GHG Emissions Calculation Methodology and GHG Audit

ISCC 11-01-14
V 1.16 11-01-14

Document title: ISCC 205

GHG Emissions Calculation Methodology and GHG Audit

Approved by: **Date:**

Issue date:

Application date:

Content

1 Introduction

The goal of the greenhouse gas (GHG) emissions calculation is the calculation and verification of GHG emissions along the value chain. This includes the emissions from biomass production, conversion processes, and transport.

Information about the generated GHG emissions and about the GHG abatement in comparison to the use of fossil energy is one element of the data that is necessary for the traceability of sustainable biomass.

Members of the value chain that have gone through a successful audit can be assigned an individual GHG emissions value in connection with the sustainability and chain of custody audit. The individual GHG value is expressed in GHG emissions per ton of product and they can provide this information together with their product to their customers.

The liquid biomass/biofuel used must demonstrate a greenhouse gas reduction potential of at least 35% compared to the fossil alternative. As of 01 January 2017, this value will increase to a minimum of 50%, followed by an increase to 60% on 01 January 2018 in cases where the interface started operation after 31 December 2016.

2 Scope

Specification of the relevant elements of the GHG auditing for the individual elements of the value chain and defines the minimum requirements for the GHG emissions calculation.

In general, the following elements of the supply chain must provide their GHG emission values, either by the use of default values or individually determined values:[1]

(1) Biomass producers

(2) Conversion units (Conversion of solid biomass into liquid biomass or processing of liquid biomass)

(3) Transport

The provision of all values must be audited. At the different elements of the value chain auditors primarily check the following aspects:

(1) Correct application of the default values (based on default values from Directive 2009/28/EC and Biokraft-NachV, BioSt-NachV)[2]. Default and disaggregated default

[1] The “Guideline Sustainable Biomass Production”, published by the BLE includes further information.

[2] For disaggregated default values stated in emissions per tonne of product that are required in flexible chains, please refer to the official notification of greenhouse gas emissions values “Bekanntmachung von Treibhausgas-Emissionswerten auf Grund des § 16 Absatz 3 Satz 1 der Biomassestrom-Nachhaltigkeitsverordnung”. The default values for pure palm oil and pure soya oil that are marketed as biofuel and/or used for electricity generation may no longer be used in the calculation of GHG reduction potential after 01 January 2011. In Germany the authorised estimated values can be used for the process stage that covers cultivation of barley, rye and triticale in accordance with §8, Paragraph 3, Number 2 b of Biokraft-NachV/BioSt-NachV. Other estimated values may not be used.

values can only be used in place of an actual calculated value under certain conditions.

It must be noted that the disaggregated default value for cultivation from Directive 2009/28/EC (Annex V, Sections D and E of the Directive) can only be used if the biomass was produced in third countries or certain regions of the European Union as detailed in a list in accordance with Article 19, Paragraph 2 of Directive 2009/28/EC.[3]

(2) In the case of individual calculations the following elements need to be verified:

a. Data and data sources for all relevant in- and outputs of the production process

b. Emission factors and their sources

c. Lower heating values for the main product and by-products

(3) Method of calculation of the individual GHG emission value and provision of the correct value. Should one element in the value chain have to deal with different individual GHG emission values (e.g. if a biodiesel plant receives inputs of vegetable oils with different GHG emission values), the worst one of these values (the one with the highest emissions) can be used for the entire production as long as mandatory maximum values are not exceeded (see also ISCC 204, chapter 4.3.8)[4].

Old operational units (old plant) that started operation before 23 January 2008 do not have to comply with the minimum greenhouse gas reduction potential until 01 April 2013. The greenhouse gas reduction potential must not be calculated in cases where old operational units take advantage of this option. However, old operational units also have the option of declaring greenhouse gas reduction potential by means of default values or individual calculations.

[3] In accordance with Article 19, Para. 2, by 31 March 2010, Member States shall submit to the Commission a report including a list of those areas on their territory classified as level 2 in the nomenclature of territorial units for statistics (NUTS) or as more disaggregated NUTS levels where the typical greenhouse gas emissions from cultivation of agricultural raw materials can be expected to be lower than or equal to the emissions reported under the heading 'Disaggregated default values for cultivation' in part D of Annex V to the Directive. The corresponding reports are published here: http://ec.europa.eu/energy/renewables/transparency_platform/emissions_en.htm.
However, it is not intended that the NUTS2 values published in these lists be used in situations where they fall short of the default value. NUTS2 values for cultivation from these lists can be used in cases where the disaggregated default value for cultivation taken from the NUTS2 values is exceeded or where no default value for cultivation is available (e.g. rye or triticale).

[4] A list of maximum emissions values can be found in the official notification of greenhouse gas emissions value "Bekanntmachung von Treibhausgas-Emissionswerten auf Grund des § 16 Absatz 3 Satz 1 der Biomassestrom-Nachhaltigkeitsverordnung". This list of maximum values for aggregation must only be used within the scope of BioSt-NachV. Beginning on the date that the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety publishes the maximum values for use within the scope of Biokraft-NachV, aggregation must also be carried out using those maximum values within the scope of Biokraft-NachV.

3 Normative references

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

Relevant references:

ISCC	201	System Basics
ISCC	202	Sustainability Requirements – Requirements for the Production of Biomass
ISCC	202-01	Checklist for the Control of the Requirements for the Production of Biomass
ISCC	203	Requirements for Traceability
ISCC	203-01	Checklist for the Control of the Requirements for Traceability
ISCC	204	Mass Balance Calculation Methodology

ISCC Audit Procedures

4 GHG emissions calculation methodology

4.1 Options for the provision of GHG information

Within ISCC there are three options for GHG information provision:[5]

(1) Use of default value: The Directive 2009/28/EC determines default values for different types of biofuels. These values are feedstock-, region- and partly process-specific. Besides an overall default value for the sum of the emissions for the final product, the Directive also includes default values for cultivation, processing and transport and distribution which could be used by the respective elements of the supply chain.

(2) Use of individually calculated values: Individually calculated values for specific elements of the value chain can be used if they have been calculated based on the calculation methodology from the Directive 2009/28/EC and national requirements of the Member States (see below for calculation methodology).

(3) Combination of default value and individually calculated value: A combination of these values is possible at the different elements of the value chain (for example input of certain amounts of rape with default value and certain amounts with individually calculated value into an oil mill) but also between different elements of the value chain (for example default value for cultivation plus individually calculated value for the oil mill).

It is important to recognise that there is no GHG emissions default value for land use change. If default values are used for cultivation, net emissions from land use change always need to be added.

The relevant elements of the value chain need to declare which one of the three options above is being applied.

Default values need to be taken from the Directive 2009/28/EC, or the German Sustainability Ordinances and from further documents with respect to implementation.

4.2 Calculation based on actual values

4.2.1 Data basis

4.2.1.1 On-site data gathering

The following data for the calculation of GHG emissions must be gathered on-site:

- Amount of main product and by-products,
- Amount of chemicals used (e.g. methanol, NaOH, HCl, hexane, citric acid, fuller's earth, alkali),
- Amount of P_2O_5-, K_2O-, CaO- and N-fertilizer,

[5] These options result from the Directive 2009/28/EC and also from the German Sustainability Ordinances. Please also see "Guideline Sustainable Biomass Production", published by BLE.

- Diesel consumption, electricity consumption,
- Thermal energy consumption,
- Process energy source,
- Amount and use of by-products and wastes, e.g. Palm Oil Mill Effluent (POME) or Empty Fruit Bunches (EFBs).

4.2.1.2 Data gathering from literature

The following data can also be taken from scientifically recognized literature. Sources must be denoted (in particular authors, title, journal, volume, and year of publication).

- Heating values of main product and by-products,
- Emission factors of for example fertilizers, diesel use in agricultural machinery or for transport, chemicals, electricity, POME in its different uses, thermal energy, and
- Emission factor of N_2O.

Data measured and gathered on-site must be documented (e.g. within field record system, delivery orders, invoices, etc.). For data taken from literature or data bases (heating values, emission factors, etc.) the respective source and year of publication must be documented and verified by the auditors.

In addition, the possibility to collect data (e.g. emission factors) by individual measurements also exists. However, the methodology must be made transparent so that measurements can be reproduced.

4.2.2 Requirements for the calculation of GHG emissions from raw materials production

GHG emissions (EM) from cultivation e_{ec}, including the GHG emissions from cultivation itself, and harvest as well as the emissions from the production of the inputs necessary for cultivation must be calculated according to the following formula (EM = emissions; EF = emission factor):

$$e_{ec}' = \frac{EM_{fertilizer}\left[\frac{kg\ CO_2}{ha * yr}\right] + EM_{diesel}\left[\frac{kg\ CO_2}{ha * yr}\right] + EM_{electricity}\left[\frac{kg\ CO_2}{ha * yr}\right] + EM_{inputs}\left[\frac{kg\ CO_2}{ha * yr}\right]}{crop\ yield_{main\ product}\left[\frac{kg\ crop\ yield}{ha * yr}\right]}$$

The main product from cultivation is passed on for processing to the next element in the supply chain that produces the liquid biomass out of it. The liquid biomass is then used directly for energy production or is going through another processing step.

At this element of the value chain (raw materials production) fertilizers, pesticides, diesel or process energy, and probably further inputs which might be used.

Formula components in detail:

$$EM_{fertilizer} = fertilizer\left[\frac{kg}{ha*yr}\right]*\left(EF_{production}\left[\frac{kgCO_2}{kg}\right]+EF_{field}\left[\frac{kgCO_2}{kg}\right]\right)$$

$$EM_{diesel} = diesel\left[\frac{l}{ha*yr}\right]*EF_{diesel}\left[\frac{kgCO_2}{l}\right]$$

$$EM_{electricity} = electricity\left[\frac{kWh}{ha*yr}\right]*EF_{regional electricity\ mix}\left[\frac{kgCO_2}{kWh}\right]$$

$$EM_{input} = input\left[\frac{kg}{ha*yr}\right]*EF_{input}\left[\frac{kgCO_2}{kg}\right]$$

During raw materials production, GHG emissions from the following activities need to be included:

- Cultivation, harvest, processing of the feedstock
- Use of chemicals and other inputs (e.g. diesel)

For the calculation of e_{ec}, as a minimum, the following data needs to be collected on-site, i.e. the respective quantities must be extracted from respective operating documents and must be verified by the auditors:

- Fertilizers (mineral and organic) [kg/(ha*yr)] – total yearly amount of applied fertilizers in the cultivation period (N, P_2O_5, K_2O, CaO-fertilizer)
- Diesel [l/(ha*yr)] – total yearly amount of diesel used per hectare, e.g. for transport machinery or water pumps
- Electricity consumption – total yearly electricity consumption per hectare, e.g. for drying and water pumps
- Crop yield main product [kg crop yield/(ha*yr)] – Yearly crop yield of the main product in kg per hectare. In case of drying the mass of dried product is necessary
- Yield of relevant by-products
- Return of by-products or wastes from the next element in the value chain (first conversion unit) to the fields (for example POME, Empty Fruit Bunches etc.)

In case further emissions from additional inputs occur they must be documented and included in the calculation.

For the calculation of e_{ec} the following emission factors can be withdrawn from literature or a database. Sources must be documented and verified by auditors:

- Emission factor diesel [kg CO_2/l diesel]
- Emission factor fertilizer production [kg CO_2/kg fertilizer]
- Emission factor for fertilizer emissions from the field [kg CO_2/kg fertilizer]
- Emission factor regional electricity mix [kg CO_2/kWh]

These data must be used for the different elements of the calculation formula.

All GHG emissions data is given in mass units in relation to the main product of the respective element in the value chain (e.g. diesel [l]/ rape seed [kg]).

The carbon dioxide fixation during feedstock cultivation is not considered in the calculation formula.

Estimates of emissions from cultivation may be derived from the use of averages calculated for smaller geographical areas than those used in the calculation of the default values from the Directive 2009/28/EC, as an alternative to using individually calculated values.

In the end, the respective element of the value chain passes on the GHG information in kg CO_2eq-emisisons/t feedstock together with the feedstock itself.[6] In case that by-products which can be subject to allocation of emissions are produced (see below), the allocation of emissions to the main product and by-products already takes place for the element of raw materials production within the value chain.

There are no GHG emissions attached to the production of residues (e.g. starch residues from a starch factory). If these residues come from a factory and are not produced on a farm/ plantation a proof of compliance with sustainability requirements must not take place. However, at the producer of the residues, the mass balance must be verified in the framework of the BioKraft-NachV.

4.2.3 Requirements for the calculation of GHG emissions in case of land use change

Generally, land use changes taking place after the cut-off date of January 1, 2008 must be taken into account. This is also the case when default values are used as they do not include possible GHG emissions or savings from land use change.

We refer to land use change if the carbon stock of the cultivated are has changed after the cut-off date, e.g. through a change between or within the categories of forest, crop land, grassland, wetland, settlement areas, degraded land and any other area. It must be taken into account that based the issue of an ISCC certificate is per se not possible if the conversion of some of these areas has taken place (please see ISCC 202 and 202-01).

[6] Wastes and agricultural crop residues shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials.

The annualized emissions from carbon stock changes caused by land use change e_l are calculated by dividing total emissions equally over 20 years based on the following formula:

$$e_l' = \frac{CS_R\left[\frac{kgC}{ha}\right] - CS_A\left[\frac{kgC}{ha}\right]}{crop\ yield_{main\,product}\left[\frac{kg}{ha*yr}\right] \mathrm{X}\, 20[yr]} \mathrm{X}\, 3{,}664 - \frac{e_B}{AF\ \mathrm{X}\, CF}$$

AF, CF = product specific allocation and conversion factor to calculate the emissions per kg of product.[7]

For entitlement to the bonus e_B of 29 g CO_2eq/MJ of liquid biomass for cultivation on degraded land, the element in the value chain needs to provide documentation that the respective land:

- was not in use for agriculture or any other activity in January 2008
- is severely degraded land or
- heavily contaminated land.

The bonus e_B is applicable for a period of up to ten years beginning at the point in time when the land has been converted into agricultural land, if

- a continuous rise of the carbon stock and a relevant decline of erosion on heavily degraded land is taking place and
- soil contamination on highly contaminated land is being reduced.

The carbon stock of the land is defined by the mass of carbon in soil and vegetation per unit of land.

CS_R (land carbon stock before conversion into agricultural land) is the carbon stock associated with the reference land per unit of land (measured as mass of carbon per unit of land 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 latest.

CS_A (carbon stock per unit of land after conversion into agricultural land) is the carbon stock per unit area associated with the actual land use (measured as mass of carbon per unit of land, including both soil and vegetation). In cases where the carbon stock accumulates over more than one year, the value attributed to CS_A shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earliest.

e_B is the bonus of 29 gCO2eq/MJ liquid biomass if biomass is obtained from restored degraded land.

Land that is not excluded from cultivation according to the requirements from the Directive 2009/28/EC or national requirements (e.g. from the sustainability ordinances in Germany)

[7] For detailed factors please see “Guidelines Sustainable Biomass Production”, published by BLE.

can be converted if the net GHG emissions from the land use change are calculated and added to the other emission values. Therefore, the land use category on January 1, 2008 must be determined.

If it is proven that no land use change took place after the reference year, i.e. if the land was classified as agricultural land or falls within one of the exceptions as described in ISCC Document 202, e_l equals zero. Only if this is the case, overall default values or default values for cultivation may be applied.

e_l need not be calculated if the land use change took place before the time reference point.

Heavily contaminated land means land that is not suitable for food and feed production due to soil contamination. 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. Severely degraded land also includes former agricultural land.

Salinated land which includes salination and sodification exists if:

- Soil horizons at the surface or within 100cm under the surface include secondary accumulations of salts that have a higher solubility than gypsum and generating an electric conductivity within a ground saturation extract >4 dS m-1 and
- The salinated horizons altogether reach a minimum depth of 15 cm

or if

- Soil horizons at the surface or within 100cm under the surface have a saturation of exchangeable sodium percentage (ESP) of at least 15 % and
- The sodified horizons altogether reach a minimum depth of 15 cm.

Such land shall include land that has been the subject of a decision by the European Commission in accordance with the fourth subparagraph of Article 18(4) of the Directive 2009/28/EC. Possible future specifications regarding degraded land by the European Commission will be incorporated.

4.2.4 Requirements for the calculation of GHG emissions from processing

Every processing unit in the value chain must guarantee that all GHG emissions from processing, e_p, GHG emissions from wastes (wastewater) and from the production of all inputs are included in the emissions calculation and that the calculation is based on the following formula:

$$e_p' = \frac{EM_{electricity\ consumption}\left[\frac{kgCO_2}{yr}\right] + EM_{heat\ production}\left[\frac{kgCO_2}{yr}\right] + EM_{inputs}\left[\frac{kgCO_2}{yr}\right] + EM_{waste\ water}\left[\frac{kgCO_2}{yr}\right]}{yield_{main\ product}\left[\frac{kg\ yield}{yr}\right]}$$

Components of the formula in detail

$$EM_{electricity\ consumption} = electricity\left[\frac{kWh}{yr}\right] * EF_{regional\ electricity\ mix}\left[\frac{kgCO_2}{kWh}\right]$$

$$EM_{heat\ production} = fuel\ consumption\left[\frac{kg}{yr}\right] * EF_{fuel}\left[\frac{kgCO_2}{kg}\right]$$

$$EM_{inputs} = inputs\left[\frac{kg}{yr}\right] * EF_{additional\ inputs}\left[\frac{kgCO_2}{kg}\right]$$

$$EM_{wastewater} = waste\ water\left[\frac{l}{yr}\right] * EF_{wastewater}\left[\frac{kgCO_2}{l}\right]$$

For the calculation of GHG emissions from processing (e_p) as a minimum, the following data needs to be collected on-site, i.e. the respective quantities must be extracted from respective operating documents and must be verified by the auditors.

The use of alternative reference points (month, kg of the main product, etc.) is possible.

- Electricity consumption [kWh/yr] – annual total electricity consumption from external sources, i.e. not produced in an internal combined heat and power production (CHP) plant,
- Heat production – Type of fuel used for steam production, e.g. heating oil, natural gas, crop residues,
- Fuel consumption [kg/yr] – annual total fuel consumption for heat production, e.g. heating oil [kg], natural gas [kg], bagasse [kg],
- Further inputs (operating supplies, e.g. methanol, acids, etc.)
- Yield main product [kg main product/yr] – Annual yield of the main product, e.g. rape oil,
- Yield of by-products,
- Amount of wastewater [l/yr] – Annual amount of wastewater and wastes (e.g. POME),
- Feedstock inputs (Amounts, conversion rates, and GHG value of feedstock inputs)

GHG emissions from wastes are included in the calculation of e_p.

For the calculation of e_p the following emission factors can be taken from a scientifically recognized literature source:

- Emission factor fuel [kg CO_2/kg],
- Emission factor wastewater [kg CO_2/l] and wastes [kg CO_2/l] and
- Emission factor regional electricity mix [kg CO_2/kWh].
- Emission factors for operating supplies

If palm oil mills are operating methane capture devices that can guarantee actual methane capture, the following aspects need to be checked and fulfilled:

- Absorption of total wastewater in a closed system (only short-term storage of fresh POME) and supply to a biogas plant,
- Use of the produced biogas for energy purposes, or in the worst case flaring of the biogas and
- The biogas plant is in good condition, leakages are nonexistent, and the producer provides a guarantee about the maximum methane leakage that does not exceed the current state of the technology.

The GHG emissions are calculated per unit mass of the main product (e.g. CO_2-emissions [kg]/rape oil [kg])

For the calculation of the GHG emissions from electricity consumption in the case that electricity is sourced externally, the emission factor for electricity from the regional electricity mix shall be used.

If wastes like crop residues, straw, bagasse, husks, cobs and nut shells as well as production residues, including crude glycerine are used for the production of biofuels and bioliquids, the GHG emissions of these materials are considered to be zero up to the point of their collection.

Emission savings from surplus electricity from CHP production (e_{ee}) are calculated based on the following formula:

$$e_{ee}' = \frac{excess\ electricity\left[\frac{kWh}{yr}\right] * EF_{fuel}\left[\frac{kgCO_2}{kWh}\right]}{yield_{main\ product}\left[\frac{kg}{yr}\right]}$$

For the calculation it is assumed that the size of the CHP plant is that of the minimum size necessary to supply the needed amount of heat for the production of the liquid fuel.

The amount of GHG emission savings from excess electricity equals the amount of GHG emissions from the production of an equivalent amount of electricity in a power plant using the same fossil fuel as the CHP plant. This is the only case where for the treatment of by-products (excess electricity) the substitution method and, not as for all other by-products, the allocation method based on lower heating values of the main product and the by-products is being used.

For the calculation of e_{ee} the following data is collected on-site:

- Excess electricity [kWh/yr] – Annual amount of electricity produced in an internal CHP plant but fed into an external grid,
- Type of fuel for CHP plant – Type of fuel used within the CHP plant, e.g. heating oil, natural gas, coal and

- $Yield_{main\ product}$ [kg/yr] – Annual yield of the main product, e.g. rape oil [kg/yr]

- Type of CHP plant (e.g. CHP, steam co generation plant, gas-steam power plant).

For the calculation of e_{ee} the following data can be withdrawn from a scientifically recognized source:

- Emission $factor_{fuel}$ [kg CO_2/kWh] – Emission factor for the type of CHP plant that is being used

Emission saving from carbon capture and geological storage e_{ccs}, that have not already been accounted for in e_p, shall be limited to emissions avoided through the capture and sequestration of emitted CO_2 directly related to the extraction, transport, processing and distribution of fuel.

Emission saving from carbon capture and replacement, e_{ccr}, shall be limited to emissions avoided through the capture of CO_2 of which the carbon originates from biomass and which is used to replace fossil-derived CO_2 used in commercial products and services.

At the end of the processing step the respective element in the value chain passes on the GHG information in kg CO_2eq-emisisons/t product together with the product itself.

If by-products that are eligible for the allocation of emissions (see below) are produced, the allocation of emissions to the main product and by-products already takes place for the respective element in the supply chain. The GHG emissions value that is passed on is the value after allocation procedures (see below).

4.2.5 Requirements for the calculation of GHG emissions from transport

All respective elements in the value chain calculate the GHG emissions from transport e_{td} of biomass taking account of all transport steps based on the following formula:

$$e_{td}'\left[\frac{kgCO_2}{kg}\right]=\frac{\left(d_{loaded}[km]*K_{loaded}\left[\frac{l}{km}\right]+d_{empty}[km]*K_{empty}\left[\frac{l}{km}\right]\right)*EF_{fuel}\left[\frac{kgCO_2}{l}\right]}{m_{intermediate\ product}[kg]}$$

GHG emissions already accounted for in feedstock production and harvest need not be considered.

For the calculation of e_{td} the following information needs to be provided:

- Transport distance (d) [in km] loaded/ respectively empty – Distance the biomass is transported to the next element in the value chain, e.g. average distance between plantation and oil mill (return transports that are not taking place empty do not need to be taken into account),

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

- Amount of biomass transported.

The following impact factors can be withdrawn from recognized scientific literature or can be measured:

- Emission factor fuel (EF_{fuel}),
- K_{loaded} [l/km] – Fuel consumption of the respective mode of transport per km when loaded and
- K_{empty} [l/km] – Fuel consumption of the respective mode of transport per km when empty.

The reference unit (m) for transport is always kg of the product transported.

The GHG emissions from transport always need to be documented and included into the GHG calculations by the element in the value chain that is receiving the product.

4.2.6 Allocation based on lower heating values

Generally, an allocation of GHG emissions to the main product and by-products can take place. An allocation is the distribution of emissions to the main product and by-products. This needs to be done in proportion to the lower heating value of the products. The only exception to this rule is the feed-in of excess electricity to an external grid (see 4.3.6).

An allocation takes place at every element in the value chain that in addition to the main product that is passed on in the value chain also produces by-products. All emissions up to that point can then be distributed between the main product and the by-products based on their lower heating values. The GHG value after this allocation product is passed on within the value chain.

The following formula is used for the calculation:

$$e'_{allocated} = sum\ GHG\ emissions * allocation\ \ factor$$

A by-product is one out of multiple products coming from the same production process and for which an allocation takes place.

Those products from a production process the owner wants to or must get rid off are not considered as by-products but as waste. To such products an allocation is not possible.

The lower heating value is defined as the maximum amount of usable heat from a combustion process that does not cause the condensation of the steam from the exhaust emissions in proportion to the fuel used.

The energy content of by-products that have negative energy content is defined as zero.

For the calculation of the allocation factor, the lower heating values that relate to the dry matter are multiplied with the yield of the dry matter. If lower heating values that relate to the original matter are used, they must be multiplied with the yield of the original matter.

The following formula is used for the calculation of the allocation factor:

$$allocation\ \ factor = \frac{energy\ content_{main\ product}[MJ]}{energy\ content_{main\ product}[MJ] + energy\ content_{by-product}[MJ]}$$

with

$$energy\ content_{main\ product} = yield_{main\ product}\left[\frac{kg}{yr}\right] * lower\ heating\ value_{main\ product}\left[\frac{MJ}{kg}\right]$$

$$energy\ content_{by-product} = yield_{by-product}\left[\frac{kg}{yr}\right] * lower\ heating\ value_{by-product}\left[\frac{MJ}{kg}\right]$$

For the calculation of the share of GHG emissions that are allocated to the different products, total GHG emissions up to the production process where the by-product is produced need to be summed up and multiplied with the allocation factor.

All by-products are accounted for in the calculation, except for crop residues (straw, bagasse, husks, cobs and nut shells)

For the calculation of the allocation factor at least the following components must be measured on-site and verified by the auditors:

- Yield main product [kg main product/yr] and
- Yield by products.

4.2.7 Aggregation of GHG emissions

For the aggregation of different batches of sustainable biomass with different GHG values please refer to ISCC document 203 and 204 regarding the requirements for traceability and mass balance calculation.

4.2.8 Requirements for the final interface in the value chain

The final interface in the value chain calculates the overall GHG emissions in g CO_2/MJ (and not only in g/kg product) using the lower heating values from the Directive 2009/28/EC. Another option would be the calculation of overall GHG emissions of the supplied biofuel or bioliquid using the default value from the Directive 2009/28/EC or respective national legislation (e.g. from the German BioSt-NachV and Biokraft-NachV).

The final interface in the value chain calculates into which regions the liquid biomass can be transported without violating the minimum GHG saving potential, unless upstream elements in the value chain have already used the default value for transport and distribution (e_{td}).

The final interface uses the following formula for the calculation of the GHG saving potential:

$$GHG\ saving\ potential\ [\%] = \frac{GHG\ emissions\ fossil\ fuel - GHG\ emissions\ biomass}{GHG\ emissions\ fossil\ fuel}\ X\ 100$$

The following fossil comparators must be used:

- Biofuels for transport: 83,8 g CO_2eq/MJ fossil fuel[8],
- Bioliquids used for electricity production: 91 g CO_2eq/MJ fossil fuel,

[8] This value shall be used until a new value according to Directive 98/70/EC is available.

- Bioliquids used for electricity production in CHP plants: 85 g CO_2eq/MJ fossil fuel and
- Bioliquids used for heat production: 77 g CO_2eq/MJ fossil fuel.

4.3 Documentation

To proof compliance with all the requirements for sustainable production of biofuels and bioliquids all relevant elements in the value chain need to provide documentation on the:

- Calculation of GHG emissions,
- Measured data that is used in the calculation,
- Default, reference values and conversion rates used as well as their sources and
- Data that has to be collected in the framework of the mass balance system.

5 Calculation formula

Overall GHG emissions of a bioenergy value chain are calculated based on the following formula[9], comprised of emissions and emissions savings:

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

where

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

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

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

e_p *emissions from processing,*

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

e_u *emissions from the fuel in use*,

e_{sca} *emission saving from soil carbon accumulation via improved agricultural practices,*

e_{ccs} *emission saving from carbon capture and geological storage,*

e_{ccr} *emission saving from carbon capture and replacement, and*

e_{ee} *emission saving from excess electricity from cogeneration.*

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

The unity of the different variables is g CO_2/MJ final product.

In practice, however, there are normally no clearly defined and closed value chains. Therefore, every element in the supply chain must calculate overall emissions for the product it supplies and must pass on this information together with the product. For the upstream elements in the supply chain must receive this information always from the element one step up.

Every element in the value chain calculates the aggregated GHG emissions, including the upstream process (GHG value comes from the element one step up) and emissions from its own production in kg CO_2eq/t of the product produced before the product is passed on to downstream elements in the value chain.

GHG emissions from transport in between the different elements of the value chain must always be added by the element in the chain that is receiving a product and must be included in overall emissions of the product that is passed on in the value chain.

The respective element in the value chain calculates the GHG emissions (e') per product output (g CO_2/kg product). Thereby it takes account of the emissions from the inputs (GHG information on their inputs must be provided by the element one step up that provides the

[9] The formula correlates to the one from Directive 2009/28/EC.

input product) and of emissions from its own production process. The allocation of emissions to the main product and by-products in proportion to their lower heating values always takes place for the products produced by the respective element in the chain. This means that the product it sells to the next element in the chain has a GHG information attached, after an allocation that includes the respective step of production.