor.	19.05.2025
Section 3.10	Missing formula added (C_h)	19.05.2025
Section 5	references updated	19.05.2025

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