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ENZO₂

Greenhouse gas calculator
for biofuels and bioliquids

– Manual –

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Greenhouse gas calculation tool

For biofuels and bioliquids

Manual

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1 Introduction

1.1 About the ENZO₂ greenhouse gas calculation tools

Background

The European Renewable Energy Directive 2009/28/EG (hereafter 'RED') stipulates sustainability requirements for the energetic utilisation of liquid biomass. These requirements apply to all vegetable oils (e.g. rape seed, soybean, palm oil) and biofuels (e.g. biodiesel, bioethanol, vegetable oils) on the European market regardless of their origin. In German legislation, the European Directive was implemented with two sustainability regulations, i.e. the Biomass-electricity-sustainability Ordinance (BioSt-NachV) and the Biofuels-sustainability Ordinance (Biokraft-NachV).

Sustainable biomass production in Germany is monitored and regulated with a certification procedure. Certification systems and certifying agencies have to be officially recognised by the German Federal Office for Agriculture and Food (BLE). Sustainability certificates are issued to biofuels and bioliquids if they comply with the sustainability criteria. These certificates qualify the product for compensation and tax relief schemes, and are essential to be included in production quota. The certification procedure includes biomass and bioenergy sources produced in Germany as well as imported products.

In order to comply with the sustainability criteria, bioliquids are required to document reduced greenhouse gas (GHG) emissions. The current requirement stipulates a reduction of 35% in comparison with fossil fuels (e.g. heating oil or diesel). Calculation of the GHG emissions of a bioenergy source includes the sum of all emissions accrued during the production process, which is in turn compared with the GHG emissions of the equivalent fossil energy carrier. Accurate calculation therefore depends on precise documentation and reporting of arising emissions by all individual stakeholders (e.g. growers, processing plants) involved in biomass production. Thus, it is possible to calculate the final total emission value based on reported values from the individual stages of the production pathway. Furthermore, the conservation of GHG emissions in comparison with fossil energy carriers may be determined.

For these purposes, the IFEU developed an excel-based calculation tool (funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)). The calculation tool ENZO₂ (Emissionsberechnung zur Nachhaltigkeits-Zertifizierung für CO₂-Äquivalente, i.e. emission calculation for sustainability certification of CO₂ equivalents) currently includes six individual tools for a variety of biofuels. These tools were designed to assist by facilitating the calculation process. The modelling factors in the entire production pathway and complies with the rules and regulations of the RED. Thus, the computational efforts for the individual stakeholder are much reduced. Furthermore, the implementation of a standardised and scientifically sound method is ensured. A uniform GHG calculation tool provides support for stakeholders who do not possess extensive GHG modelling skills. Moreover, the tools were harmonised with RED calculation methodology throughout Europe. Harmonisation and transparency were achieved within the scope of the BioGrace project (see Chapter 1.2).



The ENZO₂ calculation tools were formally recognised by the BLE according to Biokraft-/BioSt-NachV §8(3)2b in March 2013. This recognition refers to version 1.3 (February 2013). Thus, they may be employed by all recognised certification systems for the calculation of GHG emissions in compliance with German legislation.

Applications

The GHG calculation tools may be employed for the following purposes:

- **Calculation of actual values:** Input of relevant process data (e.g. crop yields, fertiliser quantities) allows each individual stakeholder within the biomass production pathway the accurate calculation of actual GHG emissions generated.
- **Accumulation of actual values across the entire production pathway:** The tools assign each individual stage of the production pathway an individual excel worksheet. Thus, each stage may be analysed separately. It is further possible to add the emissions of several individual stages. For this purpose, the emission value of an individual stage has to be transferred to the subsequent worksheet. The emissions of the production stage under investigation will thus be added automatically to the preceding stages.
- **Combination of actual values with disaggregated default values:** Within every individual production stage, a choice is available between actual emissions generated in the preceding stages or rather the application of disaggregated default values. Consequently, actual and disaggregated default values may be combined within the production pathway. It is further possible to combine these values when balancing the GHG emissions of individual batches.

Target audience

The GHG calculation tools may be employed at any point in the certification system which requires the calculation or control of GHG emissions.

Thus, the tools address the following groups of users:

- **Domestic and foreign members of the production pathway of bioliquids liable to certification:** You may calculate your individual GHG emission with the support of the tools. The final interface¹ may employ the tools for the calculation of the total GHG emissions and reductions. Thus, the tools serve as a controlling element monitoring the compliance with established reduction targets. Furthermore, the calculations generated by the tools may be used by all stakeholders as documentation for presentation to the relevant certification agencies.
- **Auditors/ Certification Agencies:** You may make use of the data in the worksheets submitted by stakeholders liable to certification for comprehension and auditing purposes of GHG emission calculations.
- **Members of the BLE:** You may also employ the tools to audit the GHG emission calculations of all individual stakeholders. This may be particularly helpful in the case that the GHG calculations under examination were computed with alternative models.

¹ Referred to as “last interface” by the BLE; for linguistic correctness, however, the term “final interface” is used in this document.

1.2 Harmonisation with BioGrace

The method for GHG emission calculation described in the RED was implemented with a GHG calculation tool within the scope of the IEE-funded BioGrace project. The aim of this project is to harmonise the calculation of GHG emissions across Europe. The calculation tool serves the purpose of reproducing and elucidating the default values in the RED by 'recalculating' the individual production pathways. Furthermore, the listed values may be replaced for individual calculations. New production pathways may also be added.

In addition, the background data that were included in the calculations of the default values were published and thus made accessible. Among those are CO₂ emission values and lower heating values. These data were supplemented by the publication of additional values, such as the emissions of national electricity mixes.

In 2013 the BioGrace calculation tool has been recognised as a voluntary scheme by the European Commission. It can be used in combination with other schemes, either national or voluntary, that cover the origin of raw materials and provide a mass balance system as well as requirements for verification. Many of the other recognised voluntary schemes allow for using BioGrace as an add-on for the calculation of GHG emission savings.

ENZO₂ was harmonised with the BioGrace methodology, data and procedures. This pertains to both the structuring of the production pathways and the applied background data. Furthermore, the ENZO₂ tools in default mode operate with the values that were employed in the calculation of the RED default values. Since other foreign national calculation tools are also harmonised with BioGrace, a uniform harmonised calculation of GHG emissions across Europe is ensured.

Furthermore, the BioGrace effort introduced so-called calculation rules (*BioGrace calculation rules, version 4c*). These include guidelines for completing the individual cells of the BioGrace calculation tool (e.g. which period of time should be included when entering the quantity of fertiliser applied). The rules are in accordance with the RED GHG calculation method. The underlying passages of the RED as well as other relevant supporting documents of the European Commission are referenced in the corresponding chapters on calculation rules. The same rules also apply for data entry into ENZO₂. In the following, the individual corresponding rules are referenced both in the relevant chapters of this manual and when operating ENZO₂.

The BioGrace calculation tool, as well as the calculation rules and a reference list of background data may be obtained at www.biograce.net.

1.3 Where to find additional information?

This manual is designed for the purpose of illustrating the ENZO₂ GHG calculation tools only. Further information illustrating the general background of sustainable biomass production and certification in Germany may be found at:

Item	Keywords	Source
BLE – Leitfaden nachhaltige Biomasse (available in German only)	Background information on the sustainable production of biomass in Germany: current regulations, definitions, requirements, structure and elements of the certification system for sustainable biomass	http://www.ble.de/EN/02_Control/05_SustainableBiomassProduction/01_InformationMaterials/InformationMaterials_node.html
Leaflets ‘Production of Sustainable Biomass’ by the BLE (available in English)	Definitions, sustainability criteria, reporting and documentation requirements specifically addressed to stakeholders: General information, growers and agricultural operations, first interfaces, final interfaces ² , installation and network operators	http://www.ble.de/EN/02_Control/05_SustainableBiomassProduction/01_InformationMaterials/InformationMaterials_node.html
BioGrace project	Harmonisation of the RED compliant GHG calculation at the European level; publication of relevant background data, provision of a tool for all production pathways included in the RED: exemplary calculation of the RED default values as well as the calculation for individual purposes	http://www.biograce.net/
EU Transparency Platform	As per RED Art. 24, the EU is obligated to establish a transparency platform. This source includes a link to the reports of the individual member states in compliance with Art. 19(2). These reports cover the country-specific GHG emissions resulting from the cultivation of the individual raw materials itemised by NUTS2 regions (→Article 19(2) of the Renewable Energy Directive - Emissions from cultivation in Member States).	http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm

² Referred to as “last interface” by the BLE; for linguistic correctness, however, the term “final interface” is used in this document.

2 General information on the ENZO₂ tools

2.1 Layout of the tools

2.1.1 General structure

Calculation tools were developed for six separate biofuels and bioliquids. Their default values are included in the RED:

- Vegetable oil / biodiesel:
 1. Palm oil
 2. Other vegetables oils (rape seed, sunflower, soybean)
 3. Biodiesel plant
- Ethanol:
 4. Sugar cane
 5. Sugar beet
 6. Cereals (rye, barley, triticale, corn/ maize)

Each of the six calculation tools contains several worksheets in a modular structure: each stage of the biomass production pathway corresponds to an individual worksheet. For instance, vegetable oil is associated with the production stages (and worksheets) 'Grower/ first gathering point', 'oil mill', 'refinery' and 'final interface'. An individual stakeholder, such as an oil producer or a cereal merchant, will not be required to calculate the entire biomass production pathway. Instead, each individual stakeholder may begin calculation with the relevant worksheet that applies to the individual production stage. Thus, the structuring of the tools allows the implementation of the fundamental principle of GHG calculation for certification purposes: each individual stakeholder in the biomass production pathway is required to calculate the GHG emissions he is responsible for, to subsequently add his individual emission to emissions reported from the preceding stages and to finally report the sum to the following stakeholder carrying out the next stage.

For a graphic representation of the modular structure of the calculation tools for vegetable oil / biodiesel and bioethanol, please see Fig. 2-1. Each coloured box represents an individual worksheet in the calculation tools. For the purpose of individual calculations for vegetable oil and biodiesel, a separate calculation tool for biodiesel plants is available. This tool may be combined with the vegetable oils if required.

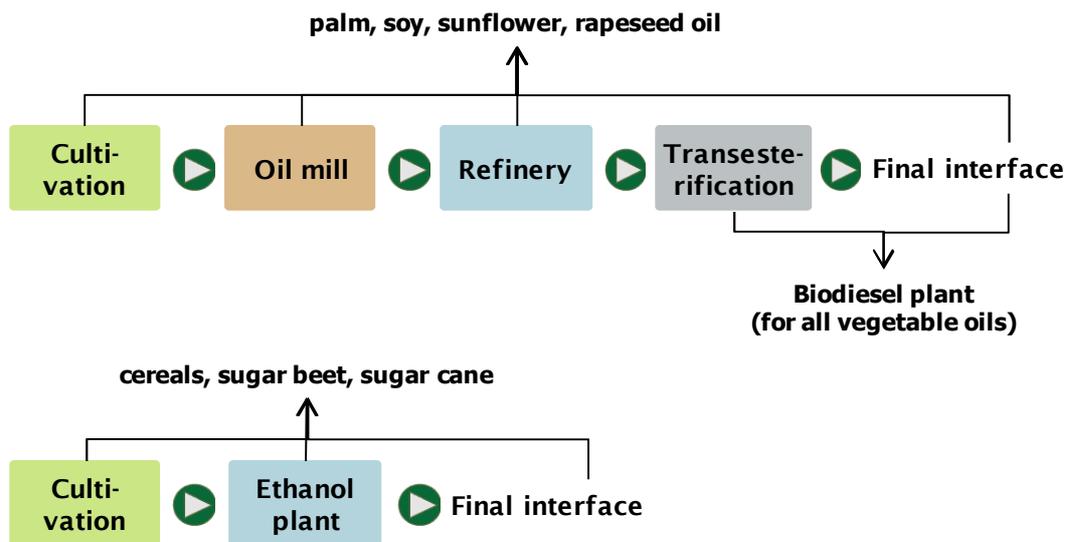


Fig. 2-1 Modular structure of the GHG calculation tools

For practical purposes, several stages of the production pathway are frequently executed by the same stakeholder. The modular approach of the tools may be applied to a range of scenarios and combinations: if a stakeholder is responsible for a single stage of the production pathway, he is required to fill out the appropriate worksheet only. If the stakeholder however maintains several stages of the pathway, it is his responsibility to complete all corresponding worksheets. For instance, oil extraction, refining and transesterification are processes frequently carried out in the same plant. In this case, the stakeholder would have to complete the worksheets 'oil mill', 'refinery' as well as the separate calculation tool 'biodiesel plant'. However, if the operator of the biodiesel plant purchases readily refined vegetable oil, he is required to complete the calculation tool for the biodiesel plant only.

Furthermore, at the conclusion of the production pathways there is often an overlap, due to the fact that the final interface is usually a processing operation, such as an ethanol or biodiesel plant. In these cases, the operator is required to complete the worksheets applicable to the plant, as well as the worksheet for the 'final interface'.

The disaggregated default value for transport-derived GHG emissions represents a special case. All individual transport steps along the entire production pathway are subsumed into an aggregated default value. Consequently, this value may not be added to the other GHG emissions generated in the individual production pathway stages until the final interface. In order to avoid miscalculations due to double application, it has to be ascertained that all stakeholders within a production pathway apply the default value, or calculate the actual value, i.e. the two options should not be confounded. To avoid intermixing, two separate calculation lines were created and colour-coded as follows:



Each individual stakeholder with the exception of the grower is required to decide between the options 'disaggregated default value' and 'actual value', to be specified on the cover page. When applying the former, the disaggregated default value is added at the end of the production pathway under the final interface. When applying the latter actual value, the relevant data will have to be entered into the corresponding worksheet.

2.1.2 Opening the tools and the Start Page

Opening the tool files

A number of functions of the calculation tools are operated with macros. These have to be enabled after opening the files. As a reminder to enable macro content, the Start Page initially reports the following error message, which will disappear after enabling of macros:

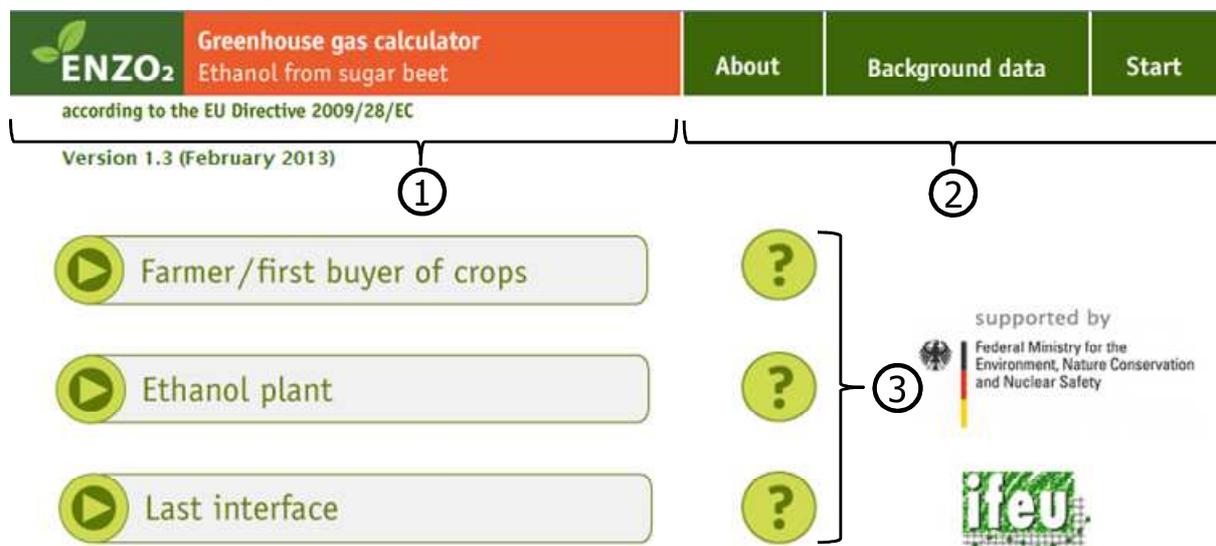


Enabling macro content follows a different procedure depending on the Excel version in use:

- **Excel 2003 and before:** The prompt to enable macro content appears immediately when opening the document file, before the Start Page is displayed. After enabling macro content, the Start Page is displayed correctly. The red error message above appears in a brief flash during the opening of the file.
- **Excel 2007 and higher:** The document file will open without the macro content prompt and the red error message above is masking the Start Page. A security warning will be displayed in the yellow status bar. After enabling content in the status bar, the red error message will disappear and the Start Page will be displayed.

The Start Page

When macro content is enabled, the Start Page is displayed:



① The left section of the header displays which of the six individual biomass production pathways may be investigated with the tool in operation.

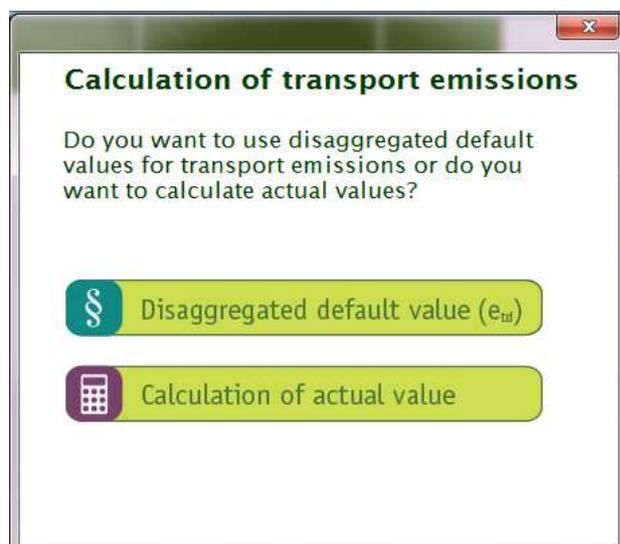
② The navigation bar is on display in each individual worksheet and allows fast and fluent navigation to the general information section (see Chapter 2.1.3), and instant return to the Start Page.

③ Depending on the calculation tool in use, this section may display varying numbers of buttons leading to the worksheets for the individual production pathway stages. Each individual stakeholder may proceed to the individual worksheet corresponding to the relevant production pathway stage to commence data entry. The general organisation of the worksheets is described in Chapter 2.1.4 with specific directions for stakeholders in Chapter 3.

Clicking the '?'-Button will display additional information illustrating the assorted buttons.

Dealing with transport emissions

If the option 'processing operation' or 'final interface' is selected on the Start Page, an info box will prompt the user to specify the calculation mode for transport emissions. A decision has to be made whether to apply the disaggregated default value, or rather to calculate actual transport emissions. Depending on the selection, the subsequent worksheets will be modified accordingly.



2.1.3 General information sheets

In addition to the worksheets, all calculation tools include the following material:

- **Info:** A brief description of structure and function of the individual calculation tool. Furthermore, this sheet contains a list of all abbreviations and definitions as well as information on the original data sources.
- **Background data:** A list of all conversion factors employed in the calculation of GHG emissions. These are primarily CO₂ emission values, i.e. the quantities of CO₂ emissions that are associated with the input unit (e.g. CO₂ emissions per kg of nitrogen fertiliser). Furthermore, this sheet reports lower heating values of energy carriers and products, energy efficiency data etc. All data included were harmonised and published within the scope of the BioGrace project (see Chapter 1.2).

2.1.4 The worksheets

The buttons introduced in Chapter 2.1.2 direct to the worksheets for the individual stages of a biomass production pathway. These worksheets include three main sections:

Greenhouse gas calculator
Ethanol from sugar beet

according to the EU Directive 2009/28/EC

About
Background data
Start

I. Market actor: Farmer, first purchaser
 Step-by-step manual for calculating GHG emissions of cultivation of sugar beet

Final result

Please provide this information together with your batch to the ethanol plant.

The GHG emissions from sugar beet cultivation amount to

35,6 g CO₂eq/kg beet ?

Size of the sugar beet batch

0 t sugar beet

Enter your operating data in step 1-3 to calculate GHG emissions of your sugar beet batch

STEP 1 – GHG emissions from land use changes

Do sugar beets originate from plantation areas that were plantation areas before January 1st 2008?

yes

Emissions from land use change are zero.

no

Click here to calculate emissions in sheet "land use changes".

Which emissions arose from land use changes?

0,0 kg CO₂eq per ha per year

Calculation of emissions (automatic)

Emissions fertiliser	1.862,49 kg CO ₂ eq per ha per year
N-fertilisers	703,62 kg CO ₂ eq per ha per year
N ₂ O field emissions sugar beet	969,02 kg CO ₂ eq per ha per year (default)
N ₂ O field emissions	0,00 kg CO ₂ eq per ha per year (calculated acc. to IPCC)
P2O5-fertiliser (kg P2O5)	60,35 kg CO ₂ eq per ha per year
K2O-fertiliser (unspecified)	77,70 kg CO ₂ eq per ha per year
CaO-fertiliser (kg CaO)	51,80 kg CO ₂ eq per ha per year
MgO (kg MgO)	0,00 kg CO ₂ eq per ha per year
Sodium (Na) fertiliser (kg Na)	0,00 kg CO ₂ eq per ha per year

①

②

③

① Final result

This section is organised differently among the individual worksheets:

Grower / first gathering point & processing operations: After completion of data entry, the final results will be displayed here. The upper value reports the calculated GHG emissions generated in the production pathway stage under investigation. The lower value reports the quantity delivered to the next or final interface, which acts as the reference quantity for the emission value. Both values are required to continue calculations in the subsequent interface.

In the case that a processing operation has elected to calculate actual transport emissions, these transport emission data are entered here and will be included in the final result. Thus, the subsequent stakeholder may in turn elect to deduct these emissions to employ the disaggregated default value.

Final interface: After completion of the worksheet, three values may be read. The first reports the percentage of GHG savings across the entire production pathway of the liquid bioenergy carrier. This value influences the award of a sustainability certificate: the minimum savings to achieve certification would be 35%. The second value reports the total GHG emissions generated over the entire production pathway of the bioenergy carrier. The purpose of the liquid biomass is entered in the third box (e.g. fuel, electricity generation, cogeneration of heat and power (CHP)) in order to select the type of fossil fuel acting as a reference. After completion of the worksheet, the data will be computed automatically.

In addition to the information detailed above, the section is characterised with one of two different **logos**, depending on the employment of disaggregated default values or actual values for the calculation of transport values (see Chapter 2.1.1).

② Step by step tutorial

The second part of the worksheet has to be completed by the individual stakeholders. The data entered are employed in the automatic computation of the GHG emissions. Various input values and other data are required, e.g. process data or information of transport. For some calculations, e.g. the emissions derived from land use change, buttons will direct the user to external worksheets. These worksheets are initially hidden, but will be enabled when in use.

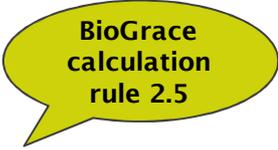


The default mode of the calculation tools includes predefined default values in the data entry boxes. The default values correspond to the data used for computation of the RED default values as published within the scope of the BioGrace project³. Emissions calculated on the base of the values will slightly differ from the RED disaggregated default values, although they are derived from the same input data. For transparency purposes, these input data are reported in the worksheets under the tick mark buttons. The deviation arises from an inconsistency between the calculation of the RED default values and the methods specified in the RED. For the calculation of the RED default values, global warming potentials (GWPs) were allocated to CH₄ (GWP = 25) and N₂O

³These values were labelled “starting values” in the BioGrace calculation rules.

(GWP = 298). However, in Annexe V.C, the RED stipulates GWPs of 23 for CH₄ and 296 for N₂O. The ENZO₂ calculation tools apply the latter values, whereas the cited values were calculated with the former.

Regarding the predefined values in the calculation tools, please note that all values will have to be amended if a single value is exchanged. Therefore, it would not be legitimate to adjust, for instance, the yield while retaining the fertiliser consumption unchanged with the predefined values. For facilitation and (self) control purposes, the predefined values are formatted in red italics. As soon as a value is altered, the font format changes to plain black.



③ Automatic computation

In addition to the boxes for data entry, there are boxes computing automatic calculations to illustrate the conversions and to clarify the entire calculation process. The contents of these may not be altered. The fixed boxes include the conversion of the individual process input data to GHG emissions.

2.2 Principles of GHG calculation

The GHG calculations that are mandatory in compliance with the RED, and as such implemented with the ENZO₂ calculation tools, follow the principles of life cycle assessments (LCAs). The following stipulations apply:

- Calculation of GHG emissions includes all production pathway stages from the initial biomass production to the utilisation of the resulting bioenergy carriers. Within the calculation tools, each individual production pathway stage is associated with an individual worksheet.
- The GHG emissions of all individual production pathway stages are added to calculate the emission total across the entire production pathway. The emission total thus derived is compared with a corresponding quantity of a fossil fuel equivalent acting as a reference to calculate relative GHG savings.
- The functional unit in this comparison is defined as the 'production and utilisation of 1 MJ of bioenergy carrier', i.e. GHG emissions are calculated per MJ bioenergy carrier (e.g. biofuel). Initially, the values refer to differing units within the individual production pathway stages (see Chapter 2.3). Conversion to the functional unit is being carried out automatically with the calculation tools.
- In the case that a process yields main and co-products (e.g. rape seed oil and rape seed cake), the emissions generated in the process will be allocated to the respective products as appropriate. This allocation is performed based on the lower heating values of the products. The main product is thus assigned part of the burden (and will therefore carry only the assigned part over to the subsequent production stage). The calculation tools perform the allocation automatically.

- Emissions of utilisation for bioenergy carriers are estimated zero, due to the fact that the CO₂ emitted is of biogenic origin. Ensuing methane emissions are considered negligible and thus fall under the cut-off rule, i.e. they are not factored into the model.
- Each individual worksheet requires entry of all relevant process and transport data. The resulting emissions of the three most significant GHGs carbon dioxide (CO₂), methane (CH₄) and nitrous oxide (N₂O) are computed automatically. The methane and nitrous oxide emissions are converted to CO₂ equivalents based on the respective GWP. The GWPs of the gases are reported in the sheet 'background data'.

Interested users may learn of the individual equations employed in calculation by clicking on the respective cells in the worksheets. Thus, the employed methodology may be inferred.

2.3 Additional information

Disaggregated default values and actual values

The RED stipulates two options for GHG calculation:

1. The calculation of individual values ('actual values')
2. The utilisation of default values

Actual values may be computed with the ENZO₂ tools based on the entry of input data.

Default values are derived from generic emissions, and were published both in the RED and in German legislation. Default values are available for 22 biomass production pathways. They are reported both as total emissions across an entire production pathway and as disaggregated default values⁴ for cultivation, production and transport.

In general, each individual stakeholder may decide whether to include disaggregated default values or actual values for the modelling of 'his' stage of the production pathway. Disaggregated default values may only be employed if the following conditions are met:

- Availability of an appropriate default value for the production pathway under investigation (i.e. default values for ethanol derived from rye are not readily available).
- No change of land use has occurred (appropriate documentation is required for the entire production pathway).
- Within the European Union, the biomass under investigation has to originate in areas that are listed in reports⁵ compiled in compliance with the RED Article 19 (2).

In the case that one or more of these stipulations is not met, the use of actual values is mandatory. There is no legal obligation to employ default values even if all of the stipulations above apply. For the stakeholders of the individual production pathway stages it may be of interest to calculate the actual value in cases when the actual value is superior to the generic default value, or for case studies for individual optimisation purposes. Furthermore,

⁴ These correspond to the "disaggregated default values" reported in the RED

⁵ Each EU member state was required to submit documentation in the form of a report published of the EU Transparency Platform, for further information please see:
http://ec.europa.eu/energy/renewables/biofuels/biofuels_en.htm

suppliers or subsequent stakeholders in the production pathway may insist on the reporting of actual values.

Unit conversion

The units for input data entered in the worksheets differ and reflect the most common reported unit for each individual product. For instance, fertiliser quantities are requested in kg per ha, whereas energy consumption is reported in kWh or MJ. The user is required to enter all input data as quantity per year initially. The automatically computed CO₂ emissions are then reported per kg product that is exiting from this particular stage, e.g. per kg cereals, vegetable oil or ethanol. At the conclusion of the production pathway, i.e. at the final interface, all accumulated emissions will be automatically referenced to 1 MJ of fuel.

Colour coding in the calculation tools

To improve clarity in the calculation tools, the colour coding within the cells of the worksheets was standardised:

- **Green cells** indicate data for entry. In default mode, these cells are already filled out. The data entered represents values employed for the calculation of RED default values that were published within the scope of the BioGrace project.
In default mode, all entries in green cells are formatted in **red italic font**. As soon as changes are made to any of these data, the formatting changes to plain black font. The change in font denotes changes in the data entered, thus providing control for users and facilitating audit procedures.
- **Grey cells** denote sections with fixed equations and values that are not subject to change by the user. These sections are provided for information purposes only. The user may click on grey cells to display equations in use. Thus, the methodology is illustrated and the calculations may be understood in detail.

3 What to do as a...

The following chapters provide detailed information on the structure and organisation of the worksheets for the individual production pathway stages, and how to complete data entry. Regardless of the stage in the production pathway, each stakeholder is required to carry out the following actions:

1. **Selection of the production pathway stage under investigation:** From the Start Page of the calculation tools, the buttons automatically direct the user to the relevant worksheet. Furthermore, all processing operations are required to decide between disaggregated default values or actual values for the quantification of transport emissions.
2. **Consideration of pre-products:** The first step when completing a worksheet is the entry of the accumulated emissions from all preceding production pathway stages. For growers or first gathering points, this step does not apply, as they represent the first stage of the production pathway. However, emissions from land use changes may have to be considered where applicable.
3. **Entry of input data:** Users are required to enter all process data of 'their' production pathway stage (e.g. yields, energy consumption) as well as transport information where applicable.

Based on the data entered by the user, **automatic emission calculation** for the particular production pathway stage is performed. For the final interface, the emissions will include the accumulated burdens across the entire production pathway of the liquid bioenergy carrier, as well as emission savings relative to the individual equivalent fossil energy carriers.

3.1 ... grower / first gathering point?

3.1.1 General approach

Agricultural operations and first gathering points start off the production pathway and represent its first stage (see Fig. 3-1). Therefore, no pre-products with accumulated emissions exist as yet, and the only emissions to be considered are generated during cultivation.

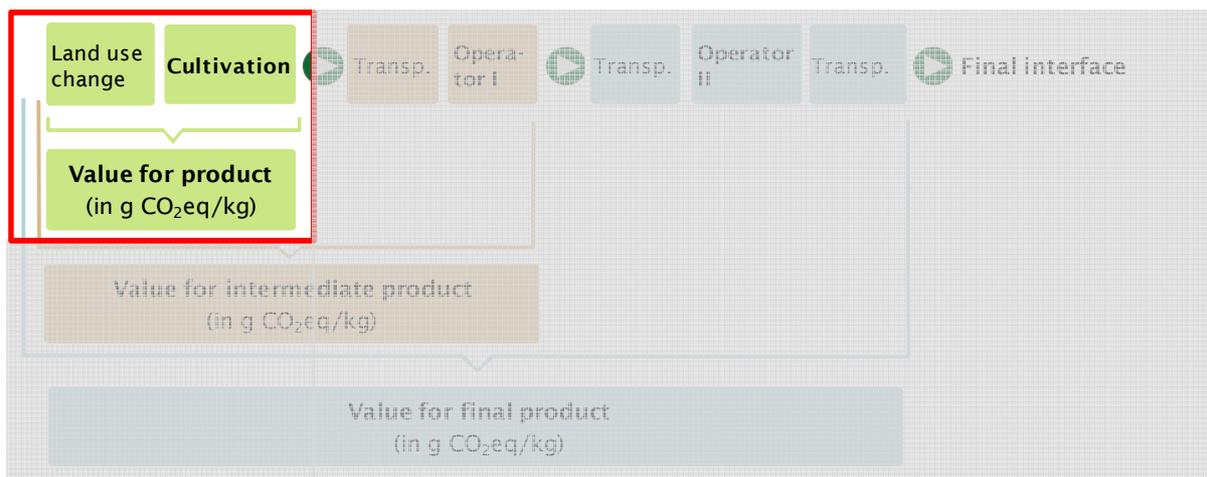


Fig. 3-1 Position of agricultural operations within the biomass production pathway

Agricultural operations may wish to explore whether they are obligated to carry out their own calculations. If none of the restrictions introduced in Chapter 2.3 apply, agricultural operations are legally permitted to apply disaggregated default values for the calculations of emission generated during cultivation. The decision concerning disaggregated default values will have to be communicated to the first gathering point. It may, however, occur that suppliers and subsequent stakeholders insist on the disclosure of actual values.

In the case that actual values are applied for the calculations, the liability for these data resides with the grower or the first gathering point, depending on the certification system. In the latter case, the first gathering point will assume responsibility after obtaining all relevant process data and information (including appropriate documentation) from the grower.

The worksheets include the following steps:

1. Specification of land use changes
2. Entry of cultivation data for calculation of inherent emissions
3. Automated calculation steps including the calculation of the emission total

3.1.2 Specification of land use changes

Initially, the question arises whether the cultivation area was already a registered agricultural area on 1. January 2008 (see Fig. 3-2).

STEP 1 - GHG emissions from land use changes

Do sugar beets originate from plantation areas that were plantation areas before January 1st 2008?

yes Emissions from land use change are zero.

no Click here to calculate emissions in sheet "land use changes".

Which emissions arose from land use changes?

0.0 kg CO₂e

I. Market actor: Plantation operator, first purchaser
 Step-by-step manual for calculating GHG emissions from land use change

The European Commission has published *Guidelines for the calculation of land carbon stocks* (notified under document C(2010) 3751). These consist of tables with values for carbon stocks in soils, above and below ground biomass for different soil types, climate regions, vegetation types. Based on exactly these values, GHG emissions from direct land use changes are calculated on this sheet.

Result value will be added in sheet "actor cultivator" step 1: **0.0** kg CO₂e per ha per year

confirm value and back

Specify the parameters in step 1-5 to calculate GHG emissions from land use changes

REFERENCE LAND USE before land use change (CS₀)
STEP 1 - Carbon stock in above and below ground biomass on 01.01.2008 (C_{ref})

Please select:

Vegetation type	Cropland (annual)
Domain	--
Climate region	All
Ecological zone	--
Continent	--
Above and below ground carbon on 01.01.08	0.0 t C/ha

STEP 2 - Standard Soil Organic Carbon (SOC_{st})

Please select:

Climate region	Tropical, montane
Soil type	Low activity clay soils
Standard Soil Organic Carbon	85 t C/ha

Fig. 3-2 Specification of land use changes

If so, all emissions from land use changes are set to zero. If a change of land use has occurred, resulting emissions will have to be calculated. This calculation is performed in a separate worksheet.

BioGrace calculation rule 5

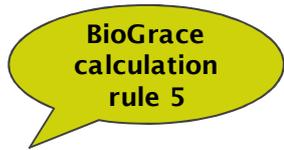
The worksheet implements the calculations methods recommended by the European Commission (see *guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC* (notified under document C(2010) 3751)). Carbon stocks in biomass above and below ground are included.

Calculation is carried out in six steps. The selection of vegetation type, climatic region, continent etc. automatically prompts the calculation of the carbon stock before (step 1 to 3) and after (step 4 to 6) the land use change. Changes in carbon stock are automatically computed in the final step.

After completion of all fields, clicking the button 'Confirm and back' will return the user to the worksheet. Emissions generated in land use change will automatically be transferred.

NB: Bonus for cultivation on degraded and contaminated land

In the case that cultivation was undertaken on degraded and contaminated land (see RED Annex V, Paragraph C, Nr. 8), a bonus of 29 g CO₂eq/MJ may be credited. The bonus is referenced to 1 MJ of fuel; therefore it will be offset against fossil fuel equivalents at the final interface (see chapter Fehler! Verweisquelle konnte nicht gefunden werden.). It is of vital importance that appropriate documentation is maintained along the entire production pathway. At this point in time, no official definition by the European Commission for degraded areas is available as yet.



3.1.3 Entry of input data

Returning to the main worksheet, the second step requires the user to enter input data on cultivation into the green cells (see Fig. 3-3)



Data must be entered in the predefined units, to ensure reliable calculations with the model equations. The conversion to the required unit may involve separate independent calculations by the user.

STEP 2 - GHG emissions from cultivation		
What is your sugar beet yield per ha per year?		
	68.860	kg sugar beet per ha per year
What is the moisture content of the sugar beets?		
	75%	%
How much residues are removed from field per ha per year?		
		kg residues per ha per year (dried)
What is the size of your cultivation area?		
		ha
Which type of N-fertilisers and how much did you apply per ha per year?		
N-fertiliser (kg N)	119,7	kg N per ha per year
N-fertiliser (unspecified)		kg N per ha per year
N-fertiliser (unspecified)		kg N per ha per year
Organic manure		kg N per ha per year
Which type of other fertilisers and how much did you apply per ha per year?		
P2O5-fertiliser (kg P2O5)	59,7	kg P ₂ O ₅ per ha per year
K2O-fertiliser (unspecified)	134,9	kg K ₂ O per ha per year
CaO-fertiliser (kg CaO)	400,0	kg CaO per ha per year
MgO (kg MgO)		kg MgO per ha per year
Sodium (Na) fertiliser (kg Na)		kg Na per ha per year



Fig. 3-3 Entry of cultivation data



3.1.3.1 Cultivation data

- **Yield:** Entry of the annual average crop yield per ha of biomass (e.g. cereals, soybeans, sugar cane). Please note that for cereals and oil seed crops, the quantities entered should represent the dried and purified product.
- **Water content of the product**
- **Quantity of residues harvested:** Information required for the calculation of N_2O field emissions, which further factor in the quantities of residues remaining in the fields.
- **Size of the area under cultivation**
- **Supplies:** Depending on the production pathway, fertiliser, pesticides and seeds are included.

NB: Fertiliser

A number of different types of fertiliser are included. These individual types may be selected, and in the case of nitrogen fertiliser, may be combined.

The predefined default values may not be utilised for the purpose of independent internal calculations of the grower. Specific calculation is facilitated by selecting the accurate type of fertiliser from the list. In the case that the fertiliser in use is unknown or not included in the list, the last list option 'not specified' should be selected. Selecting an unspecified type of fertilised prompts the automatic application of additional CO_2 data deposited for this case. The utilisation of organic fertilisers (e.g. farmyard manure) has to be reported. Emissions for the manufacture of manure are classified as zero; however, field emissions will be factored into the model.

In principal, the total quantities of all types of fertilisers applied between the harvest of the preceding crops and the harvest of the bioenergy crop will be considered in the calculations.

The calculation of **N_2O field emissions** is carried out automatically in a separate hidden worksheet under application of the following parameters: yield, harvested raw materials and quantity of mineral and organic fertiliser.



The calculation of field emissions currently complies with the IPCC method. Due to the circumstance that the final selection of a methodology by the European Commission has yet to take place, changes affecting the required data and documentation may be expected in the future.

- **Energy consumption:** Entry of the quantities of fuel and electricity required for the annual farming per ha, including irrigation or drying of the product. In the case that electricity is consumed, the national electricity mix has to be reported.
- **Transport of vinasse and filter mud cake (sugar cane only):** If vinasse and / or filter mud cake is applied to cultivation areas, data on the means of transport, transport distance, and the method of application are required.

**BioGrace
calculation
rules 2.2.3,
3.4, 3.3, 3.1**

- **Pre-harvest burning of arable land (sugar cane only):** In the case that a sugar cane field was subject to pre-harvest burning, the ensuing methane emissions will be automatically computed and entered.
- **Batch size:** Information required for subsequent stakeholders to allow calculation of the weighted average emissions of a partial delivery. The value will be displayed automatically in the upper part of the worksheet under 'final result'.

3.1.3.2 Additional emissions and savings

The default mode of the calculations tools does not cover all conceivable production practices. For instance, emission savings may be achieved by the utilisation of biofuels during cultivation. On the other hand, some practices may cause additional emissions not regularly encountered. These additional emissions or savings may be entered after completion of the cultivation data entry. The data, however, will have to be calculated independently and reported as CO₂eq per ha (see sample calculation below). Additional cells offer space for a brief description of the practice in question (see Fig. 3-4). During an audit, detailed documentation on the independent calculations may be required. The ENZO₂ tools automatically factor in additional emissions or offset GHG emission savings with the regular emission, and perform allocation to co-products where appropriate.

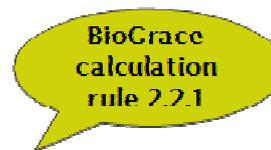
STEP 3 - Additional GHG emissions and emission reductions ?	
Are there any other sources of greenhouse gas emissions during your production process? Please describe:	<i>example text</i>
How much CO ₂ eq arise from these sources? Note that you may be required to provide detailed evidence of this number in the auditing process.	kg CO ₂ eq per ha per year
Do you apply any measures that reduce CO ₂ emissions in your production process? (e.g. soil carbon accumulation via improved agricultural management (<i>e_{sca}</i>), nitrification inhibitors, N-fertilisers that have been shown to come from best practice production, tractors run on vegetable oils). Please describe: ?	<i>example text</i>
How much CO ₂ eq are saved by these measures per ha per year? Note that you may be required to provide detailed evidence of this number in the auditing process.	kg CO ₂ eq per ha per year

Fig. 3-4 Additional GHG emissions and savings

Sample calculation – GHG savings derived from the utilisation of biodiesel in rape seed cultivation

Fossil diesel emits approximately 88 g CO₂eq per MJ (see 'background data'). Consumption of 83 l of diesel per ha in a rape seed cultivation operation generates approximately 261kg CO₂eq per MJ per ha. Biodiesel by contrast emits only 52 g CO₂eq per MJ (see RED default values). Therefore, emissions per ha amount to only 154 kg CO₂eq, thus saving 107 kg CO₂eq per ha. The savings may be reported under additional savings.

Please note that independent background data (e.g. emission values) may only be utilised if there is precise and unambiguous documentation available. Reliable sources have to be cited, and the derivation of the independent data has to be clear, so that it may be easily replicated in an audit. Furthermore, it is required for independent values to comply with the BioGrace calculation rules.



3.1.4 Automated calculation steps

In addition to the cells that require data entry, the worksheets include fields reporting automated conversions. These areas are included for information purposes only and do not offer the option of changing the entries.

3.1.4.1 Calculation of the emissions

Based on the cultivation data entered, the individual GHG emissions are calculated automatically (see Fig. 3-5).

For this purpose, the calculation tool accesses the CO₂ emission values as well as other conversion factors in the 'background data' directory. Interested users may learn of the individual equations employed in calculation by clicking on the respective cells in the worksheets. Thus, comprehension of the employed methodology and the data sources is facilitated.

Calculation of emissions (automatic)		
Emissions fertiliser	1874,20 kg CO₂eq per ha per year	
N-fertilisers	708,00 kg CO ₂ eq per ha per year	
N ₂ O field emissions sugar	975,57 kg CO ₂ eq per ha per year	(default)
N ₂ O field emissions	0,00 kg CO ₂ eq per ha per year	(calculated acc. to IPCC)
P2O5-fertiliser (kg P2O5)	60,51 kg CO ₂ eq per ha per year	
K2O-fertiliser (unspecified)	78,13 kg CO ₂ eq per ha per year	
CaO-fertiliser (kg CaO)	51,99 kg CO ₂ eq per ha per year	
MgO (kg MgO)	0,00 kg CO ₂ eq per ha per year	
Sodium (Na) fertiliser (kg N)	0,00 kg CO ₂ eq per ha per year	
Seeds- sugarbeet	21,35 kg CO ₂ eq per ha per year	
Pesticides	14,29 kg CO₂eq per ha per year	
Diesel	554,84 kg CO₂eq per ha per year	

Fig. 3-5 Calculation of emissions

3.1.4.2 Combination of emission values

Here, all individual emission values including potential emissions from land use changes (if applicable) as well as emissions from cultivation and additional emissions or savings are added to reveal the total emissions per ha (see Fig. 3-6). The corresponding value will be automatically displayed as the 'final result' reported in the upper section of the worksheet.

Combination of values (automatic)	
Emissions (cultivation)	2.464,7 kg CO ₂ eq per ha per year
Emissions (land use chang	0 kg CO ₂ eq per ha per year
Additional emissions and r	0 kg CO ₂ eq per ha per year
Total emissions	2.464,69 kg CO₂eq per ha per year

Fig. 3-6 Combination of emission values

3.1.4.3 Final result

After data entry is complete, the cumulative emissions generated in biomass cultivation (converted to 'per kg product'; see Fig. 3-7) and the batch size are automatically displayed at the head of the worksheet.



Fig. 3-7 Final result

There are two options to proceed:

1. The grower / first gathering point supplies the product to the next interface, e.g. to a processing operation: both values are reported when delivering the product.
2. The agricultural operation is further in charge of the next stage in the production pathway, i.e. the product is not delivered to a separate entity: both values are recorded and entered manually into the subsequent worksheet. The entry is carried out as the first step in said worksheet in the section accounting for pre-products (see Chapter Fehler! Verweisquelle konnte nicht gefunden werden.).

3.2 ...processing operation?

3.2.1 General approach

'Processing operations' are defined as all interfaces between the first gathering point and the final interface, i.e. all stakeholders that participate in processing the harvested biomass into the final product (see Fig. 3-8). These include oil mills, refineries, and biodiesel and ethanol plants. In many cases, these operations are also the final interface. Requirements and tasks for final interface users are illustrated in Chapter 3.3.

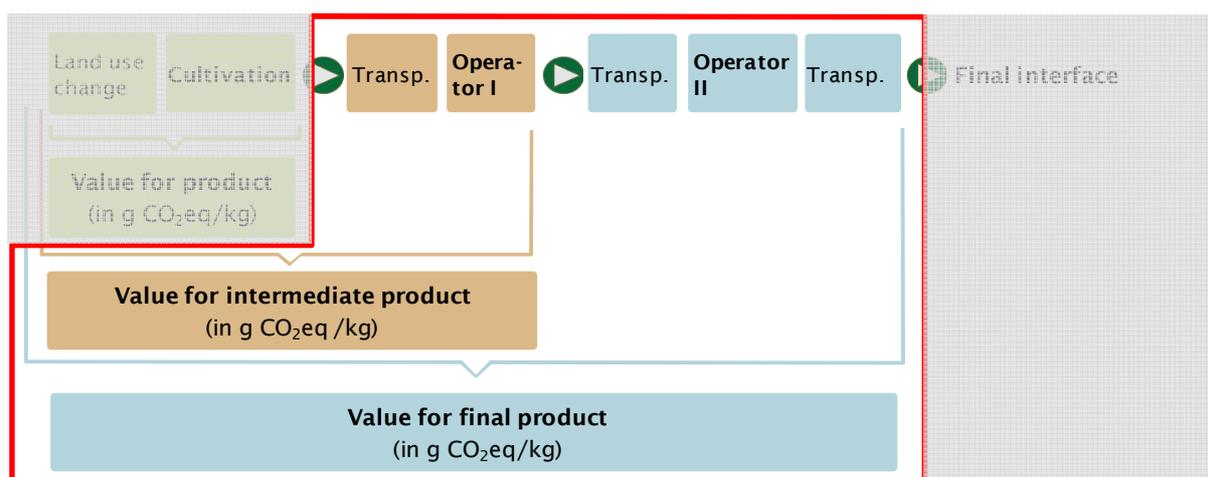


Fig. 3-8 Position of processing operations within the biomass production pathway

Biomass production pathways may include one or more processing operations that may be operated by the same or several independent operators. Operators are required to complete the number of worksheets corresponding to the number of stages in the production pathways under their supervision (see Chapter 2.1.1).

The worksheets include the following steps:

1. Accounting for pre-products
2. Entry of input data for calculation of emissions generated in the specific production pathway stage
3. Automated calculation steps for emission calculation

In the case that the calculation tool in use covers more than one plant species (cereals, vegetable oil), the species under investigation will have to be specified.

3.2.2 Accounting for pre-products

Initially, the operator is required to select between disaggregated default values and actual values reporting the emissions of preceding operations in the production pathway (see Fig. 3-9).

The disaggregated default value is used

STEP 1 - GHG emissions of pre-products

What GHG emissions arose from the production of sugar beet? Indicate whether you want to use the default value or a calculated value.

default value Click here to use default value 35.79 g CO₂e/kg sugar beet

calculate value Click here to calculate your emissions in g CO₂e/kg sugar beet

35.79 g CO₂e

ENZO₂ Greenhouse gas calculator
Ethanol from sugar beet

About Background data Start

According to the EU Directive 2009/28/EC

Mixing sugar beet batches from several suppliers and averaging GHG emissions

Note: averaging of consignments with different GHG emission values is only allowed under the German ordinances Biokraft-/BioSt-NachV. In other cases a separate calculation has to be carried out for each consignment.

Maximum permitted value for sugar beet	Overall quantity metric tonnes	Overall GHG value g CO ₂ e/kg beet
78 g CO ₂ e/kg beet	0	0,00

confirm value and back

Supplier#	Plantation name	Beet quantity metric tonnes	GHG value g CO ₂ e/kg beet
1			
2			
3			
4			
5			
6			
7			
8			
9			

fill in the information delivered by your suppliers

Fig. 3-9 Accounting for pre-products

In the case that the utilisation of a **disaggregated default value** is appropriate, clicking the respective button prompts entry in the relevant field. Please note that the utilisation of default values is associated with certain requirements and restrictions (see Chapter 2.3).

In the case that the **calculation** or utilisation of an independent **actual value** is selected, clicking on the respective button will transfer the user to a separate worksheet. A number of values may be entered there:

1. The emissions of the preceding production pathway stage were calculated independently by the operator: The values reported in the field 'final result' in the preceding worksheet (batch size and emission total) have to be transferred manually for entry in the first line of the current worksheet.
2. The operator processes supplies with variable emission values: For the domain under German legislation (Biokraft- / BioSt-NachV), it is permitted to balance the emission values of individual batches. The following individual values may be entered:
 - a. **Actual emission values:** Entry is permitted if the maximum emission level is not exceeded. Limits for all types of biomass during the individual production pathway stages in the have been published in the Bundesanzeiger („Bekanntmachung nach § 16 Absatz 3 Satz 1 der Biokraftstoff-Nachhaltigkeitsverordnung zu den Treibhausgas-Emissionswerten im Falle einer Vermischung von Biomasse vom 8. Dezember 2010'). In the case that the

respective limit is exceeded, the biomass quantity may not be included in balancing. A warning notice may be found in the relevant balancing sheets.

Please note that only the emissions of goods with transport emissions calculated with a disaggregated default value or actual value are eligible for balancing. Mixing options may result in a double application of emission values. In the case that the disaggregated default value was selected, yet the emissions of some batches were calculated with an actual value, it is possible to subtract this separate value from the emission total.

In refineries, actual transport emissions from deliveries may be treated separately when balancing. This allows for a separate re-declaration of the transport emissions when delivering the product to the biodiesel plant.

- b. **Disaggregated default values:** In the case that actual values are unavailable or may not be used (e.g. values exceed published limits), default values may be entered for individual deliveries, as long as the restrictions in Chapter 3.2.3 do not apply.
- c. **Regional average values:** The only data available report the cultivation step of biomass. These data were calculated by each EU member state on the NUTS2 level, and published on the EU Transparency Platform. Only data for biomass produced in Germany may be applied. Conversion of the data to the kg of product is required. Relevant conversion factors are included in the worksheets.

After completion of data entry, the calculation of average emissions is carried out automatically, and the result is transferred to the corresponding cell in the main worksheet. Clicking the button 'Confirm and back' will prompt return to the main worksheet.

3.2.3 Information on transport (actual values only)

In the case that an actual value for transport emissions is calculated, the next step performs this calculation. For this purpose, data on the delivery of goods are required. The required information relates to the transport stage from the preceding operational site to the current operational site (see Fig. 3-10).

For the purpose of this calculation, the user is transferred to a separate worksheet. A number of means of transport are available for selection. Entry of the distance in km is required. All data may be entered specifically for all individual deliveries. The resulting (average) emissions are calculated automatically. Return to the main worksheet is prompted automatically after confirmation of the data entered. Transfer of the values to the main worksheets is also performed automatically.

STEP 2 - GHG emissions from sugar beet transport

What GHG emissions arose from the transport of sugar beet?

calculate value Click here to calculate your emissions in g CO₂e/kg sugar beet

g CO₂e/kg sugar beet

----->

ENZO₂ Greenhouse gas calculator Ethanol from sugar beet About Background data Start

according to the EU Directive 2009/28/EC

GHG emissions from sugar beet transport - averaging GHG emissions of several batches

Overall quantity metric tonnes	Overall GHG value g CO ₂ e/kg beet	confirm value and back
0	0.00	

Supplier#	Name of supplier	Sugar beet quantity metric tonnes	Truck for dry product (Diesel) km	Ocean bulk carrier (Fuel oil) HFO for maritime transport km	Ship /product tanker 50kt (Fuel HFO for maritime transport km	Rail (Electric, MV) Germany km	GHG value g CO ₂ e/kg sugar beet
1							0,00
2							0,00
3							0,00
4							0,00
5							0,00
6							0,00
7							0,00
8							0,00
9							0,00
10							0,00

fill in the information delivered by your suppliers

Fig. 3-10 Information on transport

3.2.4 Entry of input data

After determination of emissions from pre-products and transport emissions, the next input screen requires entry of input data concerning the current stage of the production pathway (see Fig. 3-11).



Please note the importance of entering data in the correct units. Data must be entered in the predefined units, to ensure reliable calculations with the model equations. The conversion to the required unit may involve separate independent calculations by the user.

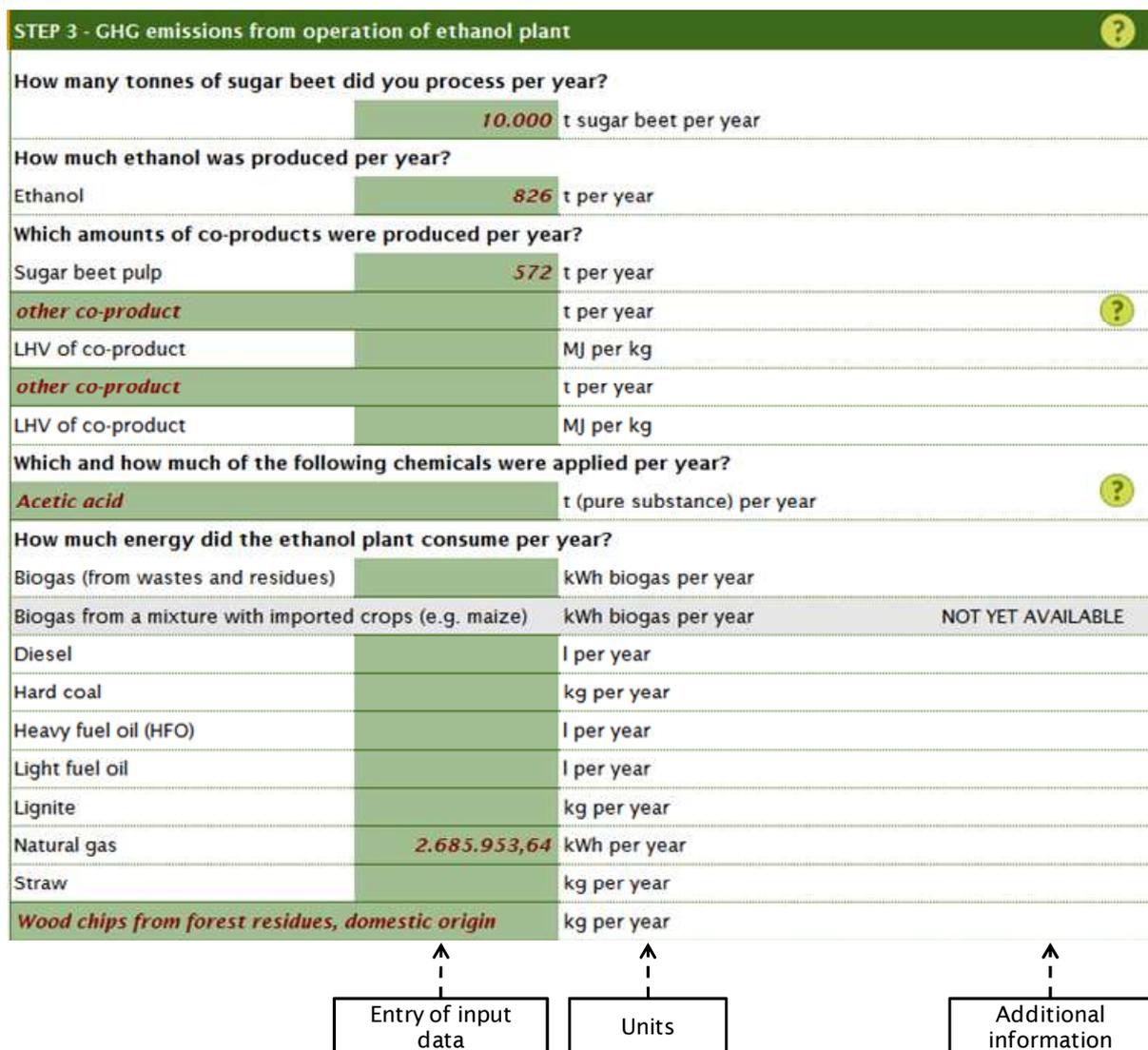


Fig. 3-11 Organisation of the input data fields (section)

3.2.4.1 Process data on the processing plant

- **Quantity of products processed and produced:** The annual quantity of biomass processed is required to match the total delivery quantity entered in a separate worksheet in Step 1 (Chapter 3.2.2).

- **Quantity of co-products:** Co-products other than those approved for allocation in the RED may not be entered. It is possible to enter further co-products individually. In this case, the corresponding caloric value has to be reported to allow allocation. The caloric value has to refer to the total quantity of co-product (wet weight). In the case that the water content is below 10%, it is permitted to assume the caloric value of the dry weight.

BioGrace
calculation
rules 4.1.2,
4.4, 4.1.1

NB: Biodiesel plants

According to the RED, only refined glycerine may be applied for allocation. In the case that the resulting glycerine exits the plant unrefined, it may not be applied for allocation and the relevant cell entry has to be zero. However, if the glycerine is treated for refinement, the appropriate quantity may be entered. Please note that in this case, the energy consumption of the treatment has to be factored into the total energy budget of the biodiesel plant.

BioGrace
calculation
rule 4.4

- **Energy consumption:** In this section, the quantities of energy carriers consumed in the generation of process energy and the energy required to cover electricity demands are entered. Please note that only energy from external sources may be reported, except in the case of an internal generation of biogas. In this case, a certain methane loss is assumed. In the case that electricity supplied by the grid is consumed, the appropriate national electricity mix has to be selected from the provided list. An average EU electricity mix was applied for the calculation of the RED default values and is reported for documentation purposes only. This mix may not be applied to perform calculations of actual values. It is not legitimate to reduce the electricity consumption of a plant by purchasing 'Green Certificates'!

BioGrace
calculation
rules 4.2, 4.3,
4.5

- **Surplus electricity:** In the case that process energy is generated in a CHP plant, it is possible to create emission savings by feeding the surplus electricity into the grid. For this purpose, the quantity of electricity made available has to be entered for each individual energy carrier. Please note that the reported quantity of surplus electricity has to be proportional to the quantity of process heat required for the processing of the relevant bioenergy product. In the case that the CHP plant is generating energy for multiple processes, the size of the operation may have to be scaled down to represent the individual process under investigation.

BioGrace
calculation
rule 6.1

- **Application of chemicals and operating supplies:** Operating supplies that generate less than 0.1 g CO₂eq / MJ of fuel across the entire biofuel production pathway are exempt from reporting. The relevant conversion factors may be found under BioGrace calculation rule 2.3.

Please note that the included emissions values of chemicals refer to the pure substance as opposed to the chemical in solution etc. Therefore, the actual quantities of pure substance may have to be calculated and entered.

- **Dealing with POME (palm oil only):** It is required to report if any methane derived from POME during the manufacture of palm oil in an oil mill is not subject to collection. In this case, the generated methane emissions will be calculated and displayed automatically.
- **Batch size:** Information on the batch size may be required in the subsequent production pathway stage to allow calculation of the weighted average emissions of a partial delivery. The value will be displayed automatically in the upper part of the worksheet under 'final result'.

3.2.4.2 Additional emissions and savings

The default mode of the calculations tools does not cover all conceivable production practices. For instance, palm oil refineries might be using palm kernels as an energy source, or POME could be composted in combination with empty fruit bunches. Both scenarios would result in GHG emission savings. In contrast, certain practices may cause additional emissions, such as the deposition of empty fruit bunches in landfills. To include such additional emissions or savings, the worksheets offer a section to enter additional data. These data have to be calculated independently, the unit required for data entry is CO₂eq per kg product (see sample calculation below). Additional cells offer space for a brief description of the practice in question (see Fig. 3-4). During an audit, detailed documentation on the independent calculations may be required. The ENZO₂ tools automatically factor in additional emissions or offset GHG emission savings with the regular emission, and perform allocation to co-products where appropriate.

STEP 3 - Additional GHG emissions and emission reductions ?	
Are there any other sources of greenhouse gas emissions during your production process? Please describe:	<i>example text</i>
How much CO ₂ eq arise from these sources? Note that you may be required to provide detailed evidence of this number in the auditing process.	g CO ₂ eq per kg ethanol
Do you apply any measures that reduce CO ₂ emissions in your production process? (e.g. emission savings from carbon capture and geological storage (e _{CCS}), carbon capture and replacement (e _{CCR}), replacing transport diesel with biodiesel). Please describe:	<i>example text</i>
How much CO ₂ eq are saved by these measures per kg ethanol? Note that you may be required to provide detailed evidence of this number in the auditing process.	g CO ₂ eq per kg ethanol

Fig. 3-12 Additional GHG emissions and savings

Sample calculation – GHG savings derived from the utilisation of biomethanol in rape seed biodiesel production

Emissions derived from the utilisation of fossil methanol amount to approximately 100 g CO₂eq per MJ (see 'background data'). The annual consumption of 1496 t methanol in biodiesel production therefore generates emissions of approximately 305 g CO₂eq per kg biodiesel. Under the assumption that biomethanol emissions amount to only 70 g CO₂eq per MJ, the emissions per kg biodiesel in this scenario total at approximately 214 g CO₂eq., thus saving 91 g CO₂eq per kg biodiesel. The savings may be reported under additional savings.



Please note that independent background data (e.g. emission values) may only be utilised if there is precise and unambiguous documentation available. Reliable sources have to be cited, and the derivation of the independent data has to be clear so that it may be easily replicated in an audit. Furthermore, it is required for independent values to comply with the BioGrace calculation rules.

**BioGrace
calculation
rule 2.2.1**

3.2.5 Automated calculation steps

In addition to the cells that require data entry, the worksheets include fields reporting automated conversions. These areas are included for information purposes only and do not offer the option of changing the entries.

3.2.5.1 Emission calculation

Based on the process data entered, the individual GHG emissions are calculated automatically (see Fig. 3-13 Fig. 3-5).

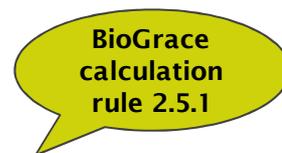
For this purpose, the calculation tool accesses the CO₂ emission values as well as other conversion factors in the 'background data' directory. Interested users may learn of the individual equations employed in calculation by clicking on the respective cells in the worksheets. Thus, comprehension of the employed methodology and the data sources is facilitated.

Calculation of emissions (automatic)		
Acetic acid	0,00 g CO ₂ eq per kg ethanol	
Biogas (from wastes and residues)	0,00 g CO ₂ eq per kg ethanol	
Diesel	0,00 g CO ₂ eq per kg ethanol	
Hard coal	0,00 g CO ₂ eq per kg ethanol	
HFO	0,00 g CO ₂ eq per kg ethanol	
Light fuel oil	0,00 g CO ₂ eq per kg ethanol	
Lignite	0,00 g CO ₂ eq per kg ethanol	
CH ₄ and N ₂ O emissions from Lign	0,00 g CO ₂ eq per kg ethanol	
Natural gas (4000 km, EU Mix quali	790,92 g CO ₂ eq per kg ethanol	
CH ₄ and N ₂ O emissions from NG br	4,14 g CO ₂ eq per kg ethanol	
Wheat straw	0,00 g CO ₂ eq per kg ethanol	
Wood chips from forest residues, i	0,00 g CO ₂ eq per kg ethanol	
Electricity EU mix MV	192,19 g CO ₂ eq per kg ethanol	
Electricity (Diesel)	0,00 g CO ₂ eq per kg ethanol	(surplus)
Electricity (Hard coal)	0,00 g CO ₂ eq per kg ethanol	(surplus)
Electricity (HFO)	0,00 g CO ₂ eq per kg ethanol	(surplus)
Electricity (Light fuel oil)	0,00 g CO ₂ eq per kg ethanol	(surplus)
Electricity (Lignite ST)	0,00 g CO ₂ eq per kg ethanol	(surplus)
Electricity (NG CCGT)	0,00 g CO ₂ eq per kg ethanol	(surplus)
Electricity (Straw ST)	0,00 g CO ₂ eq per kg ethanol	(surplus)
Emissions ethanol plant	987,25 g CO₂eq per kg ethanol	

Fig. 3-13 Calculation of emissions

3.2.5.2 Losses during transport and storage

For cereals and oil crops, the calculation of the RED default values assumed losses from transport and storage between 1 % and 2 %. These loss factors have been factored into the calculation tools, more specifically into the relevant worksheets, and may not be altered at present. The adjusted emission values are displayed in the lower part of the section (see Fig. 3-14).



Preset grain losses from drying, washing, transport	
Presumed gross shrinkage factor	1 %
Emissions transport (incl. shrinl)	0,00 g CO ₂ eq per kg grains
Emissions cultivation (incl. shrir)	0 g CO ₂ eq per kg grains

Fig. 3-14 Losses during transport and storage

3.2.5.3 Combination of emission values

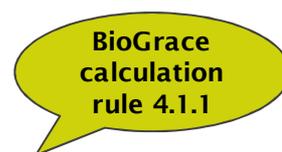
Here, all individual emission values generated during the specific production pathway stage are added up (see Fig. 3-15). Depending on the individual worksheet, the individual items include the emissions of the pre-products, transport emissions, processing plant emissions as well as additional emissions or savings where appropriate. Depending on the individual worksheet, the summed emissions will be allocated during the subsequent step (in the case that co-products are produced), or they may be the final result (if no co-products exist).

Combination of values (automatic)	
Pre-products	433,2 g CO ₂ eq per kg ethanol
Transport	0,0 g CO ₂ eq per kg ethanol
Ethanol plant	987,2 g CO ₂ eq per kg ethanol
Additional emissions and reductions	0,0 g CO ₂ eq per kg ethanol
Total emissions (not allocated)	1.420 g CO₂eq per kg ethanol

Fig. 3-15 Combination of emission values

3.2.5.4 Allocation

In the case that main products and co-products are generated during a production pathway stage, the associated emissions will be allocated, i.e. distributed, among the various products. The rules for this allocation are derived from their individual energy contents, which are in turn utilised to calculate an allocation factor. The energy content of each product is multiplied with the quantity produced. The energy value of the main product is then divided be the total (see equation).



$$\text{Allocation factor} = \frac{\text{Energy content}_{\text{main product}} [\text{MJ}]}{\text{Energy content}_{\text{main product}} [\text{MJ}] + \text{Energy content}_{\text{co-product(s)}} [\text{MJ}]}$$

Next, the allocation factor is multiplied with emissions from the corresponding production pathway stage. Thus, the proportion of the emissions associated with the main product is quantified (see Fig. 3-16). This proportion is reported as the 'final result' at the head of the worksheet.

Allocation (automatic)	
Ethanol	22.153 GJ heat content
Sugar beet pulp (dried)	8.917 GJ heat content
other co-product	0 GJ heat content
other co-product	0 GJ heat content
Allocation factor	0,71
Total emissions (allocated)	1.013 g CO₂eq per kg ethanol

Fig. 3-16 Allocation

3.2.5.5 Final result

After completion of data entry in all relevant cells, the emissions generated during the particular production pathway stage (converted to 'per kg product') are displayed at the head of the worksheet. Further data in the box include the batch size and the independently calculated transport emissions where applicable (see Fig. 3-17).

Final result

Please provide this information together with your batch to the last interface.

Actual value for transport

The GHG emissions from ethanol plant amount to ?

1.013 g CO₂eq/kg ethanol

Emissions include the following transport emissions

0 g CO₂eq/kg ethanol

Size of the ethanol batch

0 t ethanol

Fig. 3-17 Final result (exemplary for the actual transport emission value)

There are two options to proceed:

1. The stakeholder delivers the product to the next, or final, interface: the calculated values are reported when delivering the product.
2. The stakeholder is in charge of processing his product further: both values are recorded and entered manually into the subsequent worksheet. The entry is carried out as the first step in said worksheet in the section accounting for pre-products (see Chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**) under the heading 'Calculate actual value' in a separate worksheet.

3.3 ...final interface?

3.3.1 General approach

The final interface represents the final stage of the biomass production pathway (see Fig. 3-18) and issues the sustainability certificate for the biofuel or bioliquid. The purpose of the final interface is the calculation of the entire GHG balance for the bioenergy carriers. No sustainability certificate will be issued if the stipulated reduction target is not met.

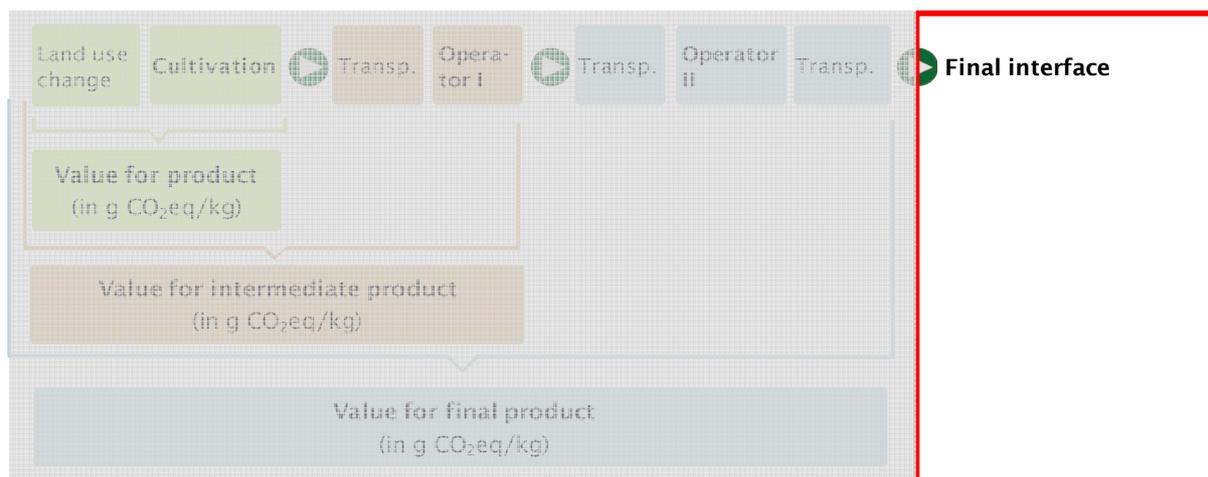


Fig. 3-18 Position of the final interface within the biomass production pathway

Often the final interface is a processing operation such as an oil mill or an ethanol plant. In these cases, the operator is required to complete all preceding worksheets that pertain to processes under his supervision (see Chapter 2.1).

The worksheets include the following steps:

1. Entry of emissions up to the final interface
2. Entry of input data (Information of transport and the bonus of cultivation on degraded land where applicable)
3. Automated calculation steps including the calculation of the total GHG savings

3.3.2 Emissions accumulated up to the final interface

STEP 1 - GHG emissions up to last interface

What are the GHG emissions of the ethanol batch?

g CO₂eq per kg ethanol

Fig. 3-19 Cumulative emissions up to the final interface

In the first step, all emissions accumulated up to the final interface are recorded (see Fig. 3-19). These will already include the greater part of the biomass production pathway. In the case that actual values are applied for calculation of transport emissions, the value reported here will already include the transport emissions accrued up to this point.

The operator of a processing operation is required to manually transfer this value from the preceding worksheet. In the case that the final interface is not a processing operation, the emission value will be reported with the delivery of the goods.

3.3.3 Information on the emissions from the final interface onwards

3.3.3.1 Transport information

The second step involves the reporting of information on transport emissions. In the case that transport emissions are calculated with a disaggregated default value, this value will be displayed here, or may have to be selected for the energy carrier under investigation (see Fig. 3-20)

STEP 2 - GHG emissions from ethanol transport and distribution	
For which ethanol do you want to use the disaggregated default value? Note that currently default values are only available for wheat and corn ethanol.	
Disaggregated default value (e_{td})	g CO ₂ eq per MJ ethanol

Fig. 3-20 Disaggregated default value for transport

In the case that calculations are desired to include the actual emission value, relevant data will be entered here. Transport of the fully processed bioenergy carrier is divided into transport to Europe as well as transport within Europe to the final destination at the petrol station (see Fig. 3-21). The latter have been included in the worksheets as fixed factors and correspond to the data employed for the calculation of RED default values. Furthermore, energy consumption levels in storage facilities and at petrol stations have been factored into the model, because the final interface may not be able to collect these data.

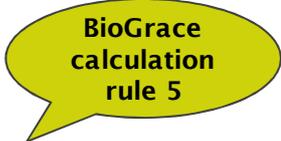
In the case that final interfaces are situated outside Europe, they are required to estimate transport to Europe in addition to the default values. For this purpose, transport by ship or by road may be selected, or a combination thereof. This step is included in the calculation tools for vegetable oil, biodiesel and cereals. In the case of sugar cane, sea transport is already incorporated in the default values, whereas ethanol derived from sugar beet is in all likelihood produced within Europe.

STEP 2 - GHG emissions from ethanol transport, depot and filling station	
Which emissions arose from the transport of ethanol to Europe?	
Truck transport	Truck for liquids (Diesel)
Distance	700 km
Fuel used	Diesel
Ship transport	Ship (product tanker 50kt (Fuel oil))
Distance	10.186 km
Fuel used	HFO for maritime transport
Emissions transport to Europe	171,8 g CO₂eq per kg ethanol
Which emissions arose from the transport of ethanol to the filling station?	
Distance	300 km
Vehicle used	Truck for liquids (Diesel)
Fuel used	Diesel
Emissions transport to filling station	26,50 g CO₂eq per kg ethanol
Which emissions arose from depots?	
Electricity (export terminal)	6,26 kWh per t ethanol
Electricity mix	Electricity (NG CCGT)
Electricity (import terminal)	6,26 kWh per t ethanol
Electricity mix	Electricity EU mix LV
Electricity (depot inland)	6,26 kWh per t ethanol
Electricity mix	Electricity EU mix LV
Emissions depots	8,62 g CO₂eq per kg ethanol
Which emissions arose from the filling station?	
Electricity	25,32 kWh per t ethanol
Electricity mix	Electricity EU mix LV
Emissions filling station	11,78 g CO₂eq per kg ethanol

Fig. 3-21 Calculation of the emissions during transport, storage and at the petrol station

3.3.3.2 Claiming the bonus for cultivation on degraded land

In the case that cultivation is performed on degraded or contaminated land (see RED Annex V, Paragraph C, Nr. 8), a bonus of 29 g CO₂eq/MJ of fuel may be credited (see Fig. 3-22). Due to the fact that the bonus is referenced to 1 MJ of fuel, it will not be offset until the final interface. The bonus may be claimed if appropriate documentation demonstrating the cultivation on eligible land is provided by the grower. At this point is time, there is no official definition for eligibility by the European Commission available as yet.



STEP 3 - Bonus for cultivation on degraded land	
Was feedstock cultivated on degraded land (in compliance with RED Annex V part C point 8) ?	
	no
Emission bonus per MJ biofuel	0 g CO₂eq per MJ ethanol

Fig. 3-22 Bonus for cultivation on degraded or contaminated land



3.3.4 Automated calculation steps

3.3.4.1 Calculation of GHG savings

The total emissions of the individual biomass production pathway will be calculated automatically (see Fig. 3-23). The intended utilisation for the bioenergy carrier (e.g. as fuel, for electricity generation or for the operation of a CHP plant) has to be specified. This specification allows the selection of an appropriate equivalent fossil energy carrier. The emissions of the fossil energy carrier are compared with those of the bioenergy carrier, thus calculating the overall GHG savings of the bioenergy carrier. The savings will be displayed as a percentage in the upper section under 'final result'.

STEP 4 - GHG savings compared to fossil fuel	
Emissions per MJ ethanol	0,00 g CO ₂ eq per MJ ethanol
Is the biofuel used for transport, electricity production or for cogeneration?	
<i>Transport fuel</i>	83,8 g CO ₂ eq per MJ

Fig. 3-23 Calculation of GHG savings

3.3.4.2 Final result

After completion of data entry into all required cells, three values are reported automatically at the head of the worksheet: the percentage of GHG savings of the bioenergy carrier in comparison with the fossil energy carrier, the total emissions across the entire biomass production pathway and the application purpose of the bioenergy carrier (see Fig. 3-24).

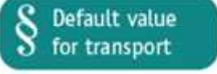
Final result Greenhouse gas savings	 Default value for transport	Greenhouse gas emission savings 0% compared to fossil fuel
		The GHG emissions from biofuel production amount to 0,0 g CO ₂ eq/MJ biofuel
		Biofuel is used for

Fig. 3-24 Final result (exemplary for transport with disaggregated default value)

4 Abbreviations and glossary

Abbreviation / term	Explanation
Actual value	Emission value calculated independently on the basis of actual input data
Allocation	GHG emissions generated during a particular bioenergy carrier production stage are partitioned among the bioenergy carrier, or rather its intermediate products, and any arising co-products. A co-product is one of several products produced in the same process and part of the allocation procedure. Waste materials do not qualify for allocation. The emissions are distributed according to the energy content of the individual products.
BLE	German Federal Office for Agriculture and Food (Bundesanstalt für Landwirtschaft und Ernährung)
CHP	Cogeneration of heat and power; heat engine operation performing a simultaneous generation of electricity and useful heat for heating or process purposes
Default value	The default value is a value that may be applied in place of an actual computed value if all conditions stipulated in the sustainability regulations are met. It characterises the aggregated production pathway, i.e. the pathway in its entirety
Disaggregated default value	The disaggregated default value characterises one stage (cultivation, processing or transport/ delivery) of a default value
First gathering point	First gathering points are operations which are the first of all stakeholders to receive the biomass required for the production of liquid biomass or biofuels from agricultural operations (e.g. traders or cooperatives)
GHG	Greenhouse gas(es); included are carbon dioxide (CO ₂), methane (CH ₄) and nitrous oxide (N ₂ O)
GWP	Global Warming Potential (CH ₄ : 23; N ₂ O:296)
Interface	Interfaces are operations liable to certification along the entire production and delivery pathway of bioenergy carriers; to be differentiated between first gathering points, oil mills and other operations processing biomass
POME	Palm Oil Mill Effluent; waste water in palm oil mills
RED	Renewable Energy Directive (Directive 2009/28/EC of 23 April 2009 on the promotion of the use of energy from renewable sources)
Refinery	In this context, a refinery is defined as an operation for the refining of vegetable oils