GHG Emissions Calculation Methodology and GHG Audit

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Content

1 Introduction

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

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 and bioliquids.

Members of the supply 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. Only the last interface will calculate the percentage saving of GHG emissions compared to the fossil reference.

Based on the Directive 2009/28/EC ISCC requires a minimum GHG emissions saving of 35% (rising to 50% in January 2017, and 60% in January 2018 for installations in which production started from 2017 onwards). The Directive 2009/28/EC contains a methodology for calculating this saving ("actual value") as well as "default values", including "disaggregated default values" that can be used in certain cases to show compliance with the criterion. ISCC is applying this methodology.

Biofuels/ bioliquids produced by old operational units (units that were in operation on 23 January 2008) are exempted from complying with the GHG saving criterion until 1 April 2013 (grandfathering). After 1 April 2013 no ISCC-compliant claim can be made without meeting the GHG threshold, regardless of the date that the feedstock or biofuel were produced. The ISCC certificates for old operational units expire on 31 March 2013.

Old operational units in the sense of the RED are oil mills, esterification plants, hydrogenation or co-hydrogenation plants, sugar mills, bioethanol plants and biogas plants which went into operation prior January 23rd 2008. These operational units have to comply with the GHG minimum reduction potential April 1st 2013 onwards. Certificates for operational units which received a certificate under the grandfathering clause in the past, expire on 31 March 2013. From April 1st 2013 onwards this unit has to comply with the relevant GHG emission savings an needs a new certificate.

Group certification for the purpose of calculating GHG savings is only acceptable when the units have similar production systems and products (for details on group auditing also see ISCC 256 Group Certification).

2 Scope

The scope of this document is the specification of the relevant elements of the GHG auditing for the individual elements of the supply chain and definition of the minimum requirements for the GHG emissions calculation.

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) Biomass producers

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

(3) Transport and distribution

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

(1) Correct application of the default values (based on default values from Directive 2009/28/EC)

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

   a. Data for all relevant in- and outputs of the production process. These data must be verified by internal documents and evidence like production reports, delivery notes or invoices of the respective element in the supply chain

   b. Emission factors and their sources. Emission should come from the "ISCC list of emission factors" (see section 6 of this document). If an emission factor that is needed for the calculation is not available on this list, it must come from scientifically peer-reviewed literature/ databases and must lie within the commonly accepted data range. The year of publication must also be documented[1]

   c. Lower heating values for the main product and co-products. For transport fuels these values must come from Directive 2009/28/EC, Annex III. If values are not available in the Directive values must come from scientifically peer-reviewed literature/ databases and must lie within the commonly accepted data range. The year of publication must also be documented[2]

(3) Method of calculation of the individual ("actual") GHG emission value and provision of the correct value. Should one element in the supply chain have to deal with different individual GHG emission values on the input side, the worst one of these values (the one with the highest emissions) can be used for the entire production.

[1] The following data sources shall be used: Ecoinvent, BLE Guideline Sustainable Biomass Production, NREL and results from the research project Biograce. In case of other sources than the mentioned ones these must be sent to ISCC for approval.

[2] The following data sources shall be used: BLE Guideline Sustainable Biomass Production, results from the research project Biograce.

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 203 Requirements for Traceability

ISCC 204 Mass Balance Calculation Methodology

ISCC 256 Group Certification

4 GHG emissions calculation methodology

4.1 Options for the provision of GHG information

Within ISCC there are three options for GHG information provision:[3]

(1) Use of default value: The Directive 2009/28/EC contains default values for different types of biofuels. These values are feedstock- and partly process-specific. Economic operators can use them to provide evidence of compliance with the GHG saving criterion. Besides an overall default value for the sum of the emissions for the final product, the Directive also includes disaggregated default values for cultivation, processing and transport and distribution, which could be used by the respective elements (farm/ plantation, conversion units) of the supply chain.[4] The Commission can update the default values. Any updates by the Commission would become valid within ISCC. So far, default values from the Direcitve 2009/28/EC are available in gram CO2eq emissions per MJ of final product (e.g. per MJ of biodiesel or bioethanol). The final producer can only apply these. For the application of these values within a mass balance system before the final producer and flexible supply chains, they must be converted to CO2eq emissions per kg of the main product produced at the different elements in the supply chain and before allocation of emissions for the rest of the supply chain (as this is not known). Values in emissions per kg of product (after allocation for the respective production step) can be taken from an appropriate reference source provided the values are directly derived from the default values (in gCO2eq/MJ fuel) taken from the Directive 2009/28/EC and based on background data from the Joint Research Centre (JRC, 2008).[5] As an example, the values published by BioGrace[6] could be considered (http://biograce.net/content/ghgcalculationtools/excelghgcalculations).[7] For the time being, farm/ plantation or conversion units throughout the supply chain must apply these values because only these values can be combined with actual calculations further downstream in the supply chain. Otherwise the final producer can only use the overall default value in emissions per MJ of final product. Should the European Commission publish any additional values in this area, these values will become valid within ISCC.

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[3] These options result from the Directive 2009/28/EC.

[4] Certain restrictions for the use of the disaggregated default value for cultivation apply. These are described in section 4.2.2 of this document.

[5] JRC (2008) "Input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology" (http://re.jrc.ec.europa.eu/biof/html/input_data_ghg.htm) must always be the reference source for deriving these values.

[6] Biograce is a research project financed by the Intelligent Energy Europe Programme.

[7] The main product is always the product that is leaving the production unit and is relevant for the further biofuel supply chain. Emissions must be reported in CO2eq per kg of main product, including possible allocations for the respective production step. For a supply chain of biodiesel from rapeseed this would be CO2eq per kg of rape, crude rape oil, refined rape oil and rapeseed biodiesel.

(2) Use of individually calculated values ("actual values"): Individually calculated values for specific elements of the supply chain can be used regardless of whether there exists a default value for the biofuel/ bioliquid in question. "Actual values" must be calculated based on the calculation methodology from the Directive 2009/28/EC (see below for calculation methodology). For the calculation of "actual values" all relevant inputs throughout the production process must be considered. It would not seem necessary to include in the calculation inputs throughout the supply chain, which will have little or no effect on the result, such as chemicals used in low amounts in processing.[8] Inputs with little or no effects are those that have an impact on overall emissions of the respective production unit that is lower than 0.5% of the total emissions of the production unit.

(3) Combination of default value and individually calculated value: A combination of these values is possible at the different elements of the supply 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 supply 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 supply 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 respective Member State 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. Documents/ evidence on these data must be provided to the auditor. This can include production reports, production information system, delivery notes, weighbridge protocols, contracts, invoices etc. The basis for the calculation should always be the previous year. Annual average figures can be used:

- Amount of main product and co-products,
- Amount and type of raw materials used,
- Amount of chemicals used (e.g. methanol, NaOH, HCl, hexane, citric acid, fuller's earth, alkali),
- Amount of pesticides,

[8] Also see Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on counting rules for biofuels (2010/C 160/02).

- Amount of P_2O_5-, K_2O-, CaO- and N-fertilizer,
- Diesel consumption, electricity consumption,
- Thermal energy consumption,
- Process energy source,
- Amount of wastes (e.g. palm oil mill effluent (POME), waste water).

4.2.1.2 Data gathering from databases and literature

The following sources can be used:

- Official statistical data from government bodies
- Scientifically peer-reviewed literature
- Emission factors of for example fertilizers (emissions from production plus field emissions), diesel use in agricultural machinery or for transport, chemicals, electricity, POME in its different uses, thermal energy should be taken from the “ISCC list of emission factors” (see section 6 of this document).

Data measured and gathered on-site must be documented (e.g. within field record system, delivery orders, invoices). The date of all data used shall be documented. The data used shall be based on the most recent available data and shall be updated over time.

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 supply chain (raw materials production) data on fertilizers, pesticides, diesel or process energy, and probably further inputs that might be used must be gathered. They will be the basis for the calculation of GHG emissions.

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:

- Seed
- cultivation, harvest, processing of the feedstock

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. Annual averages of the previous year must be used:

- 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) and pesticides, herbicides, rodenticides
- Diesel [l/(ha*yr)] – total yearly amount of diesel used on farm per hectare
- Electricity consumption – total yearly electricity consumption per hectare
- 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 co-products

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

For the calculation of e_{ec} the following emission factors must come from the "ISCC list of emission factors" (see section 6 of this document):

- 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]. An appropriate way to take into account N_2O emissions from soils is the IPCC methodology, including what are described there as both “direct” and “indirect” N_2O emissions.[9]

- 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 supply chain (e.g. diesel [l]/ rape seed [kg]).

The carbon dioxide fixation during feedstock cultivation is not considered in the calculation formula. To balance this, the emissions from the fuel in use are not taken into account for biofuels and bioliquids.[10]

The methodology for “cultivation” allows – as an alternative to actual values – for the use of averages for smaller geographical areas than those used in the calculation of the default values from the Directive 2009/28/EC. Member States can draw up lists of such average values. Once these lists are available they can also be incorporated in voluntary certification schemes. The default values were (with one exception) calculated for a global level. However, within the EU, the Directive places restrictions on their use. These restrictions operate at the level of NUTS 2 areas or a more fine-grained level.[11] Member States shall submit to the Commission a report including a list of those areas on their territory (Nuts 2 level or more disaggregated) where emissions from cultivation are equal to or lower than the disaggregated default value for cultivation as reported in the Directive 2009/28/EC, Annex V, D. Only for the cultivation in these areas the default values can be used. The respective Member State reports are available on: http://ec.europa.eu/energy/renewables/transparency_platform/emissions_en.htm

In the end, the respective element of the supply chain passes on the GHG information in kg CO_2eq-emisisons/t feedstock together with the feedstock itself.[12] In case that co-products which can be subject to allocation of emissions are produced (see below), the allocation of emissions to the main product and co-products already takes place for the element of raw materials production within the supply chain.

There are no GHG emissions attached to the production of residues. If these residues come from a factory and are not produced on a farm/ plantation a proof of sustainability requirements must not take place. Minimum GHG emissions savings must be fulfilled.

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[9] IPCC guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11, http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_11_Ch11_N2O&CO2.pdf

[10] also see Directive 2009/28/EC, Annex V, C, 13.

[11] These regions are specified in Annex I to Regulation (EC) No 1059/2003. Interactive maps of the regions are available at : http://ec.europa.eu/eurostat/ramon/nuts/home_regions_en.html.

[12] 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.

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

Land use change 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 a cultivated area, forestland or grassland has changed after the cut-off date through a change between the six land categories used by the IPCC (forest land, grassland, cropland, wetlands, settlements and other land), plus a seventh category of perennial crops, i.e. multi annual crops whose stem is usually not annually harvested such as short rotation coppice and oil palm. This means for example, that a change from grassland to cropland is a land use change, while a change from one crop (such as maize) to another (such as rapeseed) is not. 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. It must be taken into account that based on ISCC Principle I, 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).

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[13]:

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

The entitlement of a bonus of 29 g CO_2eq/MJ of liquid biomass for cultivation on degraded land according to Directive 2009/28/EC, Annex V is not possible until final **definitions from the European Commisison** of degraded land are available. Once this is the case this option will be included in the ISCC System.

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

[13] Please also use Directive 2009/28/EC, Annex V and 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).

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.

Land that is not excluded from cultivation according to the requirements from the Directive 2009/28/EC or national requirements 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.

4.2.4 Use of aggregated values for agricultural management

For agricultural management (e_{ec} and e_l in the methodology from the Directive 2009/28/EC) it is allowed to use either measured or aggregate values. When using aggregate values:

- The regional differences for these values should be taken into consideration when using this data. For the EU, a value relevant for the NUTS2 level or more fine-grained level shall be used (also see section 4.2.2 with respect to NUTS2 values). For other countries a similar level would be applicable.
- Such numbers should primarily be based on official statistical data from government bodies when available and of good quality. If not available, statistical data published by independent bodies may be used. As a third option, the numbers may be based on scientifically peer-reviewed work, with the precondition that data used lies within the commonly accepted data range when available.
- The data used shall be based on the most recent available data from the above-mentioned sources. Typically, the data should be updated over time, unless there is no significant variability of the data over time.
- For fertilizer use, the typical type and quantity of fertilizer used for the crop in the region concerned may be used. Emissions from the production of fertilizer should either be based on measured values or on technical specifications of the production facility. When the range of emissions values for a group[14] of fertilizer production facilities to which the facility concerned belongs is available, the most conservative emission number (highest) of that group shall be used.

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

- When a measured value for yields is used (as supposed to an aggregated value) for the calculations, it is required to also use a measured value for fertilizer input and vice versa.

Economic operators shall make reference to the method and source used for determining actual values (e.g. average values based on representative yields, fertilizer input, N2O emissions and changes in carbon stock).

4.2.5 Requirements for the calculation of GHG emissions from processing

Every processing unit in the supply 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. The basis for the calculation should always be the previous year. Annual average figures can be used. The calculation must be 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

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

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

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

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

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.

- 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)
- Yield main product [kg main product/yr] – Annual yield of the main product,
- Yield of co-products,
- Amount of wastewater [l/yr] – Annual amount of wastewater and wastes,
- 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 must come from the "ISCC list of emission factors":

- 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 (average emission intensity for a defined region). In the case of the EU the most logical choice is the whole EU. In the case of third countries, where grids are often less linked-up across borders, the national average could be the appropriate choice.[15]

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

[15] Also see Communication from the Commission on the practical implementation of the EU biofuels and bioliquids sustainability scheme and on countring rules for biofuels (2010/C 160/02).

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 when the CHP runs on fossil fuels, bioenergy, where this is not a co-product from the same process, or agricultural crop residues, even if they are a co-product from the same process:

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

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. Where the CHP supplies heat not only to the biofuel/ bioliquid process but also for other purposes, the size of the CHP should therefore be notionally reduced – for the calculation – to the size that is necessary to supply only the heat necessary for the biofuel/ bioliquid process. The primary electricity output of the CHP should be notionally reduced in proportion. To the amount of electricity that remains – after this notional adjustment and after covering any actual internal electricity needs – a GHG credit should be assigned that should be subtracted from the processing emissions.

The amount of GHG emission savings from excess electricity equals the amount of GHG emissions from the production of an equal amount of electricity in a power plant using the same type of fuel as the CHP plant. This is the only case where for the treatment of co-products (excess electricity) the substitution method and, not as for all other co-products, the allocation method based on lower heating values of the main product and the co-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 (after notional reduction) but fed into an external grid,
- Type of fuel for CHP plant – Type of fuel used within the CHP plant and
- $Yield_{main\ product}$ [kg/yr] – Annual yield of the main product
- Type of CHP plant (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 supply chain passes on the GHG information in kg CO_2eq-emisisons/t product together with the product itself.

If co-products that are eligible for the allocation of emissions (see below) are produced, the allocation of emissions to the main product and co-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).

4.2.6 Requirements for the calculation of GHG emissions from transport and distribution

All respective elements in the supply 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 supply chain (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 must be withdrawn from the "ISCC list of emission factors" (see section 6 of this document):

- 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 supply chain that is receiving the product.

Emissions from distribution of the final product must also be taken into account and can be calculated according to the above formula. The final producer must determine these emissions and must state into which markets the product can be transported without falling below the minimum GHG savings.

4.2.7 Allocation based on lower heating values

An allocation of GHG emissions to the main product and co-products can take place. An allocation is the distribution of emissions to the main product and co-products. This needs to be done in proportion to the lower heating value of the products. The lower heating value used in applying this rule should be that of the entire (co-)product, not of only the dry fraction of it. The only exception to this rule is the feed-in of excess electricity to an external grid (see also 4.2.4).

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

The following formula is used for the calculation:

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

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

No emissions should be allocated to agricultural crop residues and processing residues, since they are considered to have zero emissions until the point of their collection[16], nor to waste. Those products from a production process the owner wants to or must get rid off are not considered as co-products but as waste.

Allocation should be applied directly after a co-product (a substance that would normally be storable or tradable) and bioful/ bioliquid/ intermediate product are produced at 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.

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 co-products that have negative energy content is defined as zero.

[16] Similarly, when these materials are used as feedstock they start with zero emissions at the point of collection.

For the calculation of the allocation factor, the lower heating value should be that of the entire (co-)product, not of only the dry fraction of it. In many cases, however, notably in relation to nearly-dry products, the latter could give a result that is an adequate approximation.

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

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

with

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

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

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 co-product is produced need to be summed up and multiplied with the allocation factor.

All co-products are accounted for in the calculation, except for crop residues (straw, bagasse, husks, cobs and nut shells) or processing residues like crude glycerine.

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 co-products.

4.2.8 Aggregation of GHG emissions

The aggregation of GHG values is only possible for identical GHG values.

4.2.9 Requirements for the final interface in the supply chain

The final interface in the supply 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.

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

GHG emissions from energy use at the fuel depot and at the filling station must also be taken into account. Both relate to electricity use. For imported biofuels there may be several depots that need to be included in the calculation (e.g. import and export terminal). Figures for emissions at the depot and at the filling stations are available in the BioGrace Greenhouse gas calculation tool: http://www.biograce.net/content/ghgcalculationtools/excelghgcalculations. The primary source for the BioGrace figures is the Joint Research Centre.[17]

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[18],
- Bioliquids used for electricity production: 91 g CO_2eq/MJ fossil fuel,
- 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 supply 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.

[17] JRC (2008): Input data relevant to calculating default GHG emissions from biofuels according to RE Directive Methodology (http://re.jrc.ec.europa.eu/biof/html/input_data_ghg.htm).

[18] This value shall be used until a new value according to Directive 98/70/EC is available which supersedes the value of 83,8 g CO_2eq/MJ fossil fuel.

5 Calculation formula

Overall GHG emissions of a bioenergy supply chain are calculated based on the following formula[19], 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 supply 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 supply 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 supply chain.

GHG emissions from transport in between the different elements of the supply 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 supply chain.

The respective element in the supply 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

[19] 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 co-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 GHG information attached, after an allocation that includes the respective step of production.

6 ISCC list of emission factors

The choice of emission factors has an impact on the results of the GHG emissions calculation. In the framework of the Directive 2009/28/EC there is no official list of emission factors available which must be used. Consistent literature on emission factors is limited, the variance of individual factors may be large and for some inputs emission factors might not be available at all or just an approximation can be used. However, to avoid cherry picking and to assure that GHG emissions calculation and audit takes place on an objective, transparent and verifiable basis, ISCC has developed a list of emission factors. This list covers the most relevant emission factors. It should be used for all GHG emissions calculation and audits within the ISCC System. The list was developed based on experience from a two year ISCC pilot phase and from the operational phase in 2010. The list draws wherever possible from the BioGrace project. Where no values are available from BioGrace other commonly accepted databases have been used.

The ISCC list of emission factors can be supplemented and/or amended. Any ISCC Member, client or certification body can submit a new value or an update for an existing value. This proposal should be submitted to ISCC for verification and approval together with a rational of why the value should be used. Whenever a new list of emission factors is published it will be distributed via the usual channels (email, ISCC Homepage) to ISCC Members, clients and certification bodies.

Input	Unit	Emission factor	Source/ comments
Agricultural inputs			
N-fertilizer	kgCO2eq./kg N[20]	5,88	Biograce, 2011
Urea	kgCO2eq./kg N[17]	3,31	Ecoinvent 2.2, 2010; urea ammonium nitrate, as N, at regional storehouse (RER)
Ammonium nitrate	kgCO2eq./kg N[17]	8,55	Ecoinvent 2.2, 2010; ammonium nitrate phosphate, as N, at regional storehouse (RER)
Ammonium sulphate	kgCO2eq./kg N[17]	2,69	Ecoinvent 2.2 dataset; ammonium sulphate, as N, at regional storehouse (RER)
Ammonium nitrate phosphate	kgCO2eq./kg N[17]	5,27	Ecoinvent 2.2 dataset: ammonium nitrate phosphate, as N, at regional storehouse (RER)
Diammonium phosphate	kgCO2eq./kg N[17]	2,8	Ecoinvent 2.2 dataset: diammonium phosphate, as N, at regional storehouse
Calcium ammonium nitrate	kgCO2eq./kg N[17]	8,66	Ecoinvent 2.2 dataset: calcium ammonium nitrate, as N, at regional storehouse (RER)
Field emissions[21]	kgCO2eq./kg N fertilizer	4,87	Calculation of N2O emissions from N-fertilizer application according to IPCC methodology
P2O5-fertilizer	kgCO2eq/kg	1,01	Biograce, 2011
K2O-fertilizer	kgCO2eq/kg	0,57	Biograce, 2011
CaO-fertilizer	kgCO2eq/kg	0,13	Biograce, 2011
Pesticides	kgCO2eq/kg	10,97	Biograce, 2011
Agricultural inputs - seeds			
Seeds corn	kgCO2eq/kg	1,93	Ecoinvent 2.2, 2010; maize seed IP, at regional storehouse (CH)
Seeds rapeseed	kgCO2eq/kg	0,73	Biograce, 2011
Seeds soy bean	kgCO2eq/kg	0,96	Ecoinvent 2.2, 2010; pea seed IP, at regional storehouse (CH)
Seeds sugarbeet	kgCO2eq/kg	3,54	Biograce, 2011
Seeds sugarcane	kgCO2eq/kg	0,0016	Biograce, 2011
Seeds rye	kgCO2eq/kg	0,38	Ecoinvent 2.2, 2010; rye seed IP, at regional storehouse (CH)
Seeds sunflower	kgCO2eq/kg	0,73	Biograce, 2011
Seeds wheat	kgCO2eq/kg	0,28	Bjograce, 2011
Conversion inputs			

[20] Refers to the amount of nitrogen in the fertilizer.

[21] Field emissions must always be considered in addition to emissions due to N-fertilizer production and provision. Total emissions from fertilizer production and use are calculated by summing up production emissions and field emissions.

Process water	kgCO2eq/kg	0,0003	Ecoinvent 2.2, 2010; tap water, at user (RER)
Cycle-hexane	kgCO2eq/kg	0,723	Biograce, 2011
Sulphuric acid	kgCO2eq/kg	0,21	Biograce, 2011
Sodium carbonate	kgCO2eq/kg	1,19	Biograce, 2011
Magnesium oxide	kgCO2eq/kg	1,06	Ecoinvent 2.2, 2010; magnesium oxide, at plant (RER)
Potassium hydroxide	kgCo2eq/kg	0	Biograce, 2011
Sodium hydroxide	kgCO2eq/kg	0,47	Biograce, 2011
Methanol	kgCO2eq/kg	1,25	BLE, 2010, Guideline Sustainable Biomass Production
Hydrochloric acid	kgCO2eq/kg	0,75	Biograce, 2011
Fuller's earth	kgCO2eq/kg	0,20	Biograce, 2011
Phosphoric acid	kgCO2eq/kg	3,01	Biograce, 2011
Hydrogen (for HVO)	kgCO2eq/**MJ**	0,087	Biograce, 2011
Ammonia	kgCO2eq/kg	2,66	Biograce, 2011
Lubricants	kgCO2eq/kg	0,95	Biograce, 2011
Pure CaO for processes	kgCO2eq/kg	1,03	Biograce, 2011
Electricity mix			
EU	kgCO2eq/kWh_{el}	0,47	Biograce, 2011, electricity EU mix MV
Indonesia	kgCO2eq/kWh_{el}	0,9	Calculations based on information according to composition of Indonesian electricity mix, LCI information of energy carriers taken from Ecoinvent, 2010
Malaysia	kgCO2eq/kWh_{el}	0,89	IFEU, 2009; Ableitung von Defaultwerten für Anlage 2 der NachVBioSt für flüssige Biobrennstoffe, die in Anhang V der EE-RL nicht aufgeführt sind.
Brazil	kgCO2eq/kWh_{el}	0,24	Ecoinvent 2.2 dataset, 2010; electricity, medium voltage, production BR, at grid (BR)
Argentina	kgCO2eq/kWh_{el}	0,51	Calculations based on information according to composition of Argentinian electricity mix, LCI information of energy carriers taken from Ecoinvent, 2010
Excess electricity (reference for credit)			
Electricity (NG CCGT)	kgCO2eq/kWh_{el}	0,43	Ecoinvent 2.2 dataset, 2010; electricity, natural gas at combined cycle plant, best technology (RER)
Electricity (Lignite ST)	kgCO2eq/kWh_{el}	1,23	Ecoinvent 2.2 dataset, 2010; electricity, lignite, at power plant (UCTE)

Electricity (Straw CHP)	$kgCO2eq/kWh_{el}$	0,02	Biograce, 2011
Electricity (hard coal)	$kgCO2eq/kWh_{el}$	1,08	Ecoinvent 2.2 dataset, 2010; electricity, hard coal, at power plant (UCTE)
Electricity (NG boiler)	$kgCO2eq/kWh_{el}$	0,64	Ecoinvent 2.2 dataset, 2010; electricity, natural gas, at power plant (UCTE)
Electricity (HFO)	$kgCO2eq/kWh_{el}$	0,89	Ecoinvent 2.2 dataset, 2010; electricity, oil, at power plant (UCTE)
Fuels (process energy)			
Natural gas / heat	$kgCO2eq/MJ_{th}$	0,07	Ecoinvent 2.2, 2010; heat, natural gas, at industrial furnace >100kW (RER)
Natural gas / heat	$kgCO2eq/MJ_{th}$	0,09[22]	Ecoinvent 2.2, 2010; heat, at cogen 1MWe lean burn, allocation energy (RER)
Natural gas / electricity	$kgCO2eq/kWh_{el}$	0,64	Ecoinvent 2.2, 2010; electricity, natural gas, at power plant (UCTE)
Natual gas / electricity	$kgCO2eq/KWh_{el}$	0,32[23]	Ecoinvent 2.2, 2010; electricity, at cogen 1MWe lean burn, allocation energy (RER)
Oil / heat	$kgCO2eq/MJ_{th}$	0,09	Ecoinvent 2.2, 2010; heat, light fuel oil, at industrial furnace 1MW (RER)
Oil / heat	$kgCO2eq/MJ_{th}$	0,11[24]	Ecoinvent 2.2, 2010; heat, at cogen 200kWe diesel SCR, allocation energy (CH)
Oil / electricity	$kgCO2eq/KWh_{el}$	0,88	Ecoinvent 2.2, 2010; electricity, oil, at power plant (UCTE)
Oil / electricity	$kgCO2eq/KWh_{el}$	0,41[25]	Ecoinvent 2.2, 2010; electricity, at cogen 200kWe diesel SCR, allocation energy (CH)
Coal (lignite) / heat	$kgCO2eq/MJ_{th}$	0,2	Ecoinvent 2.2, 2010; heat, lignite briquette, at stove 5-15kW (RER)
Coal (lignite) / electricity	$kgCO2eq/KWh_{el}$	1,23	Ecoinvent 2.2, 2010; electricity, lignite, at power plant (UCTE)
Diesel, in diesel-electric generator	kgCO2eq/liter Diesel	3,12	Ecoinvent 2.2, 2010; Diesel, burned in diesel-electric generating set (GLO)
Diesel / electricity	$kgCO2eq/KWh_{el}$	0,87[26]	Calculation based on Ecoinvent 2.2, 2010; diesel, burned in diesel-electric generating set (GLO)

[22] used for cogenerated heat

[23] used for cogenerated electricity.

[24] is used for cogenerated heat.

[25] Is used for cogenerated electricity.

Wastes			
POME treatment in opend ponds	kgCO2eq/kg CPO	0,51	BLE, 2010, Guideline Sustainable Biomass Production
POME treatment in close ponds and flaring[27]	kgCO2eq/kg CPO	0	Biogenic CO2
EFB burning	kgCO2eq/kg EFB	0	Biogenic CO2
EFB burning and POME treatment in open ponds	kgCO2eq/kg CPO	0,51	Combination of the first two approaches
	kgCO2eq/kg POME	0,16[28]	Calculated based on BLE (2010), Guideline Sustainable Biomass Production; Stichnote et al. (2010), Comparison of different treatment options for palm oil production waste on a life cycle basis, International Journal of life cycle Assessment; IFEU (2009), Ableitung von Defaultwerten für Anlage 2 der NachVBioSt für flüssige Biobrennstoffe, die in Anhang V der EE-RL nciht aufgeführt sind.
EFB dumping and POME treatment in open ponds[29]	kgCO2eq/kg CPO	1,13	Stichnothe et al., 2010
	kgCO2eq/kg POME	0,35[25]	Calculated based on BLE 2010, Stichnothe et al. 2010 and IFEU 2009.
Returning EFB as mulch and POME treatment in open ponds[26]	kgCO2eq/kg CPO	0,59[25]	Stichnothe et al. 2010
	kgCO2eq/kg POME	0,18[25]	
EFB and POME Co-Composting[26]	kgCO2eq/kg CPO	0,03[25]	Stichnothe et al. 2010
	kg CO2eq/kg POME	0,01[25]	
Wastewater treatment	kg CO2eq/m^3	0,14[25]	Ecoinvent 2.2, 2010; treatment, sewage, from residence, to wastewater treatment, class 2.
Municipal solid waste disposal	Kg CO2eq/kg	0,5[25]	Ecoinvent 2.2, 2010; disposal, municipal solid waste, 22,9% water, to municipal incineration
Transport and fuel consumption			
Truck (loaded)	Diesel consumption: liter/km	0,49	BLE, 2010, Guideline Sustainable Biomass Production
Truck (unloaded)	Diesel consumption: liter/km	0,25	BLE, 2010, Guideline Sustainable Biomass Production
Barge, dry bulk carrier	Diesel consumption: liter/ton km	0,00725	Ecoinvent 2.2, 2010, average for different barge sizes

[26] Uses electrical efficiency of 36%.
[27] Requires gas-tight pond covers, methane capture and flaring.
[28] Refers to an amount of 3,25 kg POME and 1,15 kg EFB per kg crude palm oil.
[29] Values are draft results, further investigations necessary.

Vessel, dry bulk carrier	HFO consumption: liter/ton km	0,00208	Ecoinvent 2.2, 2010, average for different vessel size3s
Train (electricity)	Electricity consumption: MJ/ton km	0,21	Biograce, 2011
Diesel	kgCO2eq/liter	3,14	Biograce, 2011
HFO	kgCO2eq/liter	3,42	Biograce, 2011