BIOGRACE I

Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

28/04/2015

User manual
for the
BioGrace-I Excel tool

Version 4d

Supported by INTELLIGENT ENERGY EUROPE

www.biograce.net

Please note that this version 4d of the user manual is the same as version 4c of the user manual.

This support document is designed to help the economic operators to understand and use the BioGrace-I Excel tool. The main questions that arise concerning the tool are presented below, with a link to the appropriate chapter within this user manual.

If the BioGrace-I Excel tool is to be used for making actual calculations, **then the user shall also refer to the BioGrace-I calculation rules**[1]

Functions of the tool	This chapter details the different ways of using this tool. You will find why this tool was developed and what it can do.
How does the tool work?	This chapter explains how the tool is designed and the general principles of the calculations.
How to understand and pilot the results?	This part describes how the result module, in head of each pathway, works. It also explains how to choose between disaggregated default value and actual default value.
How to deal with inconsistencies?	This part gives information on how to find and how to cope with revealed inconsistencies in the calculations.
How can I use the tool to understand the default values?	These chapters allow you to make the best use of the tool depending on your personal objective.
How can I use the tool to calculate my own actual value?	
How can I create a new pathway with the tool?	
How to use the LUC sheet?	A step by step tutorial may help you to declare a land use change in one of your pathways.
How to use the Esca sheet?	Information about "Improved agricultural management" can help you take into account carbon stock changes related to improved practices.
How to use the N_2O emissions IPCC sheet?	A step by step tutorial may help you to calculate the N_2O emissions of your pathway.
Why was there a need for the BioGrace project?	You can refer to this chapter if you want more information on the context of the BioGrace project.
Glossary	This section provides you with the definition of the specific wording used in the tool or in this document.

[1] Please find the BioGrace-I calculation rules document as part of the ZIP file *BioGrace_GHG_calculations_-_version_4d* or as a separate document on the BioGrace website.

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1 Functions of the tool

Access and understanding of biofuel GHG calculations should be available to all involved or interested actors; this can cover a very large and diversified public. For this reason Excel was used to set up the tool.

This user manual gives insight on how to understand and use the BioGrace Excel tool that is available through the website www.BioGrace.net. In fact, the tool (one file) contains two versions, which are:

(1) BioGrace-I Excel tool - version 4d for Compliance
(2) BioGrace-I Excel tool - version 4d for Testing

The only difference between these two versions is that in the version for Compliance the "track changes" is turned on, whereas in the Testing version it is turned off. The "for Compliance" version can be turned into the "for Testing" version by pressing on the orange button "Track changes". This user manual is about both versions of the tool, and with "the tool" reference is made to both versions of the tool.

Three main functions have been identified when developing the tool:

1. **Give details on RED default value calculations**: the calculation sheets have been developed to detail the exact and comprehensive methodology applied to established default values of the Renewable Energy Directive.
2. **Adapt existing pathways for actual value calculations**: adapting some of the input numbers of the calculation sheet allows easy and RED compatible own actual value calculations. It is also possible to add your own standard values (or conversion factors, see the final glossary in chapter 8) in the calculations (for example, adding a specific chemical input). The tool can also be used to estimate the contribution to total GHG emissions of any process or any improvement actions.
3. **Create a new pathway**; next to the two main functions, it is also possible to create a whole new pathway within the tool. Some advice on how to do this is given at the end of this tutorial. However, the tool does not offer user-friendly functionalities for this function; the user shall first have obtained a thorough understanding of the tool before being able to create a new pathway.

Each function is described in more detail in their specific chapters.

General information about the tool is given in the following chapter before detailing how to use the tool for the functions mentioned above.

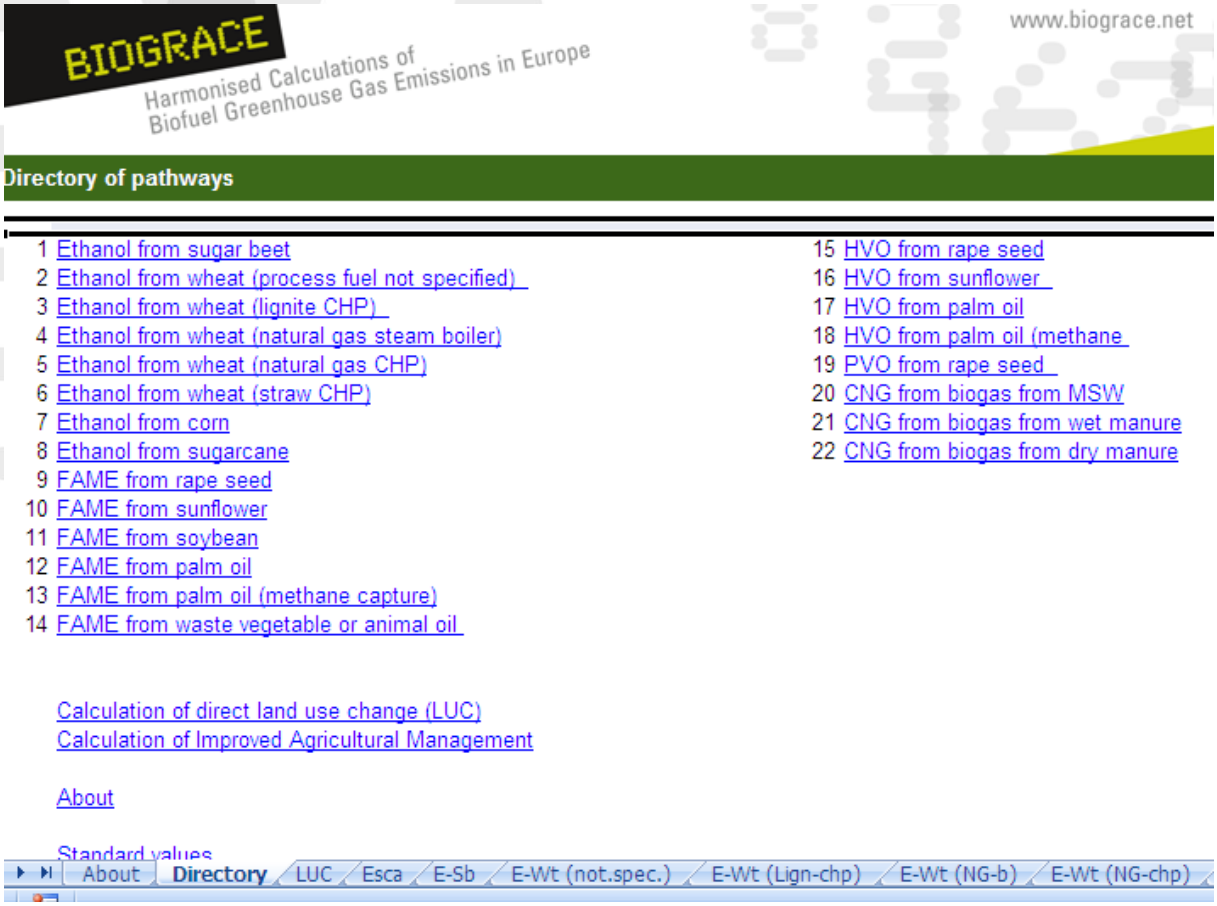
2 General presentation of the tool

2.1 First and fast navigation within the tool

The tool is organised in several excel sheets.

The first sheet, "**About**", explains some of the vocabulary and calculations allowed by this tool.

The second sheet, "**Directory"**, shows all the links to the excel sheets with explicit names; for instance, "FAME from rape seed" is linked to the "F-Rs" sheet.

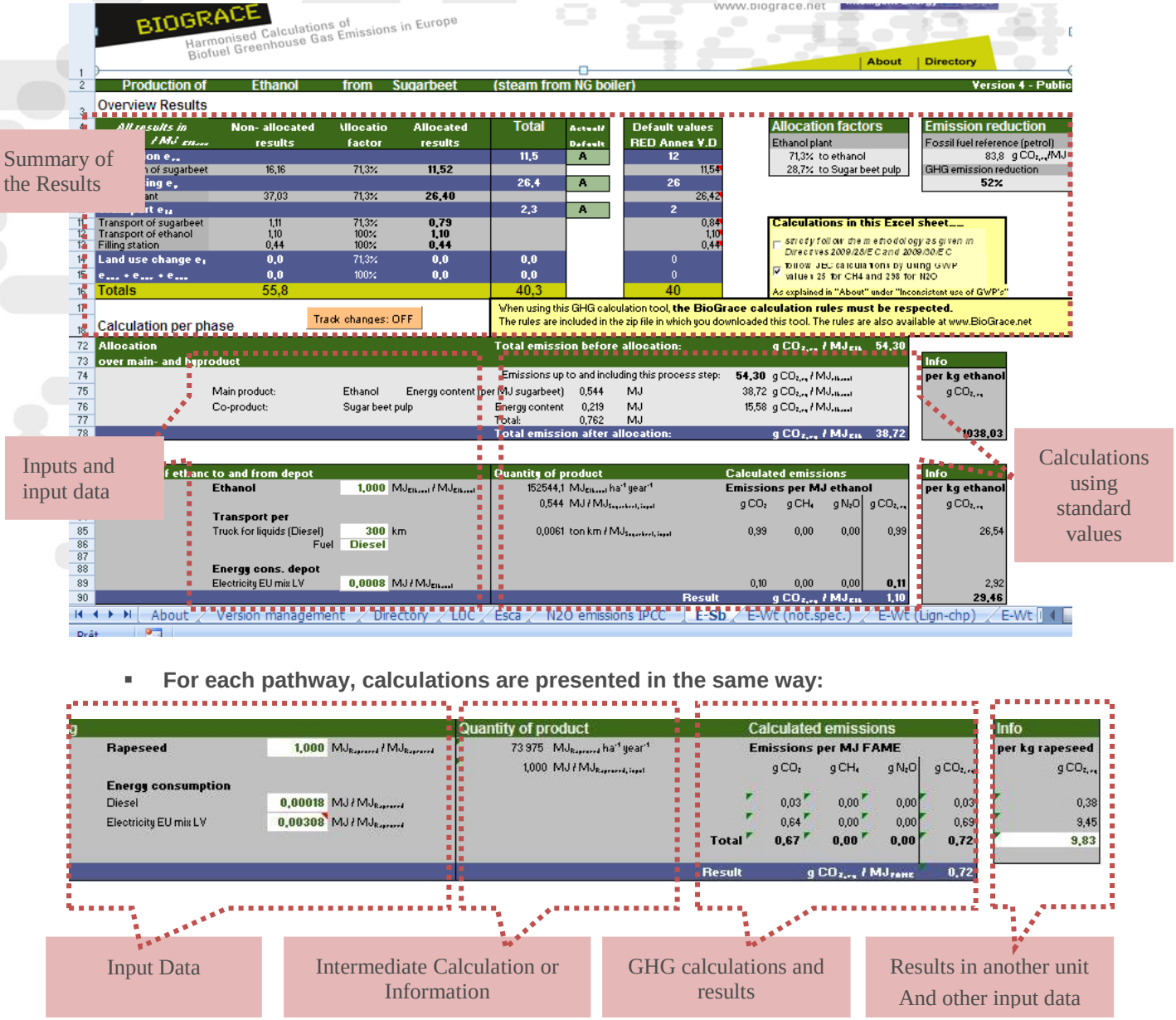


After these generic sheets, the user can find several calculation sheets dedicated to one precise aspect of the calculation:

- **LUC** assesses the GHG impacts of possible Land Use Changes,
- **Esca** for carbon stock changes due to improved agricultural practices.

- **N_2O** estimates N_2O emissions in accordance with the IPCC methodology[2].

The user will then find the pathway calculation sheets. These sheets contain all the input numbers and results for all the pathways in the scope of the tool, with one sheet per pathway, in the most transparent way possible. The following example shows how a calculation sheet is built.



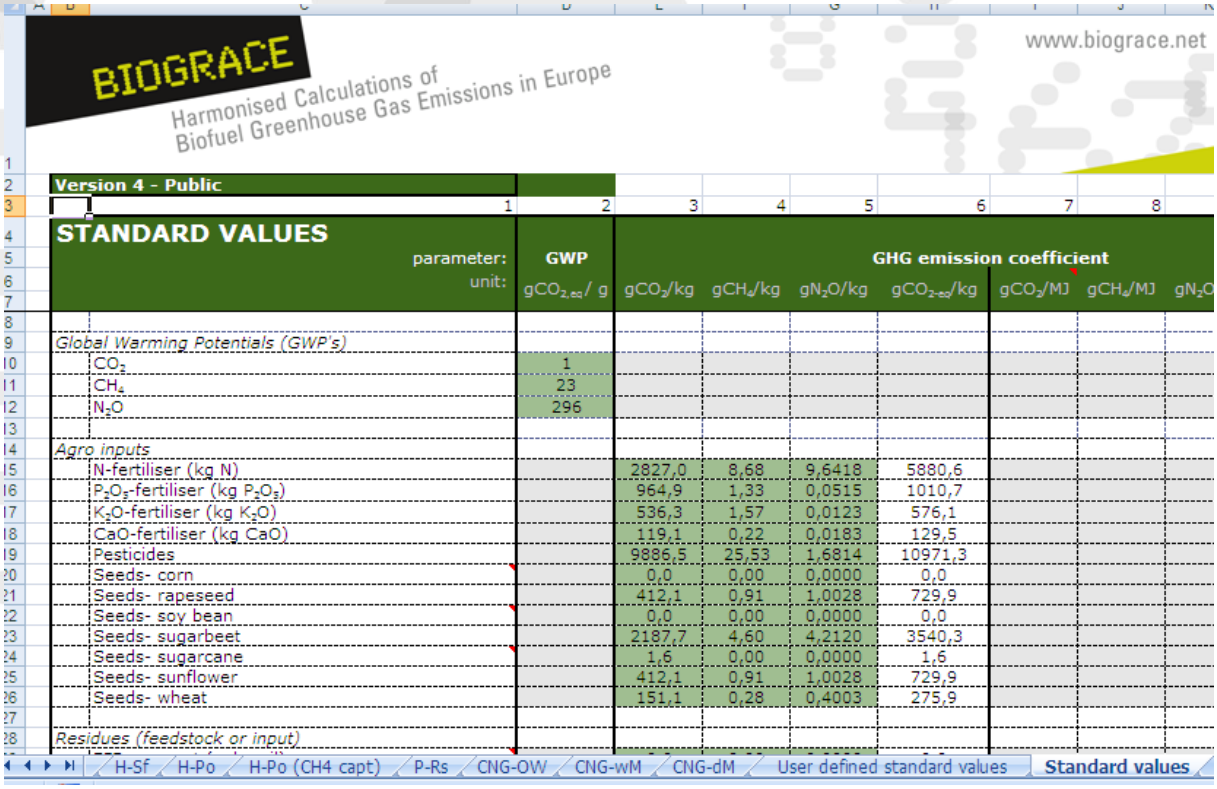
- **For each pathway, calculations are presented in the same way:**

Input Data | Intermediate Calculation or Information | GHG calculations and results | Results in another unit And other input data

The two last sheets: "**user defined standard values**" and "**standard values**" present the generic data necessary for the calculations.

[2] See the BioGrace-I calculation rules document for explanations on why this model is recommended.

The "**Standard values**" sheet refers to conversion factors used for the calculation of RED default values. Their main data are GHG emission coefficients, which are the emissions of the main GHG gas associated with 1 kilogram inputs (N-fertilizers, chemicals, etc.). It also contains other data necessary for the conversion steps of the calculation: Lower Heating Values (LHV) for fuels and energy products, fossil energy inputs, fuel efficiency for transport, etc. These data are also to be used in case the user creates a new pathway.



The "**user defined standard values**" sheet is provided in case the user wants to use conversion values that are not included in the list of standard values (see *section 5.1* detailing how to use the tool for this specific use). Please note that BioGrace has formulated rules on when own standard values can be used, these rules can be found in the BioGrace-I calculation rules.

2.2 Colour-coding of Excel cells in calculation sheets

Generalities: The tool is built on a very simple colour–code for cells.

- White cells are used for input numbers. The existing values are the ones used for the RED default value calculation. These cells can be changed by any user to test or adapt any pathway.
- Grey cells are used for calculations and information that shall not be changed (except when adapting a pathway by adding new inputs or modifying the standard value called (see the section on how to modify or add an input)).

- Blue cells offer calculation results for a module or for an aggregation of modules.

Please note!: in case a calculation is made that will be used to show the GHG performance of a biofuel as part of fulfilling the sustainability criteria of the RED or FQD, the "for Compliance" version must be used. In this "for Compliance" version the "track changes" is always turned on. This will cause that a change in a cell will be marked by a yellow background-colour and a red box around the cell. This helps to keep track of changes from the original document which will be helpful for any certification supervision of any actual value certification.

2.3 Comments

Comments have been attached to some cells. Comments appear with the usual format of Excel comments, as a small red triangle in the right corner of the commented cells.

These comments are helpful to understand how the calculations for the RED default value were made.

2.4 How GHG calculations are made within this tool

2.4.1 General principles

The RED Directive and the calculations in the BioGrace Excel tool follow a Life Cycle Assessment (LCA) perspective to evaluate the GHG emissions of one MJ of fuel. This means that:

- The functional unit is here "the production and use of one MJ of fuel".
- All life cycle steps from biomass production to fuel use are taken into account. Each step of the life cycle is presented in the calculation sheet within a dedicated module representing one step in the biofuel production pathway.
- For biofuels, the use phase bears no emission of GHG as the CO_2 emitted is biogenic (and the CH_4 emissions occurring when burning a fuel are insignificant and fall under the cut-off rule).
- A module gathers the inputs' consumptions and calculates the emissions of the three main gases contributing to climate change (CO_2, CH_4, and N_2O). Details of the contribution of each gas in the results are presented in the last step of the calculation in order to have a high traceability of the contributions as required in the ISO norm.
- GHG emissions of each module are then summarised to obtain the GHG emission of the whole pathway. Details of the modules aggregated under each of the RED defined step are given under *2.4.3 Result module and general information*.

- Detailed calculation formulas can be seen by clicking each cell in the sheet. Methodological rules can be understood from looking at the formula calculated. All the different rules cannot be defined here. For more details, please refer to Annex V.C of the RED directive, and to the BioGrace-I calculation rules.

2.4.2 Presentation of a module

A module contains the following data (please refer to the previous picture for visual example):

Input data: the left hand side shows the main technical information of the process step modelled in the module.

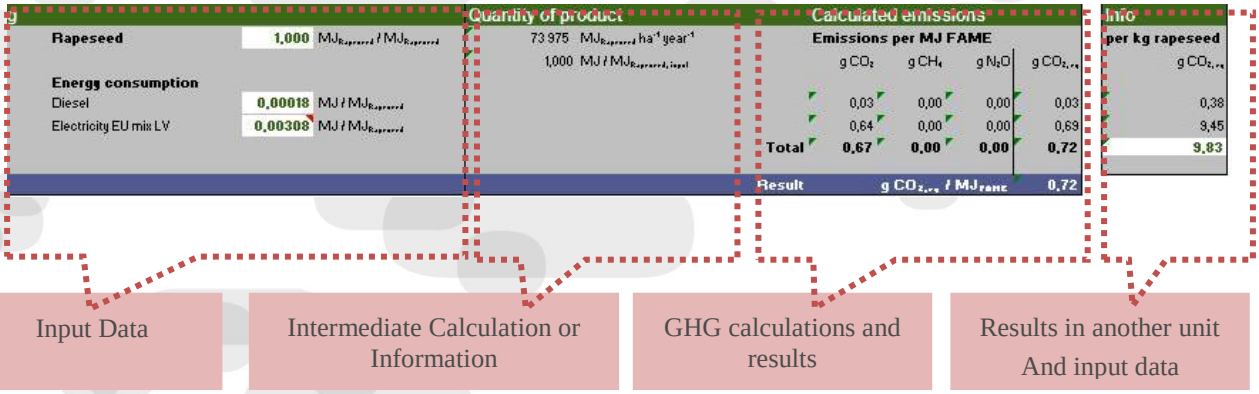
- Names and quantity of inputs, of yields, etc, are given here. Three main types of input data are listed in the module :
  - **Yield of the step**, using the appropriate unit. These yields are given for the main product, and also for all the existing co-products. No co-product mentioned means that this step doesn't have any co-product.
  - **Energy** inputs with for instance electricity or steam consumption. Steam consumption can be detailed in a calculation showing how the conversion plant generates the steam, the fuel input and possibly the electricity output in case of a CHP.
  - **Result from previous and partial GHG calculations**, it enables to make GHG calculations for part of the biofuel pathway and – after verification – use these values as inputs in a new calculation for the rest of the biofuel pathway.
  - **Other inputs** such as chemical, transports, etc.
- Units: this is the key information to take into account. Beware that the units are often given per MJ of products.

Intermediate calculation information: some relevant information is given in the central part of the module (columns E, F and G). They are helpful to give easier understanding of some calculation stages. They can also provide intermediate calculation useful for further part of the tool. In this example the quantity of product (in MJ) per hectare and intermediate yields data appear.

GHG Calculation: the right side of the tool is the calculation part. The global warming potentials for the three main gases are taken from the "Standard values" sheet.

Results: are given in the bottom of the module in blue cells. The unit is also given in order to easily keep track of it.

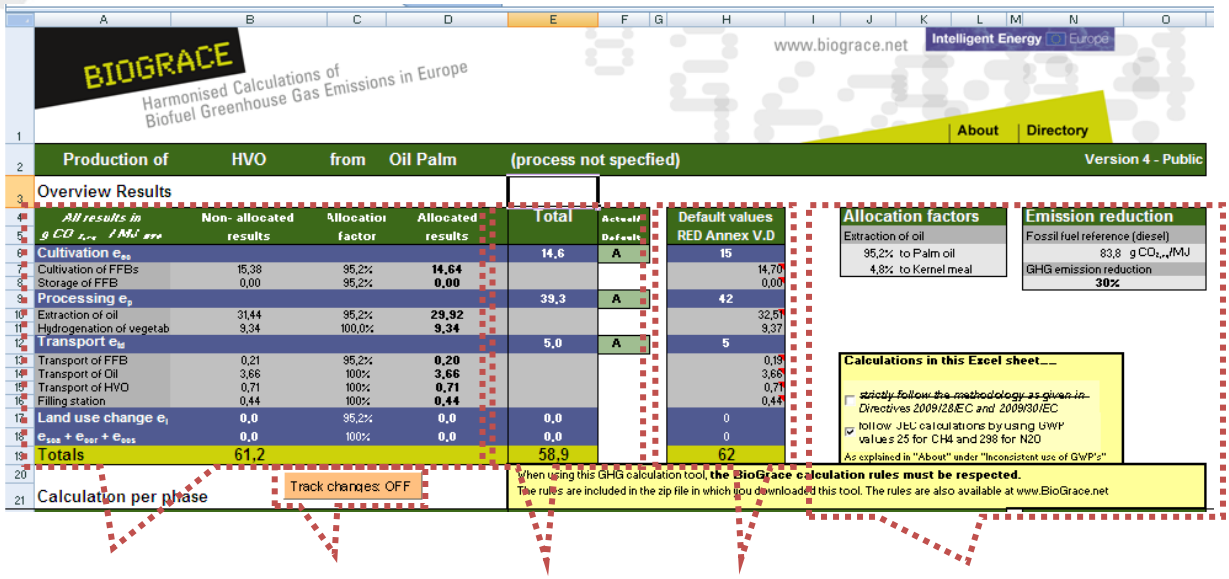
Info: the last column offers results or intermediate data in a more easy-to-manipulate unit (in general, g $CO_{2,eq}$ per kg of wheat or per kg of biofuel).



Input Data | Intermediate Calculation or Information | GHG calculations and results | Results in another unit And input data

Some modules dealing with specific issues can be found at the bottom of each calculation sheet. Indeed, some agricultural practices or local conditions also need to be taken into account within the RED methodology, for instance no tillage, or carbon storage due to straw incorporation into soils. Issues like "Land-Use-Changes", "CO_2 storage", "Improved agricultural management", have been added to specifically address and take into account these subjects in each calculation sheet. Another specific module, containing allocation calculations, is described in the following section.

2.4.3 Result module and general information



Detailed results | Track change button | Global Results to use | RED default values | General information

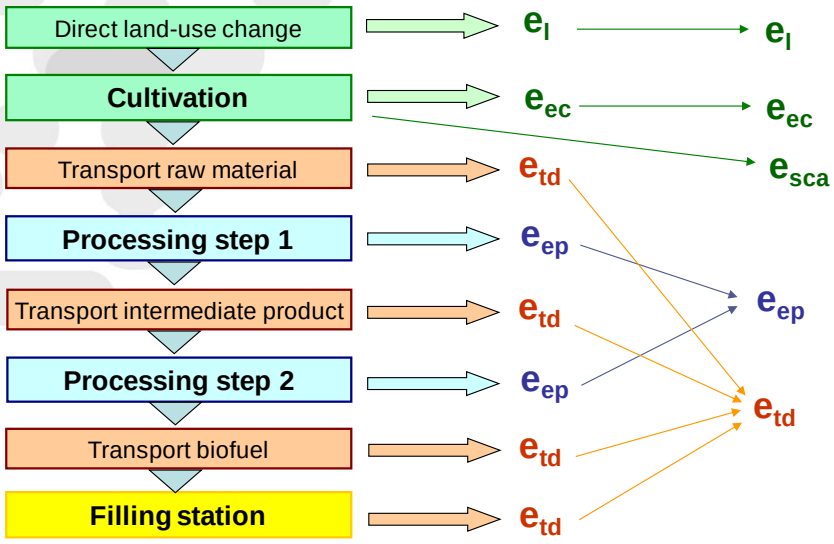
The first lines of each Excel sheet present the results synthetically for the pathway calculated in this Excel sheet. It is made of 4 main parts:

Detailed results: this first part gives the step by step results before and after allocation. The aggregated results given by white text correspond to the one given in Annex V of the RED (see the box below). Several calculation modules can contribute to each step.

C. *Methodology*

1. Greenhouse gas emissions from the production and use of transport fuels, biofuels and bioliquids shall be calculated as:

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



Global results to use: the first column of this part gives step by step actual results calculated for the present Excel sheet. The second column, column F, is very important to calculate final GHG emissions for this pathway. It enables using a mix of both disaggregated default value and disaggregated actual values. The box at the end of this paragraph of the user manual highlights this aspect.

RED default values: Column H gives a clear and direct comparison with the default values taken from RED, Annex V, part D and E for the same biofuel pathway.

General information: this part brings important information to the user. The main one is the GHG emission reduction achieved with this biofuel pathway as compared to fossil fuel. This data is to be used to show that the sustainability criteria on GHG savings[3] are met (or not). Allocation applied for the calculation is also highlighted (in percentage for the concerned step) as an important parameter in the

[3] set up by article 17, point 2, of the RED

result. A last box offers the possibility to change the Global Warming Potential in order to cope with the revealed inconsistency on this topic (for more information, please refer to *6.4 Inconsistency in use of global warming potentials* and to *2.3 Comments*).

Please note! : You will find in column F of the result module very important checkboxes. They are here for implementing the possibility left by article 19, 1, c) of the RED, to assess GHG emission from a mix between disaggregated defaults values given in Annex V, part D or E, of the RED, and disaggregated actual values. The "A" of the checkbox list means that the value used for this step in column E is coming from the Excel sheet actual calculation. The letter "D" means that the value used for this step in column E is coming from the RED disaggregated default value (presented in column H).

For instance, if you want to use for the cultivation step e_{ec} the disaggregated default value of the RED and only for this part, than you shall choose the letter "D" from the checkbox list of the line that gives the results for cultivation. The letters in the other two checkboxes (in the lines for processing and for transport) in the same column F shall stay positioned on "A" to get back actual values calculated in the modules below of the BioGrace Excel tool.

Please, also refer to BioGrace-I calculation rules for more explanation on the methodological rules for applying such possibility.

2.4.4 Allocation modules

Allocation calculations to divide GHG emissions to the main product and co-products are done in specific modules, as illustrated by the example below.

In the tool, allocations are applied right after the module where the separation of co-products takes place.

Allocation over main- and byproduct		**Total emission before allocation:**		**g $CO_{2,eq}$ / $MJ_{Ethanol}$**	**89,19**
		Emissions up to and including this process step:		**89,19** g $CO_{2,eq}$ / $MJ_{ethanol}$	
Main product:	Ethanol	Energy content (1 ton)	26 810 MJ	53,08 g $CO_{2,eq}$ / $MJ_{ethanol}$	
By-product:	DDGS	Energy content (1,14 ton dry matter)	18 240 MJ	36,11 g $CO_{2,eq}$ / $MJ_{ethanol}$	
		Total:	45 050 MJ		
		Total emission after allocation:		**g $CO_{2,eq}$ / $MJ_{Ethanol}$**	**53,08**

The emissions of processing steps up to this separation point are split based on the energy contents of products. The energy content of products can be found in the "Standard values" sheet, column P.

Energetic allocations are calculated from energy content of products, multiplied by their specific mass. This energetic part of the product leading to the biofuel is multiplied by the total result obtained up to this point to get the "after allocation result".

The formula is hereby detailed for ethanol from wheat:

$$\text{Total emission after allocation } \{1\} = \text{Total emission before allocation } \{2\} \times \frac{\text{Ethanol energy content } \{3\}}{\text{Total energy content (ethanol + DDGS)} \{4\}}$$

Units used:

{1}: g $CO_{2,eq}/MJ_{Ethanol}$

{2}: g $CO_{2,eq}/MJ_{Ethanol}$

{3}: MJ

{4}: MJ

In the box in the upper right corner of the excel sheet the calculator allocation factor is given, see the example below.

Allocation factors
Ethanol plant
59,5% to ethanol
40,5% to DDGS

2.4.5 Units used

A major point of attention is that the tool is designed with all the data associated to specific units. **Therefore, to avoid any calculation errors, changing units is not permitted; instead the user shall convert his/her data collected into the units that are used in the tool.** For each input consumed during the life cycle, the quantity of input is converted in the quantity needed per MJ of biofuel. This quantity is then multiplied by the global warming potentials for CO_2, CH_4 and N_2O which results in CO_2-equivalents.

2.4.6 Specific calculation points to be known

Yield			Yield		Emissions per MJ ethanol				per kg wheat
Wheat	5 208	kg ha^{-1} year^{-1}	76 587	MJ_{Wheat} ha^{-1} year^{-1}	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$
Moisture content	13,5%		1,000	$MJ / MJ_{Wheat, input}$					
By-product Straw	2 148	kg ha^{-1} year^{-1}	0,128	$kg_{Wheat}/MJ_{ethanol}$					
Energy consumption									
Diesel	3 717	MJ ha^{-1} year^{-1}			8,01	0,00	0,00	8,01	62,54
Agro chemicals									
N-fertiliser	109,3	kg N ha^{-1} year^{-1}			7,59	0,02	0,03	15,80	123,42
K_2O-fertiliser	16,4	kg K_2O ha^{-1} year^{-1}			0,22	0,00	0,00	0,23	1,81
P_2O_5-fertiliser	21,6	kg P_2O_5 ha^{-1} year^{-1}			0,51	0,00	0,00	0,54	4,20
Pesticides	2,3	kg ha^{-1} year^{-1}			0,57	0,00	0,00	0,63	4,92

In this example, the agro chemicals needed for the cultivation step of wheat are shown on the left, in kg per hectare and per year. On the right part the emissions of greenhouse gas per MJ of ethanol are calculated, using conversion formulas in the cells.

This calculation relies on the match between the name of the inputs ("N-fertiliser", "K_2O-fertiliser", etc.) and the names in the "standard values" sheet. Excel formulas are used to call the right GHG emission coefficients for each input (formula "VLOOKUP" in English[4]). It is therefore very important to use the appropriate name of input/output if one changes an input value in the calculation sheets. For instance, if the user wants to use an own standard value, this value has to be created in the "user defined standard value", and the same name must be used in the calculation sheet.

2.4.7 Details about N_2O calculation

N_2O field emission data for default values of non EU-imported crops are derived from calculations carried with the DNDC model. This model takes into account direct and indirect emissions. Average EU data have been used for each crops, type of soil, climate, etc. For more detail on these calculations, please refer to the JRC documents[5]. For imported crops a modified IPCC tier 1 methodology has been applied.

For the implementation of new pathways or in case of calculating actual values for cultivation (for which all the input numbers for cultivation have to be replaced, this is one of the calculation rules), one of the methods laid down in the IPCC guidelines for National Greenhouse Gas Inventories, Volume 4, Chapter 11(2006), tier one, two or three shall be used.

[4] or "VERT.ZOEKEN" in Dutch, or "RECHERCHEV" in French language respectively

[5] Linking an economic model for European agriculture with a mechanistic model to estimate nitrogen and carbon losses from arable soils in Europe, A. LEIP & al, JRC, Biogeosciences, 5, 73–94, 2008

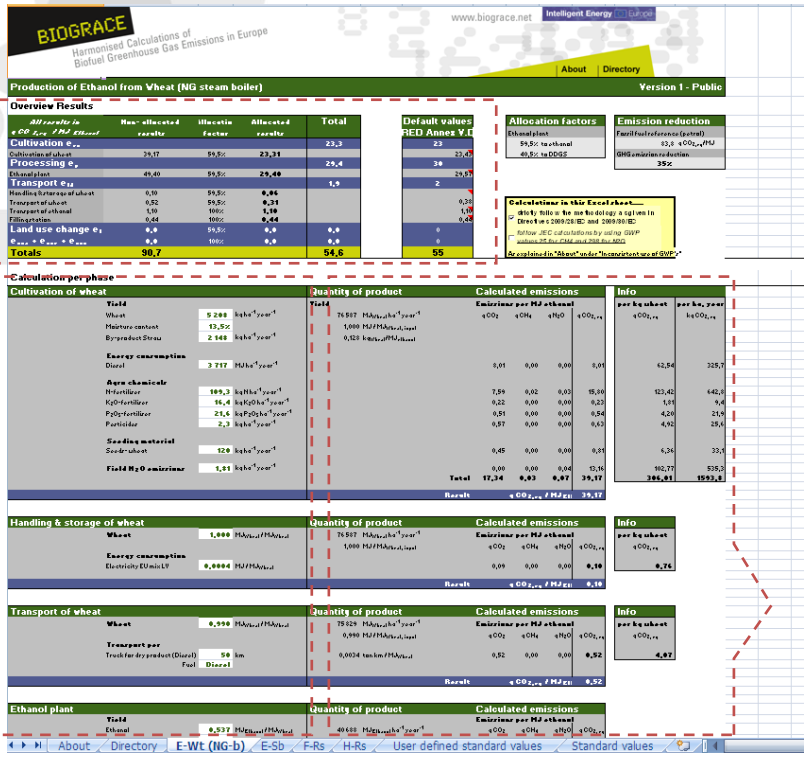
3 Function 1: using the tool to have details on default value calculations

The BioGrace Excel tool makes transparent how the default values of the RED were calculated. For each pathway of production, a dedicated Excel sheet presents the details of the default value calculations.

The list of the pathways can be found in the "Directory" sheet with links to each pathway excel sheet.

All the necessary input numbers are presented per phase on the excel sheet: cultivation step, handling and storage of the biomass, transport to plant, plant, transport to depot and filling station.

The same framework is used for all pathways:



The calculations are presented step by step, following the well to wheel approach.

Looking in detail at this calculation sheet gives a lot of information on how the calculations were made and on how the RED methodology was applied[6]. For instance and without being exhaustive, you can find detailed information on the following issues:

- Which **steps and inputs have been taken into account** in the RED default value calculations:

[6] And in some cases, the inconsistency between calculations carried out for default value and RED methodology.

- The different steps encompassed and the way they are modelled (has the drying of corn been taken into account in the RED default value? etc);
- All the different inputs taken into account for the calculation (and conversely, one can deduct the inputs not taken into account);

- **Input quantities taken into account**, for instance yields (for cultivation and processing steps), energy consumption, chemical consumption, co-product production, etc. It is possible to click on each cell in order to see if the number is a raw data figure or if it is a calculated value (the formula is then visible);
- **Standard values used for calculating default values**, like LHV, the GHG emission for producing one kg of Hydrochloric acid, etc ;
- **How energetic allocations are made** (see the allocation module for this as well as the calculation rules);
- **How energy surplus is taken into account** (see the energetic calculation in each pathway with energy surplus for detail examples);
- **Intermediate calculations**, in column E, where all the yields are expressed in $ha^{-1}.year^{-1}$ and in MJ of biomass input (wheat, etc.);
- **GHG emissions** as calculated from the input numbers, in columns H, I and J, respectively for CO_2, CH_4 and N_2O;
- **The difference between typical and default value**: this difference is achieved by multiplying the input data of the biofuel processing step by 1,4;
- **Specific emissions calculated** in modules at the end of each excel sheet: annualised emissions from carbon stock changes caused by land use change, CO_2 storage, etc;
- **Total emissions before and after allocation**. The formula used for allocation can be found by clicking on the cells of "emissions after allocation".

An overview box, summing up all the results, can be found at the beginning of each Excel sheet.

In order to compare the calculations with the "RED values", the Global Warming Potentials 1 for CO_2, 25 for CH_4 and 298 for N_2O must be chosen (see paragraph 6.4 for details) as the RED default values were calculated with these Global Warming Potential. For most of the 22 default values as listed in RED Annex V, the corresponding calculation in the BioGrace Excel tool gives a result that comes very close (deviation less than 0,1 g $CO_{2,eq}$/MJ) to the value calculated to derive the RED Annex V default value. For a number of reasons, there are larger deviations up to several g $CO_{2,eq}$/MJ for 5 of the 22 pathways:

Ethanol from corn, FAME from waste vegetable or animal oil and the three biogas pathways (biogas from organic municipal waste, from wet manure and from dry manure). We expect that these differences will disappear in the future after the update of RED Annex V and the following update of the BioGrace Excel tool.

4 Function 2: Adapting pathways to calculate an actual value

The BioGrace Excel tool allows economic operators to adapt the default value calculations for available pathways. It could thus be used for setting up calculations of its own actual value.

The following chapters give a step by step tutorial on how to adapt an existing pathway for several situations:

- Changing input data;
- Using the result from previous and partial GHG calculations;
- Adding specific standard values for existing inputs;
- Adding new input in the process.

4.1 Modifying input data only

Calculation sheets of the BioGrace Excel tool allow economic operators to calculate an actual value for existing pathways. This adaptation can be performed **by changing the input values** in the appropriate calculation sheet.

You should first take notice of the document BioGrace-I calculation rules which includes a specific chapter "Use of starting values in the BioGrace Excel tool". Complying to these rules, **you can modify the value of all white cells**.

On each of the Excel sheets for the biofuel production pathways you can find (on the left, near the top of the sheet under the results) an orange “button” which is named “Track changes: ON”. You can click on this button to change it to “Track changes: OFF”.
When track changes is on, this will cause that a change in a cell will be marked by a yellow background-colour and a red box around the cell. This helps to keep track of changes from the original document which will be helpful for any certification supervision of any actual value certification.

Please note that:

1. In case a calculation is made that will be used to show the GHG performance of a biofuel as part of fulfilling the sustainability criteria of the RED or FQD, the “for Compliance” version shall be used in which “track changes” is always turned on.
2. Once the button “Track changes” has been pressed and the Track changes has been turned off (and simultaneously the version has changed from “for Compliance” into “for Testing”), this cannot be undone as, in contrast to previous versions of the Excel tool (version 4b and before) the button will be deactivated after pressing it once.

Specific attention has to be paid when the input numbers are available in a different **unit**. The new value has to be expressed in the exact unit mentioned in column D. Please, also check the obtained result for any error or inconsistency.

4.2 Using the result from previous and partial GHG calculations

Calculation sheets of the BioGrace tool allow that GHG calculations are made for part of the biofuel pathway and are used as input in a new calculation for the rest of the biofuel pathway. These inputs can take into account individual or multiple steps. Previous and partial GHG calculations that are used for input into BioGrace shall also have been made using BioGrace.

Specific calculation rules have been written in the document BioGrace-I calculation rules. These rules shall be followed while using the result from previous and partial GHG calculations.

General information and requirements when doing such modifications:

- These results of the previous calculation shall be expressed in g $CO_{2,eq}$ per kg of feedstock (including moisture) or in g $CO_{2,eq}$ per kg of raw vegetable oil.
- Changing such a value will overwrite all values and calculations in that step.
- Changes shall be done also in the result module at the top of the sheet in order to make the modification more transparent.

There are two different kinds of values that can be entered:

- One or more unallocated results for individual steps, like cultivation and/or transport and/or the oil mill ;
- One result for multiple steps, like cultivation plus transport or like cultivation plus oil mill.

For each type of values specific modifications are needed in the pathway. The practical modifications needed are explained below followed by one example for each type of value.

1. <u>One or more unallocated results for individual steps</u>
   Step 1: Result(s) for individual step(s) shall be entered in the cells with white background colour in column N for the corresponding step.

   Step 2: In the result section of the pathway, use the drop-down selection in column E to select "individual result from a previous calculation". This causes the result line(s) (columns A-G) for the individual step(s) in question to become orange-coloured.

2. <u>One result for multiple steps.</u>
   Step 1: One combined result for more than one step shall be entered in the cells with white background colour in column N for the last step in the combined result (so the combined result for cultivation plus oil mill is put into the result in column N for the step "Extraction of oil").

Step 2: In the cells with white background colour in column N for the previous steps that are included in the combined result, the value "0" shall be entered.

Step 3: In the result section of the pathway, use the drop-down selection in column E to select "combined result from a previous calculation". This shall also be done for all the previous steps included in the combined result, causing the result lines (columns A-G) for these steps to become orange-coloured.

Step 4: If a co-product is formed in one of the steps included in the combined result, then in the BioGrace Excel tool the allocation factor for this step shall be set to 100% towards the main product and 0% to the co-product. This shall be done by entering the value "100" for the related factor placed into the "Allocation factors" box which is situated on the top of the sheet at the right of the result section (in practice this is always cell J6).

Step by step example : for one or more unallocated results for individual steps

This example explains how to use the result from an individual calculation for "cultivation of rapeseed" step in the FAME from rapeseed pathway in the BioGrace calculation tool. The unit of the result provided is in g $CO_{2,eq}$ per kg of rapeseed. This could happen in practice to a company responsible for drying rapeseeds, which receives rapeseed for which a calculation has already been made and verified. Please note that in this example there was no land use change and no improved agricultural management. In case of land use change or improved agricultural management in step 2 "combined result from a previous calculation shall be put in cells E7 and E17 or E18 (the example after this one will include land use change).

To use the result of the individual calculation for "cultivation of rapeseed", the following steps must be performed:

- **Step 1 :** The result for the "cultivation of rapeseed" step shall be entered in cell N44.

	Cultivation of rapeseed			Quantity of product		Calculated emissions				Info	
	Yield			Yield		Emissions per MJ FAME				per kg rapeseed	per
	Rapeseed	3 113	kg ha^{-1} year^{-1}	73 975	MJ$_{Rapeseed}$ ha^{-1} year^{-1}	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$	
	Moisture content	10,0%		1,000	MJ / MJ$_{Rapeseed, input}$						
	Co-product Straw	n/a	kg ha^{-1} year^{-1}	0,073	kg$_{Rapeseed}$/MJ$_{FAME}$						
	Energy consumption										
	Diesel	2 963	MJ ha^{-1} year^{-1}			6,07	0,00	0,00	6,07	83,40	
	Agro chemicals										
	N-fertiliser (kg N)	137,4	kg N ha^{-1} year^{-1}			9,08	0,03	0,03	18,89	259,57	
	Manure	0,0	kg N ha^{-1} year^{-1}			0,00	0,00	0,00	0,00	0,00	
	CaO-fertiliser (kg CaO)	19,0	kg CaO ha^{-1} year^{-1}			0,05	0,00	0,00	0,06	0,79	
	K_2O-fertiliser (kg K_2O)	49,5	kg K_2O ha^{-1} year^{-1}			0,62	0,00	0,00	0,67	9,15	
	P_2O_5-fertiliser (kg P_2O_5)	33,7	kg P_2O_5 ha^{-1} year^{-1}			0,76	0,00	0,00	0,80	10,93	
	Pesticides	1,2	kg ha^{-1} year^{-1}			0,28	0,00	0,00	0,32	4,33	
	Seeding material										
	Seeds- rapeseed	6	kg ha^{-1} year^{-1}			0,06	0,00	0,00	0,10	1,41	
	Field N_2O emissions	3,10	kg ha^{-1} year^{-1}			0,00	0,00	0,07	21,46	294,99	
	Field N_2O emissions can be calculated in the sheet				Total	16,92	0,03	0,10	48,35	580	
	N2O emissions IPCC										
					Result	g $CO_{2,eq}$ / MJ$_{FAME}$			0,00		

- **Step 2** : In the result section at the top of the pathway, the value in cell E7 shall be put to "individual result from a previous calculation" using the dropdown list. The line becomes orange-coloured.

	Production of FAME from Rapeseed (steam from natural gas boiler)						
3	Overview Results						
4	*All results in*	Non- allocated	Allocation	Allocated	Total	Actual/	Default values
5	*g $CO_{2,eq}$ / MJ $_{FAME}$*	results	factor	results		Default	RED Annex V.D
6	Cultivation e_{ec}				28,7	A	29
7	Cultivation of rapeseed	48,35	58,6%	28,33	Individual result of previous calculation		28,51
8	Rapeseed drying	0,72	58,6%	0,42			0,42
9	Processing e_p				Individual result of previc / Combined result of previ	A	22
10	Extraction of oil	6,50	58,6%	3,81			3,82
11	Refining of vegetable oil	1,06	95,7%	1,01			17,88
12	Esterification	17,51	95,7%	16,75			
13	Transport e_{td}				1,4	A	1
14	Transport of rapeseed	0,30	58,6%	0,17			0,17
15	Transport of FAME to dep	0,47	100,0%	0,47			0,82
16	Transport to filling station	0,80	100,0%	0,80			0,44
17	Land use change e_l	0,0	58,6%	0,0	0,0		0
18	Bonus or e_{sca}	0,0	100,0%	0,0	0,0		0
19	e_{ccr} + e_{ccs}	0,0	100,0%	0,0	0,0		0
20	Totals	75,7			51,7		52

Step by step example : for one value including multiple steps

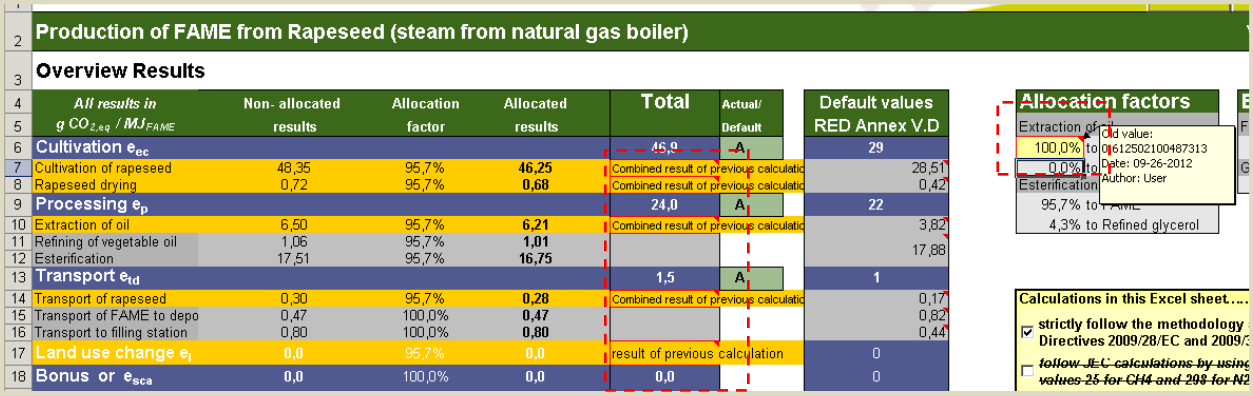
This example explains how to use the result from an individual calculation for all the emissions that occurred from "land use change" and "cultivation of rapeseed" step until the "Extraction of oil" step (also included), in the FAME from rapeseed pathway. The unit of the result provided is in g $CO_{2,eq}$ per kg of oil. This could happen in practice to a company which refines vegetable oil in order to produce a biodiesel. For that, the following steps must be performed. In this example, also land use change was included in the previous calculation (see second figure below). (If land use change was not included in the previous calculation then the result line for land use change shall not be made orange in step 2 below).

- **Step 1:** The value must be put into the result in column N for the step "Extraction of oil" (i.e. cell N87), since it is the last step in the combined result.

			Quantity of product	Calculated emissions				Info
71	Yield			Emissions per MJ FAME				per kg oil
72	Crude vegetable oil	0,6125 MJ$_{Oil}$ / MJ$_{Rapeseed}$	44 861 MJ$_{Oil}$ ha^{-1} year^{-1}	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$
73	Co-product Rapeseed cake	0,3875 MJ$_{Rapeseed\ cake}$ / MJ$_{Rapese}$	0,606 MJ / MJ$_{Rapeseed,\ input}$					
74			0,029 kg$_{Oil}$ / MJ$_{FAME}$					
75	Energy consumption							
76	Electricity EU mix MV	0,0118 MJ / MJ$_{Oil}$		1,47	0,00	0,00	1,57	54,01
77	Steam (from NG boiler)	0,0557 MJ / MJ$_{Oil}$						
78	NG Boiler			Emissions from NG boiler				
79	CH_4 and N_2O emissions from NG boiler			0,00	0,00	0,00	0,02	0,79
80	Natural gas input / MJ steam	1,111 MJ / MJ$_{steam}$						
81	Natural gas (4000 km, EU Mix quality)	0,062 MJ / MJ$_{Oil}$		4,08	0,01	0,00	4,38	150,56
82	Electricity input / MJ steam	0,020 MJ / MJ$_{steam}$						
83	Electricity EU mix MV	0,001 MJ / MJ$_{Oil}$		0,14	0,00	0,00	0,15	5,12
84								
85	Chemicals							
86	n-Hexane	0,0043 MJ / MJ$_{Oil}$		0,36	0,00	0,00	0,37	12,55
87				Total 6,06	0,02	0,00	6,50	1130
88								
89				Result	g $CO_{2,eq}$ / MJ$_{FAME}$		6,50	

- **Step 2:** A "0" is put into the cells with a white background colour in column N for all the previous steps that are included in the combined result : i.e. cells N44 for the "Cultivation of rapeseed", cell N55 for "Drying of rapeseed", and cell N64 for transport of rapeseed.
- **Step 3:** In the result section of the pathway, the value in cells E7, E8, E10, E14 and E17 shall be put to "combined result from a previous calculation" using the dropdown list. The lines become orange-coloured (see next figure). Land use change (e_l) as well as improved agricultural management (e_{sca}) shall be considered to be steps different from cultivation and as a result the combination of "cultivation" plus "land use change" as well as the combination "cultivation" plus "improved agricultural management" shall be considered to be multiple steps. Also for e_l and for e_{sca} it shall be indicated in row E when a "combined result from a previous calculation" has been inputted.

- **Step 4:** In this case rapeseed cake, which is a co-product, has been formed. Then, the allocation factor for this step shall be set to 100% towards the main product (rapeseed oil) and 0% to the co-product (rapeseed cake). To do so, the value "100" is put in cell J6.



Production of FAME from Rapeseed (steam from natural gas boiler)

Overview Results

All results in g $CO_{2,eq}$ / MJ_{FAME}	Non- allocated results	Allocation factor	Allocated results	Total	Actual/ Default	Default values RED Annex V.D
Cultivation e_{ec}				46,9	A	29
Cultivation of rapeseed	48,35	95,7%	**46,25**	Combined result of previous calculatio		28,51
Rapeseed drying	0,72	95,7%	**0,68**	Combined result of previous calculatio		0,42
Processing e_p				24,0	A	22
Extraction of oil	6,50	95,7%	**6,21**	Combined result of previous calculatio		3,82
Refining of vegetable oil	1,06	95,7%	**1,01**			17,88
Esterification	17,51	95,7%	**16,75**			
Transport e_{td}				1,5	A	1
Transport of rapeseed	0,30	95,7%	**0,28**	Combined result of previous calculatio		0,17
Transport of FAME to depo	0,47	100,0%	**0,47**			0,82
Transport to filling station	0,80	100,0%	**0,80**			0,44
Land use change e_l	0,0	95,7%	0,0	result of previous calculation		0
Bonus or e_{sca}	0,0	100,0%	0,0	0,0		0

4.3 Calculating a partial result for two or more combined steps

A user further downstream the biofuel production pathway is allowed to enter into the BioGrace Excel tool the result of a previous and partial GHG calculation (see also the previous paragraph 4.2). The current paragraph explains how such partial results can be taken from the BioGrace Excel tool when a combined result is needed from more than one step. This needs attention as in the info boxes in column N of the BioGrace Excel tool, only results are given per step. The tool does not give combined results for multiple steps in column N. Results for single steps can simply be taken from column N.

There are two possibilities to calculate the result of a partial GHG calculation for combined steps:

1. In case - for all steps to be combined into one result - the results in column N of BioGrace are given in the same unit , the combined result can simple be calculated as the sum of the individual results (see example 1 below)

2. In other cases the results as expressed in g $CO_{2,eq}/MJ_{biofuel}$ must be combined, and then the conversion into the new unit ($CO_{2,eq}$ per kg of feedstock or g $CO_{2,eq}$ per kg of raw vegetable oil) must be made using this combined result. This is further explained in example 2 below.

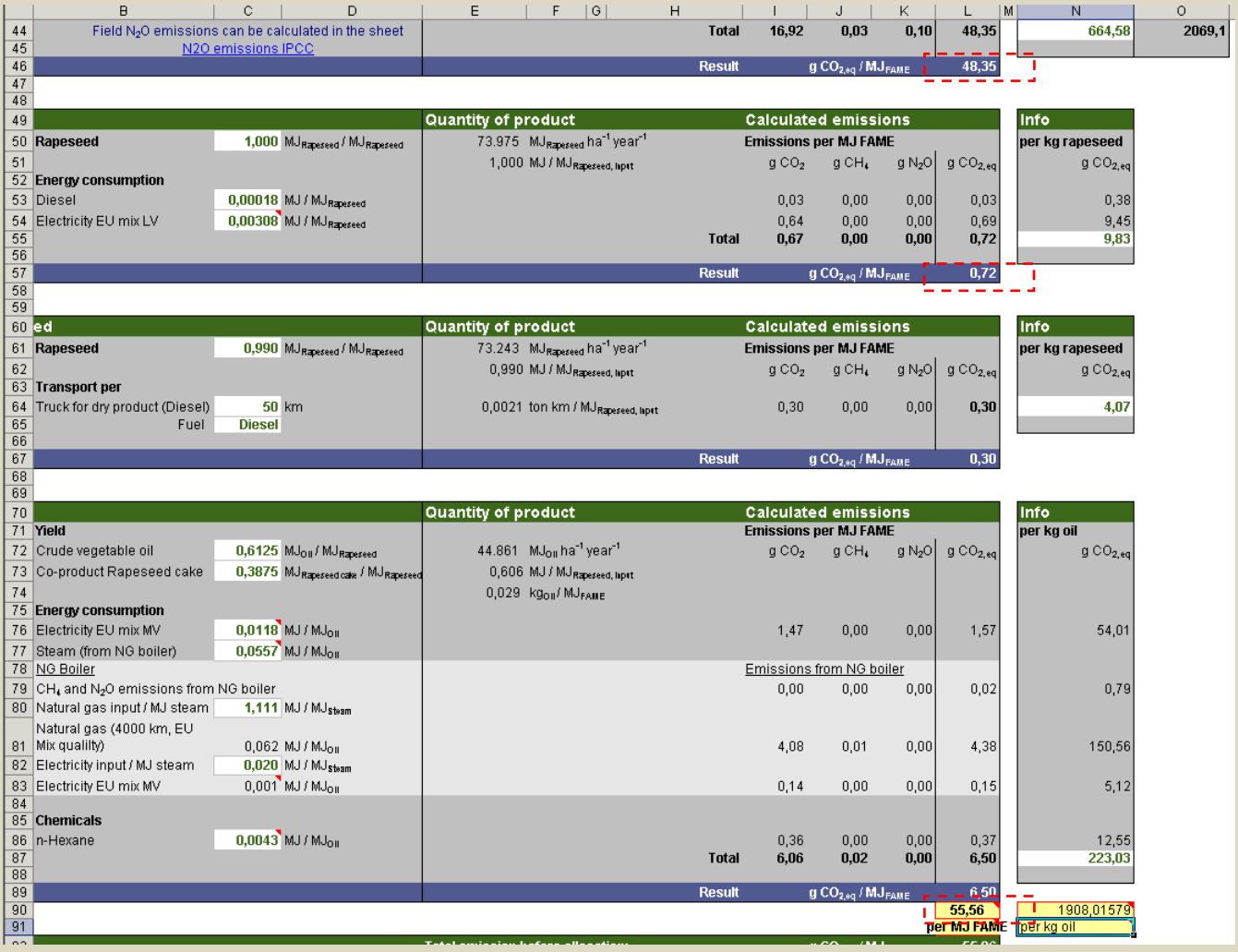
Examples

This example uses the FAME from rapeseed pathway. In this pathway, there are four steps that can be combined into one result for a combined partial calculation: (1) cultivation of rapeseed, (2) rapeseed drying, (3) transport of rapeseed and (4) extraction of oil. The results in the info boxes in column N are given in the unit "g $CO_{2,eq}/kg_{rapeseed}$" for the cultivation, drying and transport, and in "g $CO_{2,eq}/kg_{oil}$" for the extraction.

- **Example 1:** If a combined partial result of the cultivation, drying and transport is to be calculated, this can simply be done by adding the three results expressed in "g $CO_{2,eq}/kg_{rapeseed}$". This is shown below, the value calculated (which is shown with yellow background and red frame) is calculated by adding the three numbers in rows 44, 55 and 64.

40	**Seeding material**												
41	Seeds- rapeseed	6	kg ha^{-1} year^{-1}			0,06	0,00	0,00	0,10		1,41	4,4
42												
43	**Field N_2O emissions**	3,10	kg ha^{-1} year^{-1}			0,00	0,00	0,07	21,46		294,99	918,4
44	Field N_2O emissions can be calculated in the sheet				**Total**	**16,92**	**0,03**	**0,10**	**48,35**		664,58	**2069,1**
45	N2O emissions IPCC											
46					**Result**		**g $CO_{2,eq}$ / MJ_{FAME}**		**48,35**			
47												
48												
49				**Quantity of product**		**Calculated emissions**				**Info**		
50	**Rapeseed**	1,000	$MJ_{Rapeseed}$ / $MJ_{Rapeseed}$	73.975 $MJ_{Rapeseed}$ ha^{-1} year^{-1}		**Emissions per MJ FAME**				**per kg rapeseed**		
51				1,000 MJ / $MJ_{Rapeseed, input}$		g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$		
52	**Energy consumption**											
53	Diesel	0,00018	MJ / $MJ_{Rapeseed}$			0,03	0,00	0,00	0,03		0,38	
54	Electricity EU mix LV	0,00308	MJ / $MJ_{Rapeseed}$			0,64	0,00	0,00	0,69		9,45	
55					**Total**	**0,67**	**0,00**	**0,00**	**0,72**		9,83	
56												
57					**Result**		**g $CO_{2,eq}$ / MJ_{FAME}**		**0,72**			
58												
59												
60	**ed**			**Quantity of product**		**Calculated emissions**				**Info**		
61	**Rapeseed**	0,990	$MJ_{Rapeseed}$ / $MJ_{Rapeseed}$	73.243 $MJ_{Rapeseed}$ ha^{-1} year^{-1}		**Emissions per MJ FAME**				**per kg rapeseed**		
62				0,990 MJ / $MJ_{Rapeseed, input}$		g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$		
63	**Transport per**											
64	Truck for dry product (Diesel)	50	km	0,0021 ton km / $MJ_{Rapeseed, input}$		0,30	0,00	0,00	**0,30**		4,07	678,48
65	Fuel	Diesel										
66												
67					**Result**		**g $CO_{2,eq}$ / MJ_{FAME}**		**0,30**			
68												

- **Example 2:** (figure below) If a combined partial result of the cultivation, drying and extraction is to be calculated



	B	C	D	E	F	G	H	I	J	K	L	M	N	O
44	Field N_2O emissions can be calculated in the sheet						**Total**	**16,92**	**0,03**	**0,10**	**48,35**		664,58	**2069,1**
45	N2O emissions IPCC													
46							**Result**		**g $CO_{2,eq}$ / MJ_{FAME}**		**48,35**			
47														
48														
49				**Quantity of product**				**Calculated emissions**					**Info**	
50	**Rapeseed**	1,000	$MJ_{Rapeseed}$ / $MJ_{Rapeseed}$	73.975 $MJ_{Rapeseed}$ ha^{-1} year^{-1}				**Emissions per MJ FAME**					**per kg rapeseed**	
51				1,000 MJ / $MJ_{Rapeseed, lhprt}$				g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$		g $CO_{2,eq}$	
52	**Energy consumption**													
53	Diesel	0,00018	MJ / $MJ_{Rapeseed}$					0,03	0,00	0,00	0,03		0,38	
54	Electricity EU mix LV	0,00308	MJ / $MJ_{Rapeseed}$					0,64	0,00	0,00	0,69		9,45	
55							**Total**	**0,67**	**0,00**	**0,00**	**0,72**		9,83	
56														
57							**Result**		**g $CO_{2,eq}$ / MJ_{FAME}**		**0,72**			
58														
59														
60	**ed**			**Quantity of product**				**Calculated emissions**					**Info**	
61	**Rapeseed**	0,990	$MJ_{Rapeseed}$ / $MJ_{Rapeseed}$	73.243 $MJ_{Rapeseed}$ ha^{-1} year^{-1}				**Emissions per MJ FAME**					**per kg rapeseed**	
62				0,990 MJ / $MJ_{Rapeseed, lhprt}$				g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$		g $CO_{2,eq}$	
63	**Transport per**													
64	Truck for dry product (Diesel)	50	km	0,0021 ton km / $MJ_{Rapeseed, lhprt}$				0,30	0,00	0,00	**0,30**		4,07	
65	Fuel	Diesel												
66														
67							**Result**		**g $CO_{2,eq}$ / MJ_{FAME}**		**0,30**			
68														
69														
70				**Quantity of product**				**Calculated emissions**					**Info**	
71	**Yield**							**Emissions per MJ FAME**					**per kg oil**	
72	Crude vegetable oil	0,6125	MJ_{Oil} / $MJ_{Rapeseed}$	44.861 MJ_{Oil} ha^{-1} year^{-1}				g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$		g $CO_{2,eq}$	
73	Co-product Rapeseed cake	0,3875	$MJ_{Rapeseed\ cake}$ / $MJ_{Rapeseed}$	0,606 MJ / $MJ_{Rapeseed, lhprt}$										
74				0,029 kg_{Oil} / MJ_{FAME}										
75	**Energy consumption**													
76	Electricity EU mix MV	0,0118	MJ / MJ_{Oil}					1,47	0,00	0,00	1,57		54,01	
77	Steam (from NG boiler)	0,0557	MJ / MJ_{Oil}											
78	NG Boiler							Emissions from NG boiler						
79	CH_4 and N_2O emissions from NG boiler							0,00	0,00	0,00	0,02		0,79	
80	Natural gas input / MJ steam	1,111	MJ / MJ_{steam}											
81	Natural gas (4000 km, EU Mix quality)	0,062	MJ / MJ_{Oil}					4,08	0,01	0,00	4,38		150,56	
82	Electricity input / MJ steam	0,020	MJ / MJ_{steam}											
83	Electricity EU mix MV	0,001	MJ / MJ_{Oil}					0,14	0,00	0,00	0,15		5,12	
84														
85	**Chemicals**													
86	n-Hexane	0,0043	MJ / MJ_{Oil}					0,36	0,00	0,00	0,37		12,55	
87							**Total**	**6,06**	**0,02**	**0,00**	**6,50**		223,03	
88														
89							**Result**		**g $CO_{2,eq}$ / MJ_{FAME}**		**6,50**			
90											**55,56**		1908,01579	
91											**per MJ FAME**		per kg oil	

(transport is left out, so that disaggregated default values can be used later for transport), then the results in g $CO_{2,eq}/MJ_{FAME}$ must be added to give the result in cell L90. This value must then be converted into "g $CO_{2,eq}/kg_{oil}$" in the same way as the value in cell L85 is converted into the result in cell N85. The result in cell N90 combines the result for cultivation, drying and extraction and is expressed in "g $CO_{2,eq}/kg_{oil}$".

4.4 Use of the sheet "user specific calculations"

Modifications made on the sheet "user specific calculations" will not be tracked with "track changes" as all inputs into this sheet are per definition from the user. As a result, an auditor verifying an actual calculation shall always verify the data and calculations on the sheet "user specific calculations".

Calculations made on this sheet shall be company/user specific meaning that it is not allowed to make more general calculations with the intention that some companies/users using this sheet will use this more general calculation, and others will not not use the results of the calculation although the calculation itself is part of the sheet "user specific calculations".

The outcome of calculations made on this sheet shall be intermediate results that serve as input values in other BioGrace GHG calculation sheets (the sheets with the calculations on the biofuel production pathways), as explained in paragraph 4.1 above and paragraphs 4.5, 4.6, 4.7 and chapter 5 below. This means for instance that it is not allowed to calculate final results (expressed in g $CO_{2,eq}/MJ_{biofuel}$) with the sheet "user specific calculations". It is also not allowed to use the sheet "user specific calculations" to calculate "results from previous and partial GHG calculations" (expressed in g $CO_{2,eq}$ per kg of feedstock or in g $CO_{2,eq}$ per kg of raw vegetable oil) to be entered in column N of other BioGrace GHG calculation sheets (as explained in paragraph 4.2).

Examples of company/user specific calculations for which this sheet is intended, are:

- An agricultural cooperation, receiving feedstocks from multiple individual farmers, calculates average yields and fertiliser and diesel inputs, that are used in the pathway "Production of FAME from rapeseed" to make the actual GHG calculation for cultivation. Of course, the calculations on the sheet "User specific calculations" shall respect the calculation rules on average, aggregated or measured values in chapter 3 of the BioGrace-I calculation rules.

- An owner of a palm oil mill captures part of the methane emissions from the POME, but has to take into account that another part of the POME is stored in open ponds leading to CH_4 emissions. In the sheet "user specific calculations" the average POME CH_4 emissions are calculated, which are then entered in the pathway "Production of FAME from Oil Palm" to make the actual GHG calculation.

- An owner of an ethanol production plant (from sugar beet) has to calculate how much electricity and natural gas has to be assigned to the ethanol production process, because the ethanol plant is integrated with a sugar producing plant and electricity and natural gas use is measured at a number of places at the industrial site, but none of this measurements has a 1:1 relation with the ethanol plant. This calculation, based on the readings of the electricity and natural gas use over a year, can be made in the sheet "user specific calculations". The results (the amount of electricity and natural gas used for ethanol production) shall then be entered into the pathway "Production of ethanol from sugar beet".

4.5 Adding specific standard values for existing input

Standard values are used to convert input numbers into greenhouse gas emissions. The tool applied the same standard values as the European Commission has used for calculating the RED Annex V default values. However, users can define their own standard values and use them in the tool. This part gives a step by step example for modifying one of the pre-defined standard values.

In order to do so, the dedicated excel sheet named "user defined standard values" shall be used as the excel sheet "standard values" is protected and cannot be changed.

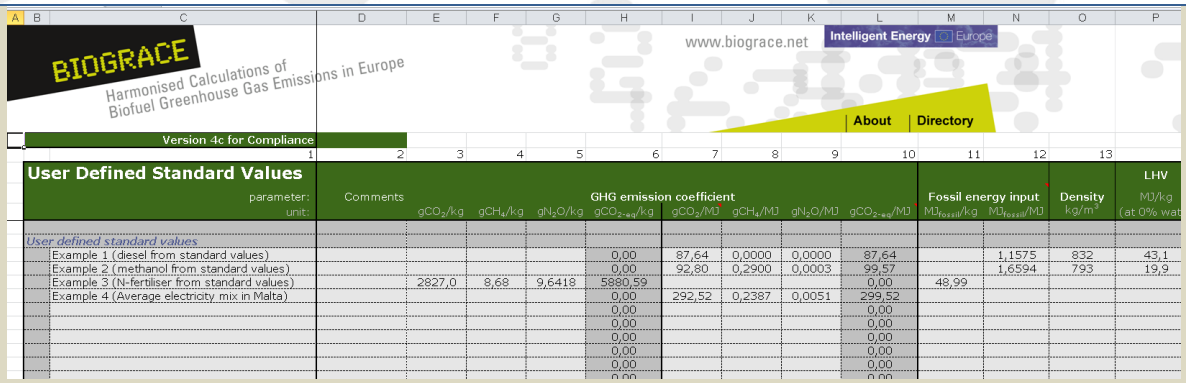
Adding new standard value requires applying the following principles:

- The name given to the added input in the "user defined standard value" shall be different from all the existing names of column C of the "standard value" sheet;
- The name of the standard value, once defined, has to be written exactly in the same way in calculation sheets where it is used;
- The formulas in columns I, J and K of the calculation sheet have to be checked. For instance, the column position of the LOOKUP function must to be modified to be coherent with the given unit of the new standard value;
- Sources of the data shall be clearly stated (see the BioGrace-I calculation rules).

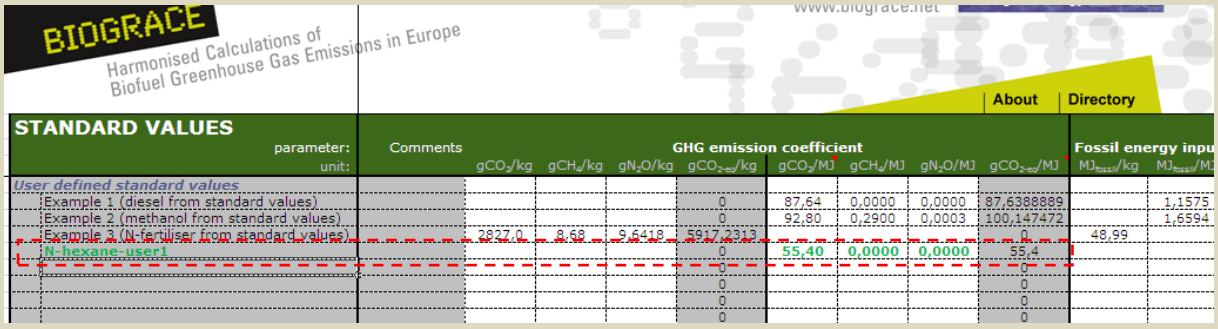
Step by step example :

The tool user wants to add a specific standard value for n-hexane instead of using the n-hexane standard value pre-defined in the tool. For that, the following steps must be performed:

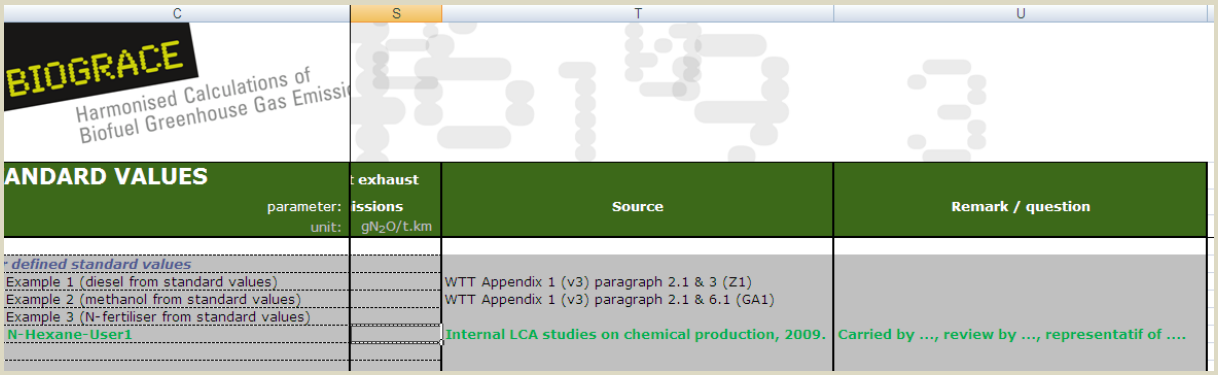
- **Step 1** : first, get to the "User defined standard value" sheet. This sheet is framed exactly the same as the "Standard value" sheet.



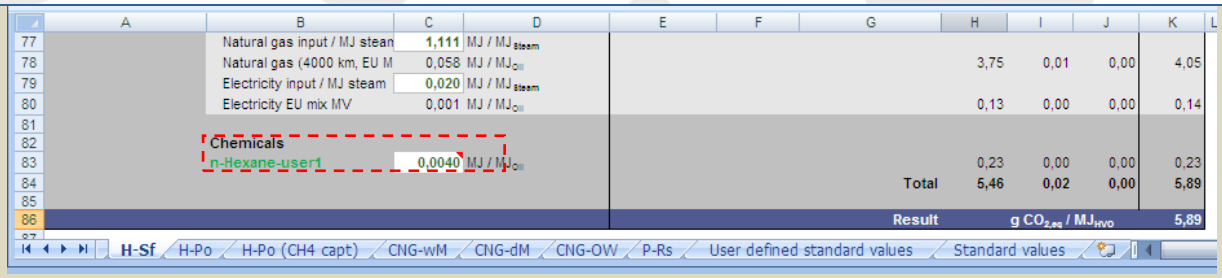
- **Step 2** : Write the name in the first available free line of the standard value in column B ("n-hexane-user1"). Make sure that the given name is different from any other of your added values and of the "Standard values" sheet.
- **Step 3** : Add your own values in the columns with the appropriate unit (from column E to S). If you have a unique value in g $CO_{2, eq}$ (and not in CO_2, CH_4, N_2O), then fill out the first column in g CO_2 as the columns H and L, with unit "g $CO_{2,eq}$" is calculated automatically and cannot be changed. Please, note that you also have to add "0" value to the two other column (for CH_4 and N_2O) the other cells to avoid error messages in pathway calculation.



- **Step 4** : Then, you need to fill in the column T and U with detailed information on the sources of these data (name of the sources in column T, and remarks and details in column U), like in the example below.



- **Step 5** : Go to the pathway where you want to use this modified standard value. Modify the name of the n-hexane input called in column B into "n-hexane-user1". Please note that the name must be exactly written in the same way as in the "user defined standard value" sheet. Modify the quantity if needed in column C of the same line.



- **Step 6** : Check and eventually modify the formulas in column I, J and K if they are not are calling the right columns. This could be the case if the unit of your modified standard value is not the same as the unit of the pre-defined standard value of the same product. For instance, the existing n-hexane standard value is given per MJ. If you want to enter GHG data per kg for n-hexane-user1, then you need to change the formula in the pathway calculation, in column I, J and K of the line where you have added "n-hexane_user1". For that, follow the example below (the column position to change are shown in yellow):

Initial formula in cell H83 of the previous picture =$C83*$E$70*VLOOKUP($B83;'Standard values'!$C$9:$S$160;7; FALSE)/$E$184

New formula in cell H83 =$C83*$E$70*VLOOKUP($B83;'Standard values'!$C$9:$S$160;3; FALSE)/$E$184

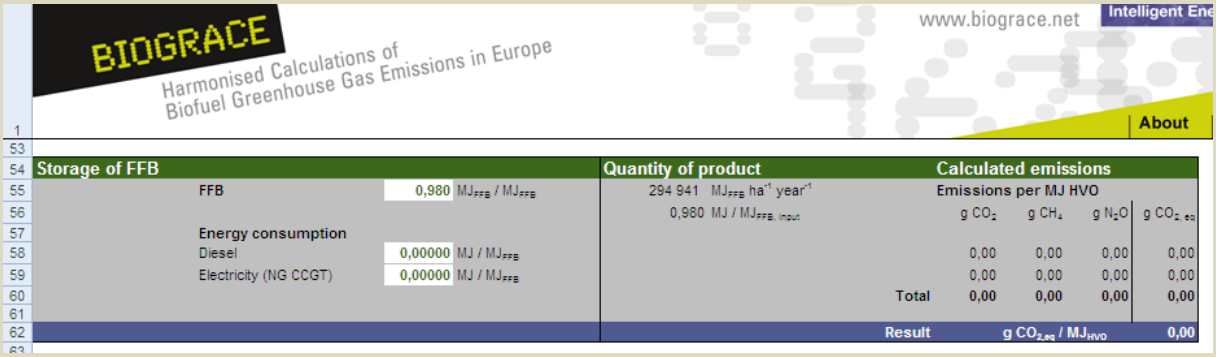
The numbers "7" and "3" refer to the columns where the values are taken from. These column numbers are listed in row 3 of both the sheet "Standard values" and the sheet "User defined standard values".

4.6 Adding an input in a pathway

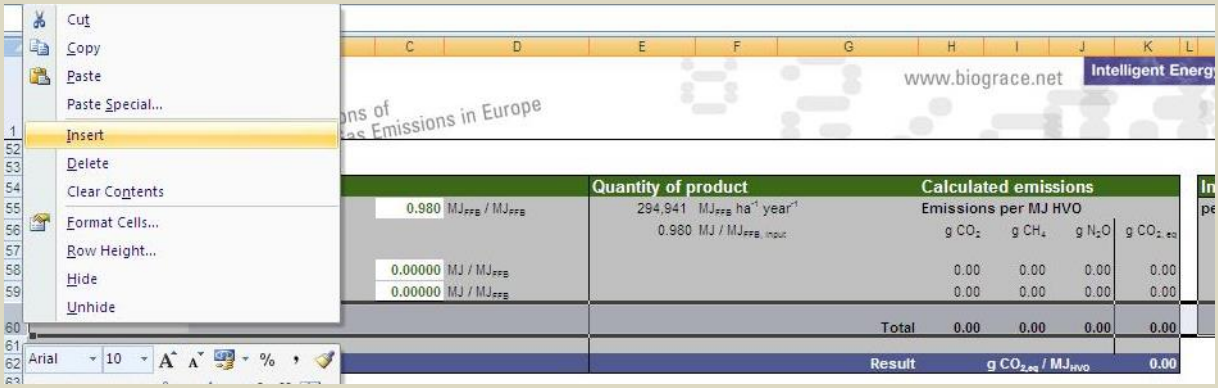
Step by step example :

The tool user wants to add a new input in one of the pathways. For that, the following steps must be performed:

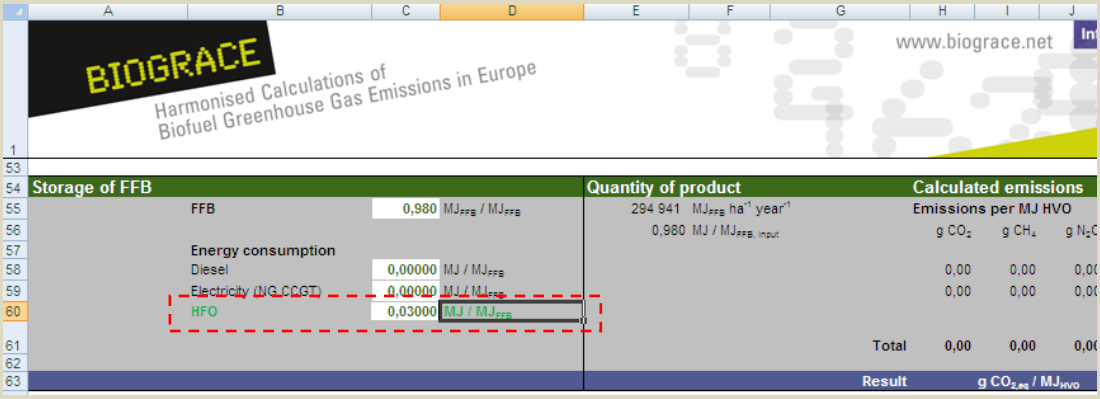
- **Step 1** : First, in the pathway you are working on, get to the module where you want to add a input.



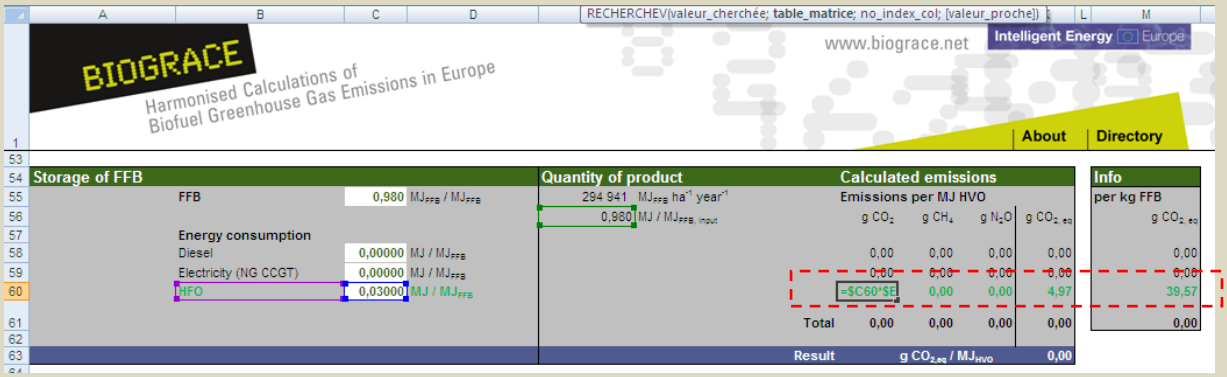
- **Step 2** : Insert a new line with the function "insert" of Excel (right click).



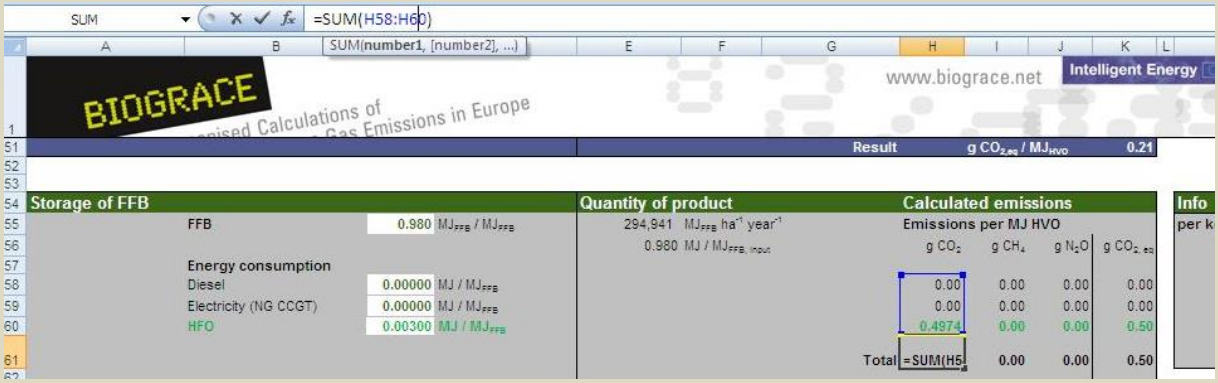
- **Step 3 :** Fill in the line with the name of the input (column B), the unit use (column D), and the quantity used (column C). Please check that the name of the added input is the same than in the table of the "standard value" sheet. Also verify that you use the same unit than existing input.



- **Step 4** : On the same line, add the calculation formulas in columns I, J and K according to the unit in which the GHG emission coefficients are expressed (per kg or per MJ). Formula can be copy paste from existing input. When formula written or copied, please check that the proper cells have been used in the formula and that units are consistent. The same work can be carry out in column N if this "info" column exists for this module.



- **Step 5** : Check that the "Total" line is correctly taking into account the added input. For that, the sum in column I to L must include the added line.



4.7 Adding a new input in a pathway

Adding a new input that does not yet exist in the BioGrace Excel tool can be done by using the two previous step-by-step tutorials. You will first have to add a new standard value in the "User defined standard value", then insert your new input in the biofuel-pathway you are working on.

5 Function 3 : Creating a new pathway

The BioGrace Excel tool can also be used to set up new biofuel production chains. This requires some knowledge of Excel and a detailed observation of how calculations are made.

The present part cannot provide a comprehensive description of the process. However, a short tutorial is provided below to highlight major steps:

- **Step 1:** Copy an existing pathway and rename it.
- **Step 2:** Erase all data in the white cells of column C. Erase the names of inputs and outputs in column B when necessary. Be sure to keep the result overview box at the top of your pathway, and the 3 last generic modules (LUC, Improved Management Practices, CO_2 storage or replacement).
- **Step 3:** the most important part is to define the frame of the new pathway, meaning the number of steps (cultivation of agricultural matter, drying, transport, industrial steps, etc.), the allocations when needed, etc. This frame is to be translated in independent modules.
- To add up new lines, please use the “insert line” function by right clicking on the appropriate line. Beware of adding allocation modules right after the separation step of the co-products.
- **Step 4:** Fill in the new frame with appropriate inputs and outputs into column B, with the associated input numbers in column C. The tool user needs to pay particular attention to the units in which the input numbers are expressed. The unit in column D has to be compatible with the units of the standard value in the “standard value” sheet.
- **Step 5:** Add new user defined standard values if needed (for more detail, please refer to "adding new standard value" part in the previous section "Adapting pathways").
- **Step 6 :** Adapt the formulas of the column I to L when needed (see "adding a new input" part in previous section "Adapting pathways" for more detail).
- **Step 7:** Add, if necessary, comments or intermediate calculations in columns E to G.
- **Step 8:** Adapt all the summing cells from allocation module and total module.
- **Step 9:** Adapt the overview results box to your new pathway by inserting lines and linking cells to each name and results obtained.

6 Technical detail on specific issues

6.1 How to use the LUC sheet?

Land Use Changes (LUC) are to be taken into account in the GHG calculation of your product. A LUC occurs when the biofuel cultivation has a different carbon stock per hectare than a reference situation (e.g. conversion of non-highly biodiverse grassland land into cropland). The RED methodology and the "Commission Decision of 10 June 2010 on guidelines for the calculation of land use carbon stocks for the purpose of Annex V of Directive 2009/28/EC" give precise instructions on when and how to take these carbon changes into account.

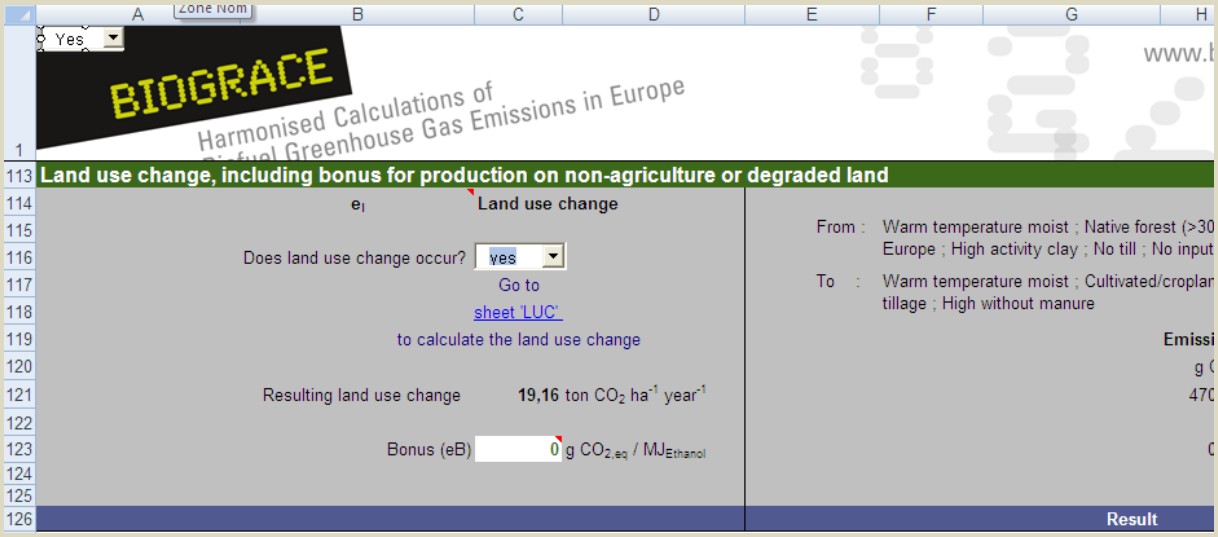
A dedicated module is available in the BioGrace Excel tool at the bottom of each pathway. It will collect the emissions caused by carbon stock changes from the LUC sheet. Thus you will need to fill in this LUC sheet to calculate your actual changes in carbon stock. A declared LUC for a pathway will apply to the whole result of the pathway.

If you have several consignments with two different LUC values to be integrated (for instance one with no LUC, and one with a conversion from grassland to crop land), please use a separate copy of the BioGrace Excel tool to declare it. **The tool has been designed with a single LUC sheet that doesn't enable calculating simultaneously two or more GHG values with different LUC values**.

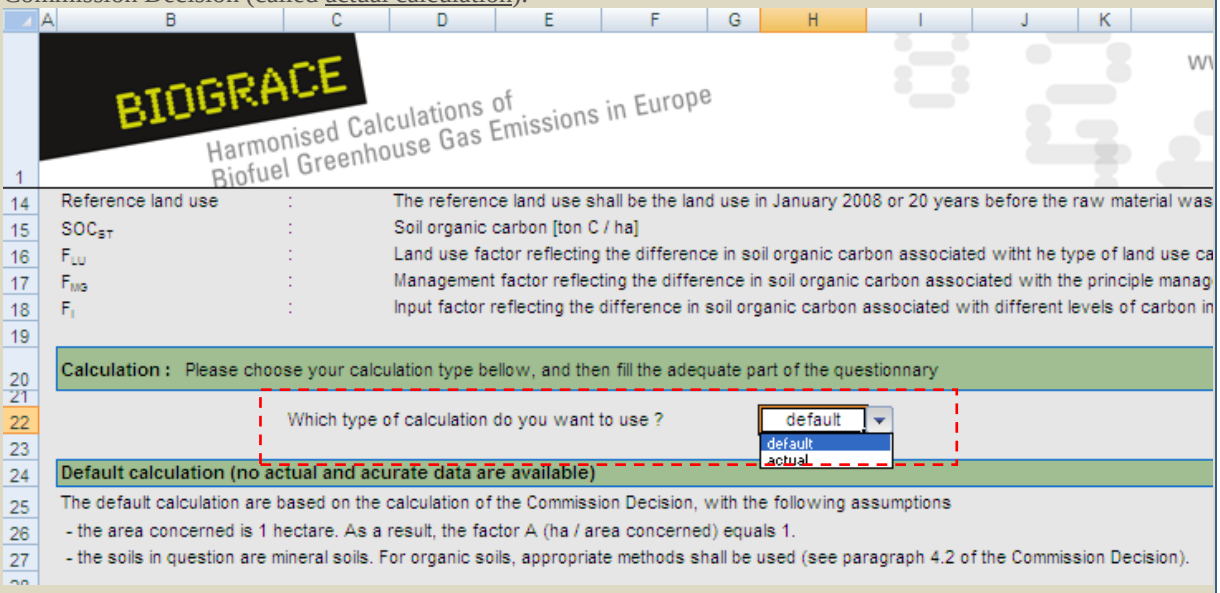
Step by step tutorial :

If you need to take into account a Land Use Change for a pathway, please apply the following steps:

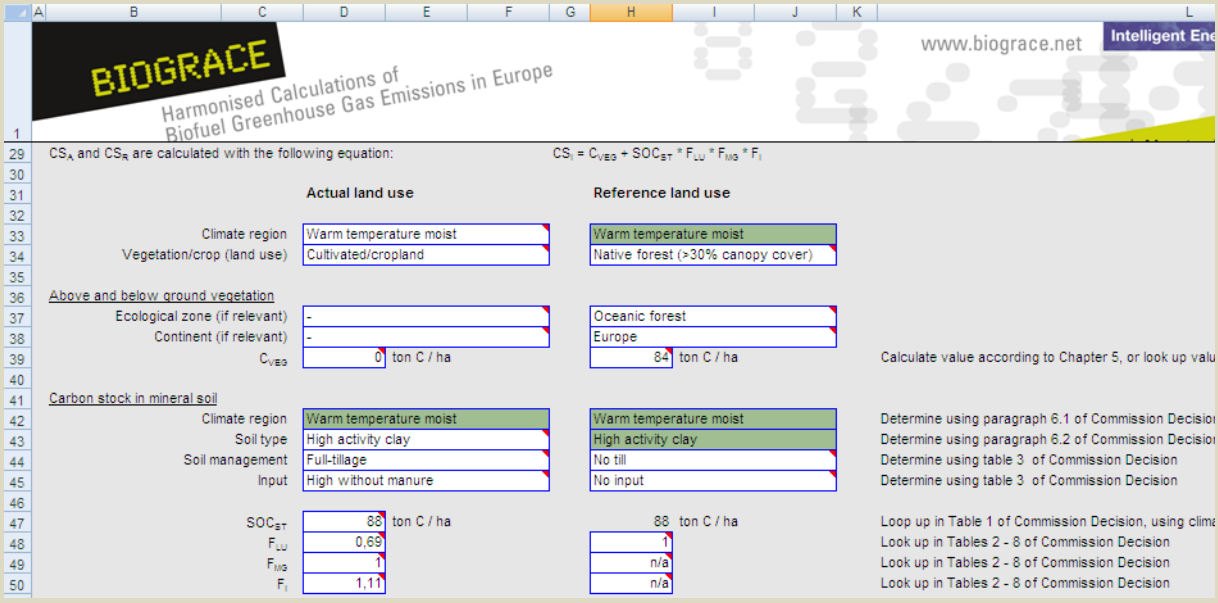
- **Step 1** : In the pathway you are studying, answer "yes" to the question "Does land use change occur?" of the LUC module. For that, use the checkbox list next to the question.
- **Step 2** : Value and text called from the LUC excel sheet then appear.



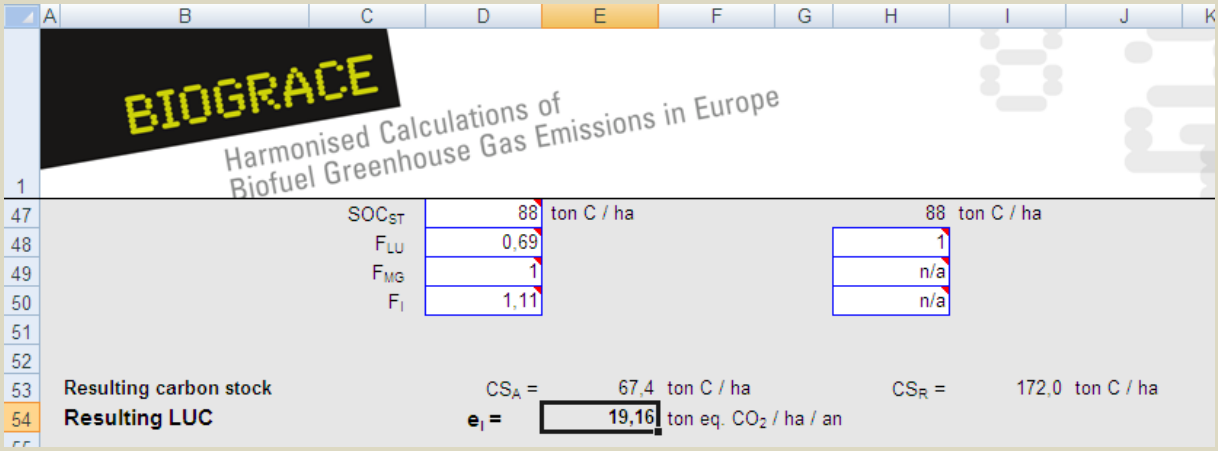
- **Step 3 :** Go to the LUC sheet. You will there find a framework for calculating the carbon stock changes from reference situation to actual utilisation. The annual GHG emissions that need to be added to your pathway will be calculated from that.
- **Step 4 :** Select the type of calculation you want to use. Two kinds of calculation are possible: one using the default values listed in de tables "Commission Decision of 10 June 2010 on guidelines for the calculation of land use carbon stocks for the purpose of Annex V of Directive 2009/28/EC", called default calculation, and a second one if you have your own value for carbon stocks calculated according to the guidelines in the same Commission Decision (called actual calculation).



- **Step 5 – Default calculation**: First, you need to have with you the "Commission Decision of 10 June 2010 on guidelines for the calculation of land use carbon stocks for the purpose of Annex V of Directive 2009/28/EC" where all formula and data are available. In the part dedicated to default calculation, fill the needed information and data in the white cells. These cells are not using a pre-defined list. You should refer to the information given in column L to find the tables from the Commission decision. Please, use the same wording than the one use in the decision of the Commission. Note that cells in light green are automatically filled from other cells. For that, begin by filling "actual land use" part. In the bellow example, the actual land use is a crop. That is why no C_{veg} is taken into account. The reference land use considered is a native forest in Europe, under an oceanic climate. No F_{MG} and F_I are needed for this type of cover.

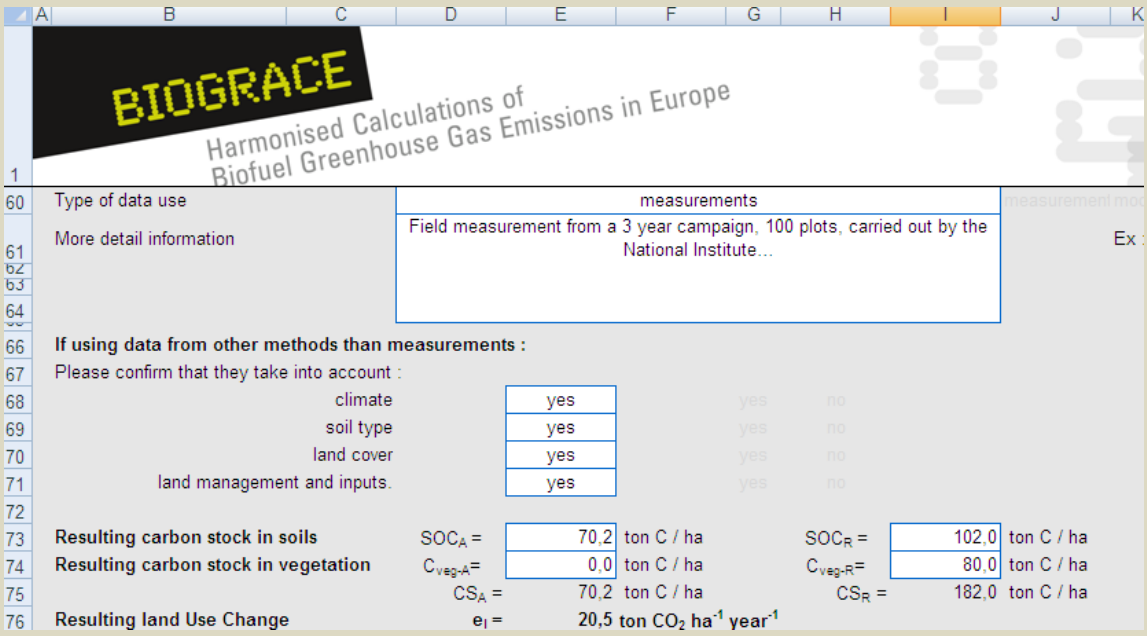


- The resulting LUC is calculated right bellow this part by applying the RED methodology. A positive value shows a carbon loss from the reference situation.



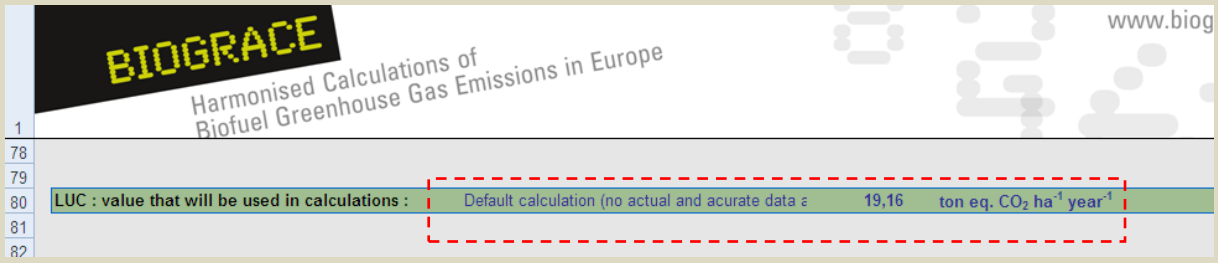
47		SOC_{ST}	88	ton C / ha	88	ton C / ha
48		F_{LU}	0,69		1	
49		F_{MG}	1		n/a	
50		F_I	1,11		n/a	
53	**Resulting carbon stock**	CS_A =	67,4	ton C / ha	CS_R =	172,0 ton C / ha
54	**Resulting LUC**	e_l =	19,16	ton eq. CO_2 / ha / an		

- **Step 5 – Actual calculation**: Fill in the white cells of the "Actual calculation" part. You should refer to the information required in column B, and to information given in column L. First, general references for your actual value shall be added in order to keep track of the source and quality of these data. In case of methods other than measurements, you shall confirm that climate, soil type, etc, are taken into account. If this is not the case, you cannot use your actual data. At last, add the actual Carbon stock in soils (SOC) and carbon contained in vegetation (CVEG) for actual and reference uses. The formula from the RED methodology is then used to get the annual carbon changes.



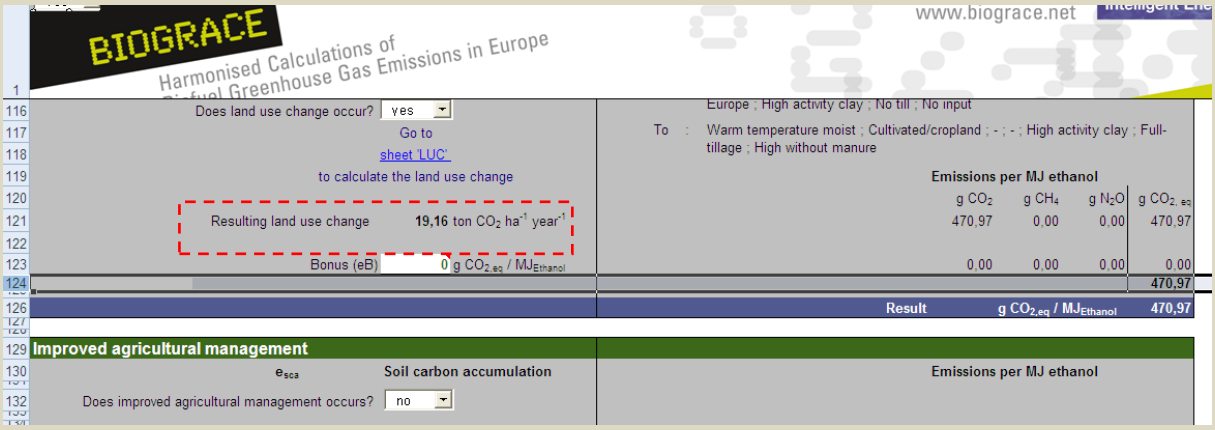
60	Type of data use		measurements			
61	More detail information		Field measurement from a 3 year campaign, 100 plots, carried out by the National Institute...			
66	**If using data from other methods than measurements :**					
67	Please confirm that they take into account :					
68		climate	yes			
69		soil type	yes			
70		land cover	yes			
71		land management and inputs.	yes			
73	**Resulting carbon stock in soils**	SOC_A =	70,2	ton C / ha	SOC_R =	102,0 ton C / ha
74	**Resulting carbon stock in vegetation**	C_{veg-A}=	0,0	ton C / ha	C_{veg-R}=	80,0 ton C / ha
75		CS_A =	70,2	ton C / ha	CS_R =	182,0 ton C / ha
76	**Resulting land Use Change**	e_l =	**20,5**	**ton CO_2 ha^{-1} $year^{-1}$**		

- **Step 6** : Check in the last line that the proper value is called. If it is not the case, get back to step 4 and choose the appropriate calculation type.



80	**LUC : value that will be used in calculations :**	Default calculation (no actual and acurate data a	19,16	ton eq. CO_2 ha^{-1} $year^{-1}$

- **Step 7** : Check in the biofuel production pathway where you need to declare a Land Use Change that the LUC value is there. Please, also check that no Improved agricultural management is declared in the module right below (See the next section for more information).



6.2 How to use the E_{sca} sheet?

The E_{sca} sheet is to be used when the user wants to claim increased carbon stock in soils because of improved agricultural practices like no tillage, increased residue incorporation, etc.

This excel sheet is built on the same model than the LUC sheet. The same steps are needed to use it. Please have a look at the LUC section to have a step-by-step tutorial.

The main difference comes from the fact that only carbon stock in soil is taken into account. Please also note that e_{sca} has a different sign than e_l : a positive e_{sca} means that carbon stocks are improving in your soil, and thus that the GHG result of the pathway shall decrease, whereas a positive e_l means carbon stock losses. This difference comes from the formula of Annex V.C of the RED, that define e_{sca} has a carbon stock accumulation from which the feedstock produced shall take some advantages.

Please note that if you have also a change in the above ground carbon stock due to a change in land use type, then you shall use the LUC sheet. **Do not use E_{sca} sheet if a land use change is also declared for the same biofuel.**

6.3 How to use the N_2O emissions IPCC sheet?

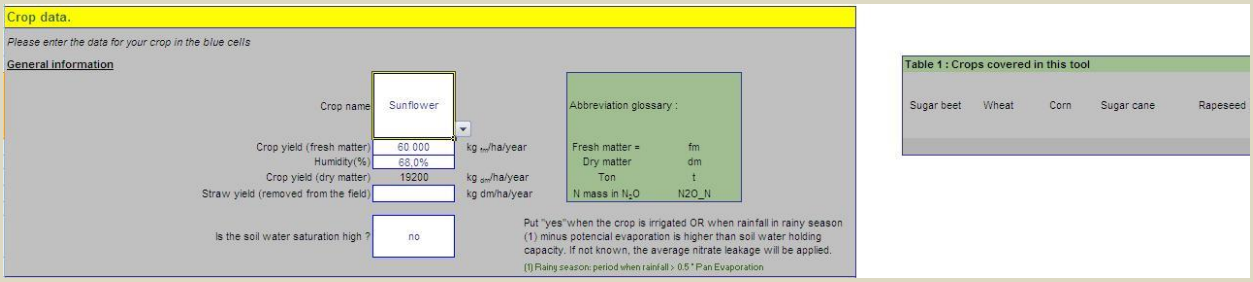
N_2O emissions are to be taken into account in the GHG calculation of your product. These emissions mainly occur during the crop production step because of soil's microorganism's activity. In each pathway, during the crop cultivation step, field N_2O emissions are to be calculated. A specific module in the sheet "N_2O emissions IPCC" is dedicated to this calculation. A short cut below the white cell to fill in leads directly to this sheet.

BioGrace Excel tool follows IPCC guidelines 2006 for N_2O emission calculation as explained in chapter 11 "N_2O emissions from managed soils and CO_2 emissions from lime and urea application" (see the "BioGrace-I calculation rules" document for specific recommendations about the use of this method). At the beginning of the "N_2O emissions IPCC" module, a short introduction presents the methodology used with the additional hypothesis used in JEC calculations that have been incorporated in the module. This module details the calculation of the three N_2O emissions sources that occur during the agricultural step: direct N_2O emissions from the field, N_2O indirect emissions due to leaching and runoff and N_2O indirect emissions due to NH_3 and NOx volatilization.

Step by step example :

For N_2O emissions calculations for a pathway, please apply the following steps:

- **Step 1**: Fill in the name of the crop and the general information about your pathway in the Crop data box. You can choose between 8 different crops.

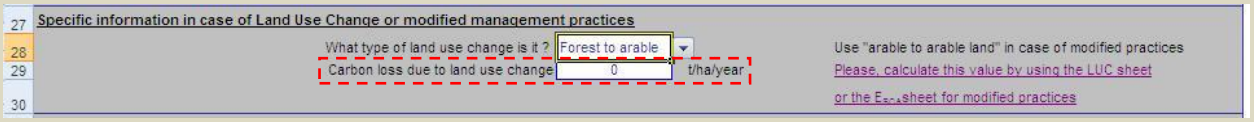


The evaluation of the soil water saturation (cell C28) is needed to calculate N_2O indirect emissions because of nitrate leaching (more details in step 5). If the user is not able to provide that information, the default value "not known" is used in cell C28. This value gives a conservative evaluation of nitrate leakage.

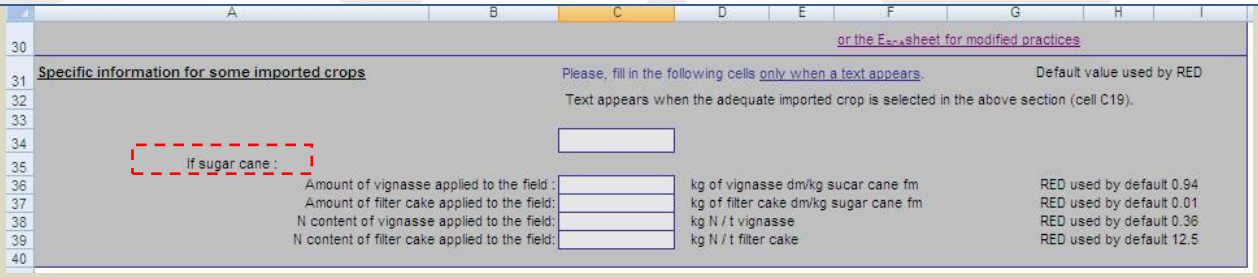
- **Step 2**: To calculate N_2O emissions for a crop that is not listed in Table 1, enter the name of the crop in Table 1 and fill in Table 4 of this module. More information on how to fill in Table 4 is available in IPCC 2006 chap 11, Table 11.2.

Table 4	N_{AG}	slope	intercept	$AG_{DM(T)}$	$(AG_{DM(T)}*1000+Crop(T))/Crop(T)$	$R_{AG(T)}$	$R_{BG-BIO(T)}$	N_{BG}	$R_{BG(T)}$	$BG_{DM(T)}$	LHV (MJ/kg)	sources
Sugar beet	0,0190	0,10	1,06	2,98	1,16	0,16	0,20	0,0140	0,23	4,44	16,30	IPCC 2006, chap 11
Wheat	0,0060	1,51	0,52	29,51	2,54	1,54	0,24	0,0090	0,61	11,69	17,00	IPCC 2006, chap 11
Corn	0,0060	1,03	0,61	20,39	2,06	1,06	0,22	0,0070	0,45	8,71	18,50	IPCC 2006, chap 11
Sugar cane				0,00	1,00	0,00			0,00	0,00	19,60	IPCC 2006, chap 11
Rapeseed	0,0110	1,50	0,00	28,80	2,50	1,50	0,19	0,0170	0,48	9,12	26,40	IPCC 2006, chap 11
Sunflower	0,0070	2,10	0,00	40,32	3,10	2,10	0,22	0,0070	0,68	13,09	26,40	IPCC 2006, chap 11
Soybeans	0,0080	0,93	1,35	19,21	2,00	1,00	0,19	0,0080	0,38	7,30	23,53	IPCC 2006, chap 11
Palm	0,0110			0,00	1,00	0,00				0,00	24,00	IPCC 2006, chap 11
New crop1												
New crop2												
New crop3												
New crop4												

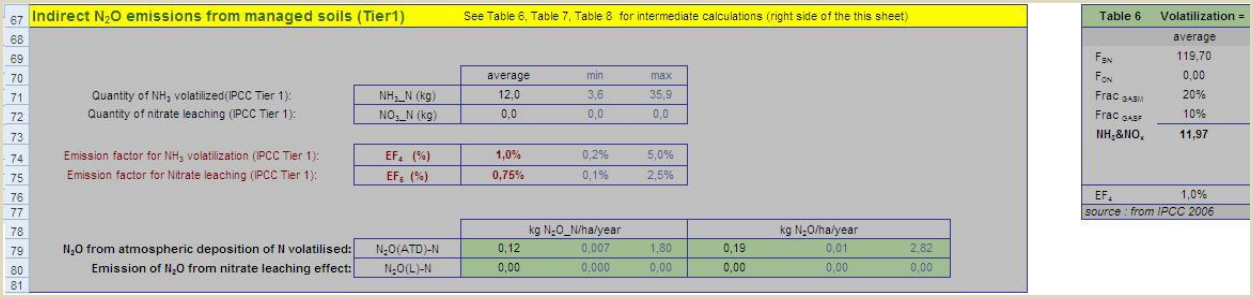
- **Step 3**: In case of Land Use Changes (LUC) or modified management practices, the "LUC" or "Esca" sheets shall be used to calculate the carbon loss and enter the value in cell C29. Go to sections 6.2 and 6.3 of this manual to know how to use these sheets. When the Esca sheet is used to calculate C losses due to change in agricultural management, please note that only when negative results are obtained, C losses are actually occurring. In this case you shall change the sign of the result and insert the obtained value in cell C29.



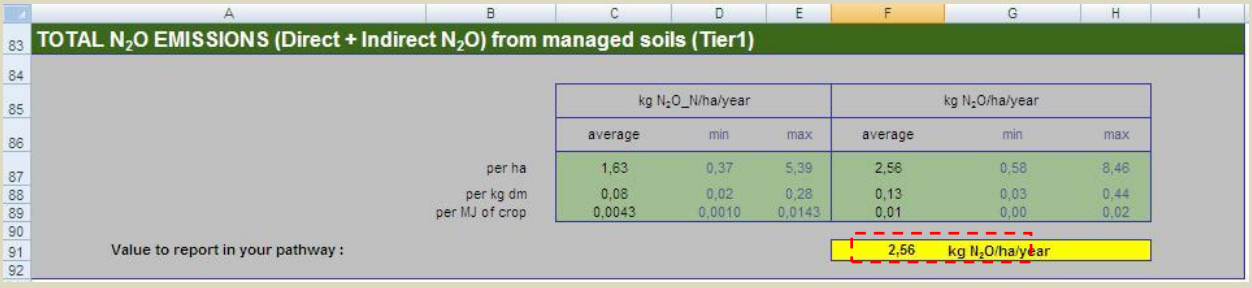
- **Step 4**: If the name of the crop selected in cell C19 is either sugar cane or palm, then further information shall be given in the third part of the Crop data box.



- **Step 4 - Calculation of direct N_2O emissions from managed soils.** Two more input data are needed for direct N_2O emissions calculations: the quantities of N synthetic fertilizer and N organic fertilizer applied. You should refer to the "BioGrace-I calculation rules" to know which fertilizer shall be taken into account. Intermediate calculations are shown in Tables 2, 3, 4 and 5 and the total of direct N_2O emissions are found at the bottom of the box.
- **Step 5 - Calculation of indirect N_2O emissions from managed soils.** Automatic calculations are made using previous input data. Intermediate calculations for N_2O indirect emissions due to NH_3 + NOx volatilisation and leaching are shown in Tables 6 and 7 (resp.).



- **Step 6:** The total N_2O emissions are given in yellow at the bottom of the sheet.



6.4 Inconsistency in use of global warming potentials

Global warming potentials (GWPs) are used to convert methane and nitrous oxide in equivalent carbon dioxide. During the project, an inconsistency was found between the GWPs used for the calculation of default values listed in Annex V.A, Annex V.B, Annex V.D and Annex V.E of RED and the GWPs prescribed in Annex V.C point 5. For this reason, two calculations are possible in the tool through the following application in each excel sheet:

Calculations in this Excel sheet.....

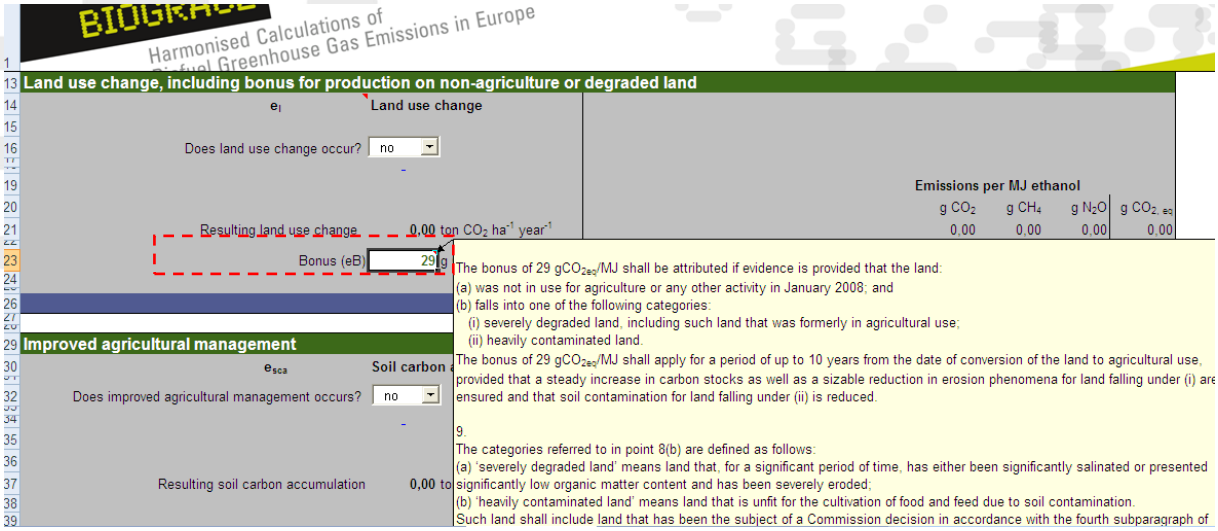
- [x] **strictly follow the methodology as given in Directives 2009/28/EC and 2009/30/EC**
- [ ] ~~***follow JEC calculations by using GWP values 25 for CH4 and 298 for N2O***~~

As explained in "About" under "Inconsistent use of GWP's"

6.5 Declaring the 29g Bonus

If you are carrying out your own calculation and that your land enters into one of the two categories of land described in point 8, part C, of annex V of the RED, you can add an extra bonus of 29 g CO_2/MJ to your pathway. This can only be done from the moment that the European Commission has defined degraded land and heavily contaminated land.

Within the BioGrace Excel tool, this bonus has to be added in the Land Use Change module, as shown in the picture bellow.



7 History and ownership of the BioGrace GHG calculation tool

7.1 History of the RED calculations

7.1.1 A need for GHG reduction guaranty

For calculation of the default values LBST (Ludwig Bölkow System Technik) and JEC consortium (JRC, EUCAR and CONCAWE) have - on request – delivered input to the European Commission. The European Commission has made the final calculations into the default values, which are presented in the RED Annex V.

As defined in article 17 of the RED, biofuels and bioliquids can be taken into account for the following purposes only if they fulfil criteria of greenhouse gas emission reductions:

- Measuring compliance with the requirements of the Directive 2009/28/EC concerning national targets,
- Measuring compliance with renewable energy obligations,
- Eligibility for financial support for the consumption of biofuels and bioliquids.

Thus, the economic operators have to provide data regarding the GHG performance of their biofuels and bioliquids[7], following the appropriate methodology. Default values defined in Annex V.A, Annex V.B, Annex V.D and Annex V.E of the RED may be used by economic operators under precise conditions (raw materials cultivated outside the Community, raw materials cultivated in the Community in areas where the typical value for raw material cultivation is expected to be lower than the corresponding disaggregated default value in Annex V.D and raw materials that are waste or residues other than agricultural, aquaculture and fisheries residues).

7.1.2 How were the default and typical value calculations developed?

The default value and typical value calculations were performed in a collaboration project with the JEC consortium (Joint Research Centre, EUCAR and CONCAWE) and LBST. The results of their calculations were used as inputs by the European Commission to be published in Annex V of RED and Annex IV of FQD. LBST developed its own model software (“E3database Software”) and underlying databases used to perform the calculations.

The input data come from several studies. The standard values were calculated as part of the E3database, taking into account all inputs and emissions from the provision of the input. The Well-to-Wheel reports from the JEC consortium give detailed information on how these standard values were calculated.

[7] Article 18 of the RED.

However, in some cases small inconsistencies exist between the values in the WtW reports and the values in the E3database. The BioGrace standard values are directly taken from E3database.

7.2 History of the tool and BioGrace project

The project BioGrace aims to harmonise calculations of biofuel greenhouse gas (GHG) emissions and thus supports the implementation of the EU Renewable Energy Directive (2009/28/EC) and the EU Fuel Quality Directive (2009/30/EC) into national laws.

This project contributes to the publication of a uniform and transparent list of standard conversion values for GHG calculations, and to the elaboration of Excel files as well as user-friendly GHG calculators for economic operators, auditors, and advisors to perform the GHG calculation step by step on their own. These Excel files address the 22 most important biofuel production pathways cited in both directives.

The project results are disseminated to European stakeholders through a website, meetings, and a series of workshops. National policy makers are asked to make reference to the list of standard conversion values in their national legislation.

This tool is a result of the first step of the project, whose objective was to make the calculations that lead to the 22 default values in the Renewable Energy Directive and the Fuel Quality Directive transparent. The elaboration of this tool was performed and commented by the partners: IFEU, ADEME, ANL, BE2020, BIO IS, CIEMAT, EXERGIA and STEM respectively.

7.3 BioGrace as a recognised voluntary scheme

The BioGrace GHG calculation tool has been recognised by the European Commission as a voluntary scheme for biofuels. The tool has been prepared by the partners of the BioGrace-I project (for more information see www.biograce.net). Since the end of this project, the companies Agency NL, IFEU and BIO IS form the consortium (and are the legal entities) being responsible for keeping the BioGrace GHG calculation tool up-to-date. This consortium can be contacted through Agency NL, for contact details see the website www.biograce.net.

8 Glossary

To use the tool, several terms have to be clearly defined. Some of these definitions are based on the directive 2009/28/EC.

Standard value: data needed to convert input numbers (given in kg, kWh, etc) into GHG emissions. Examples are Lower Heating Values and values to convert 1 kg N-fertiliser or 1 MJ of natural gas into CO_2, CH_4 and N_2O emissions. They are sometime also called "conversion factors".

Default values: default values are the GHG emissions per MJ of biofuel given in the tables part D of Annex V of the Renewable Energy Directive (see RED bellow). There are step by step default values and one global value for the whole pathway. They are derived from the typical value by adding an extra 40% of energy consumption during the process stage. They may be used instead of actual values under certain circumstances defined in the RED.

FQD: Fuel Quality Directive, or Directive 2009/30/EC is the Directive amending Directive 98/70/EC as regards the specification of petrol, diesel, gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions and amending Council Directive 1999/32/EC as regards the specification of fuel used by inland waterway vessels and repealing Directive 93/12/EEC.

Input numbers: information on the itineraries of cultivation, industrial processes, yields, etc. The input numbers are the values in the white cells in the BioGrace Excel tool. In all these cells, actual input numbers can be given to calculate an actual GHG value.

Starting values: the input numbers that are in the BioGrace Excel tool when it is downloaded and opened. These numbers were provided by the JEC consortium for the RED default values of the Directive.

RED: Renewable Energy Directive, or Directive 2009/28/EC is the “Directive on the promotion and the use of energy from renewable energy sources”.

GHG: Greenhouse gases, responsible for global warming.

LHV: Lower heating value.

LUC : Land Use Changes. This term refers to the GHG emissions linked with a change in the carbon stock because of changes in the use of the land. An excel sheet called the LUC excel sheet provides information on how assessing them.

BIOGRACE I

Harmonised Calculations of Biofuel Greenhouse Gas Emissions in Europe

Align biofuel GHG emission calculations in Europe (BioGrace)

Project funded by the Intelligent Energy Europe Programme

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