BIOGRACE II

Harmonised Greenhouse Gas Calculations for Electricity, Heating and Cooling from Biomass

User manual

for the

BioGrace-II

GHG calculation tool for electricity, heating and cooling

Version 4 - Draft

September 2020

This user manual assists in understanding and using the BioGrace Greenhouse gas (GHG) calculation tool for electricity, heating and cooling from biomass. The tool can be used for a number of purposes which are presented below including a link to the appropriate chapter within this user manual. Please note that the BioGrace consortium has produced online video instructions that also explain the BioGrace Excel tool and the calculation rules.

If the BioGrace-II tool is to be used for making actual calculations, **then the user shall also refer to the BioGrace-II 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.
How can I use the tool to calculate my own actual value?	These chapters allow you to make the best use of the tool depending on your personal objective.
How can I use the tool to understand the default values?	
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 GNOC sheet?	A step by step tutorial may help you to calculate the N_2O emissions of your pathway using the Global Nitrous Oxide Calculator (GNOC).
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 using the IPCC TIER 1 methodology.
How to use the Calculate efficiency sheet?	A step by step tutorial may help you to use this sheet.
How to use the Co-digestion sheets?	A step by step tutorial may help you to calculate new default values for co-digestion of several substrates in a biogas plant.
How to use the Final conversion only sheet?	A step by step tutorial may help you to understand the purpose of this sheet.
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-II calculation rules document as part of the zip file in which you downloaded the Excel tool and this user manual.

Contents

1 Introduction including description of functions of the tool

The BioGrace-II GHG calculation tool is a tool facilitating to understand already made, and to make own, greenhouse gas (GHG) calculations for electricity, heat and cooling produced from biomass. It does so in the European context, using values and methodologies from the recast of the Renewable Energy Directive (RED-II). The other BioGrace tool – BioGrace-I – is on GHG calculations for transport fuels.

The BioGrace-II GHG calculation tool consists of a number of documents including the BioGrace-II Excel tool, the BioGrace-II calculation rules, a BioGrace methodological background document, and this user manual. The user manual gives insight on how to understand and use the BioGrace-II Excel tool.

Three main functions have been identified when developing the tool:

1. **Give details on RED-II default value calculations**: the calculation sheets have been developed to detail the exact and comprehensive methodology applied to calculate default values presented in the RED-II and in the underlying JRC report.
2. **Adapt existing pathways for actual value calculations**: entering own input numbers into the calculation sheet allows calculation of own actual GHG results. Own standard calculation values (or conversion factors - see **paragraph 4.3**, definition in the glossary in **chapter 7**) may also be inserted in the calculations (for example, adding a specific chemical input).
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 should first have obtained a thorough understanding of the tool before creating a new pathway. The user can also contract an expert to produce a new pathway, this user manual describes two ways in which this can be done (see chapter 5).

Each function is described in more detail in their specific chapters. General information about the tool is given in the following chapter.

2 The BioGrace-II Excel tool explained

2.1 General

2.1.1 General principles

The EC reports and the calculations in the BioGrace-II tool follow a Life Cycle Assessment (LCA) perspective to evaluate the GHG emissions of one MJ of final energy. This means that:

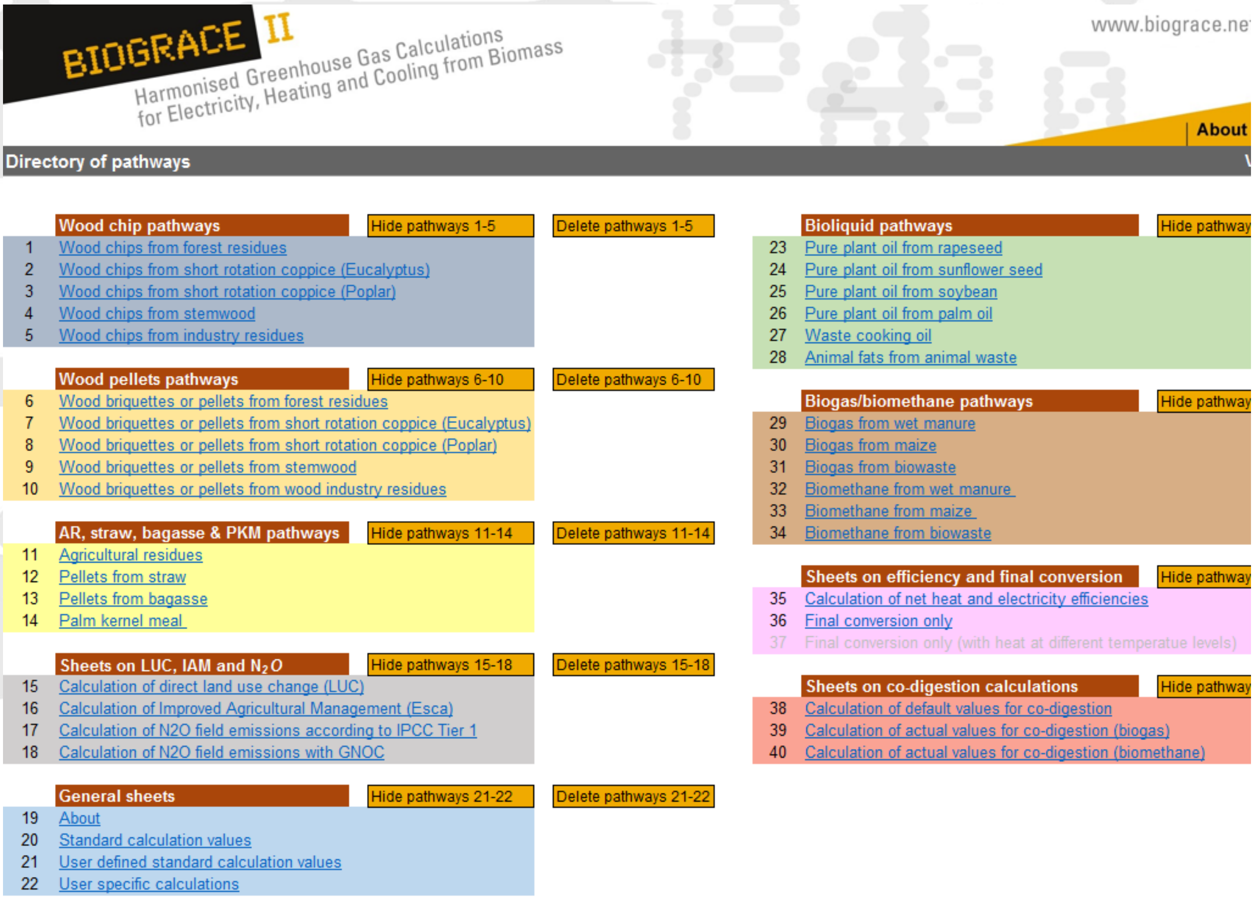
- The functional unit is “the production and use of one MJ of final energy”.
- All life cycle steps from biomass production to final energy use are taken into account. Each step of the life cycle is presented in the calculation sheet within a dedicated module representing one step in the bioenergy production pathway.
- The last step of most of the pathways (all pathways except for the biomethane pathways) is the final conversion (combustion) of the final energy carrier (final type of biomass) into electricity, heat, cooling or electricity and heat. For this final conversion, CH_4 and N_2O emissions are calculated.
- 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 JRC report defined steps are given in paragraph 2.2.1 Overview Results.
- Some cells in the BioGrace Excel tool sheets contain additional information in “help boxes”, in some cases including references to this user manual and/or to the BioGrace-II calculation rules.

2.1.2 Main elements of the tool

The tool is organized in several Excel sheets.

The first sheet, “**About**”, gives a general introduction and 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, “Wood chips from forestry residues” is linked to the “Ch-F_r” sheet.



Please note that the orange buttons starting with "Hide" (and "Unhide") and "Delete" can be clicked causing that either sheets are hidden (unhidden) or deleted from the Excel file.

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

- **LUC** sheet assesses the GHG impacts of possible Land Use Changes,
- **Esca** sheet for carbon stock changes due to improved agricultural practices.
- **N_2O emissions GNOC** sheet estimates N_2O emissions in accordance with the Global Nitrous Oxide Calculator (GNOC).
- **N_2O emissions IPCC** sheet estimates N_2O emissions in accordance with the IPCC TIER 1 methodologies[2].
- **Bg-co-dig_actual** sheet estimates the Production of electricity and/or heat, or cooling from biogas from biowaste.
- **Bm-co-dig_actual** sheet estimates the Production of electricity and/or heat, or cooling from biomethane from wet manure.
- **Co-dig_default** sheet calculates the default emissions for biogas or biomethane in case they stem from co-digestion of different substrates in a biogas plant.

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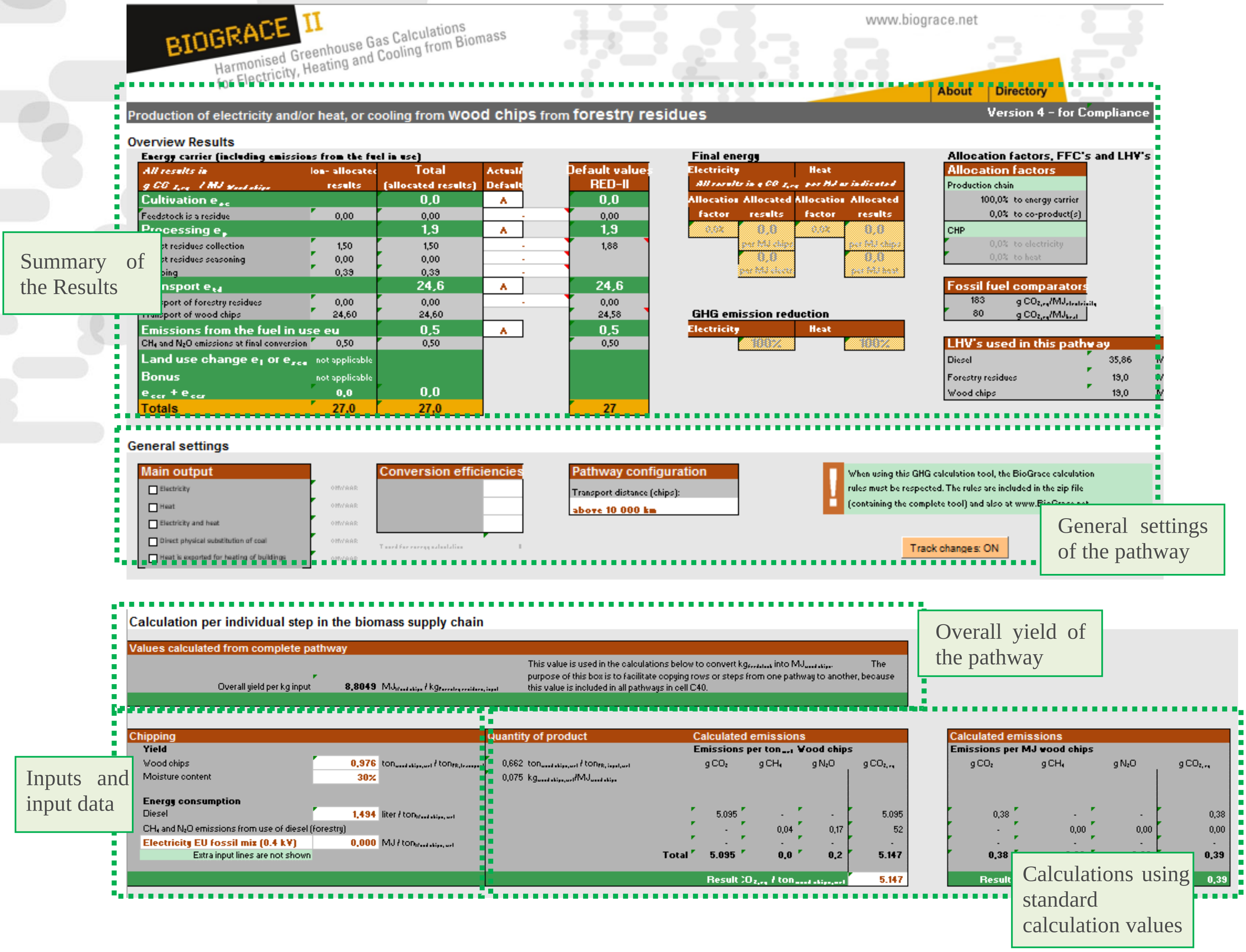
[2]: See the BioGrace-II calculation rules document for explanations on why this model is recommended.

- **Calculation efficiencies** sheet is used to calculate net heat and electricity efficiencies.
- **Final conv. only** sheet enables a company who has bought biomass or any energy carrier, and wants to use it for heat/electricity/cooling, to evaluate its final GHG emission reduction.

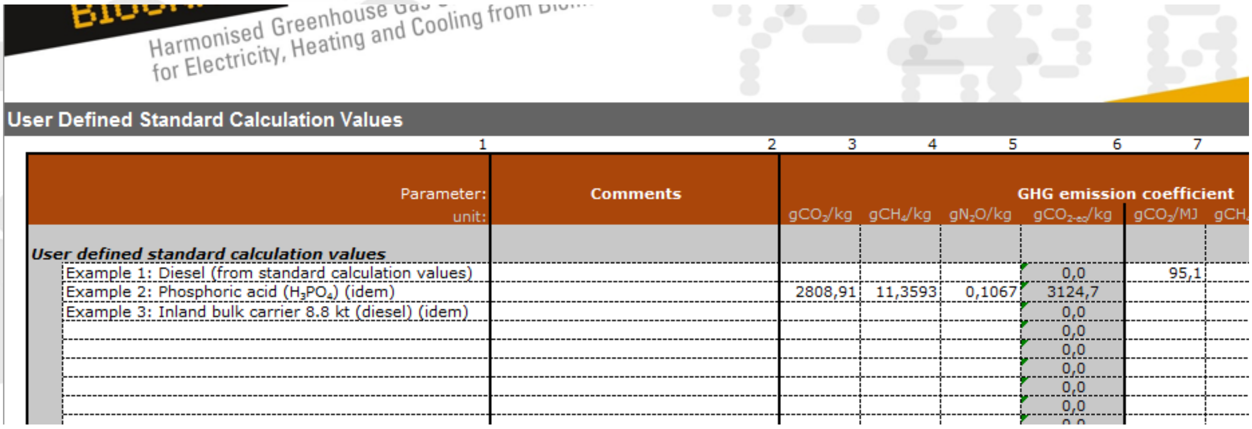
The user will then find the pathway calculation sheets. These sheets contain all the input numbers and results for all the pathways in the scope of the tool, with one sheet per pathway, in the most transparent way possible. The following example shows how a calculation sheet is built.



The two sheets: "**User defined Standard Calculation Values**" and "**Standard Calculation Values**" present the generic data necessary for the calculations.

The "**Standard Calculation Values**" sheet includes the conversion factors used by JRC to calculate the RED-II default values. These are (a) GHG emission coefficients, (b) Lower Heating Values (LHV), (c) fuel use when transporting 1 ton of goods per truck, ship or train, and (d) CH_4 and N_2O emissions from fuel combustion in trucks, ships, boilers, etcetera. The GHG emission coefficients are the emissions of the main GHG gases associated with 1 kilogram or 1 MJ of input such as N-fertilizer or natural gas. Such emissions include both combustion emissions as well as up-stream emissions for producing and transporting these inputs.

The "**User defined standard calculation values**" sheet can be used in case the user wants to use conversion values that are not included in the list of standard calculation values (see paragraph 4.3 detailing how to use the tool for this specific use). Please note that BioGrace has formulated rules on when own standard calculation values can be used, these rules can be found in the BioGrace-II calculation rules.



User Defined Standard Calculation Values

Parameter: / unit:	Comments	GHG emission coefficient gCO$_2$/kg	gCH$_4$/kg	gN$_2$O/kg	gCO$_{2\text{-eq}}$/kg	gCO$_2$/MJ	gCH$_4$...
User defined standard calculation values							
Example 1: Diesel (from standard calculation values)					0,0	95,1	
Example 2: Phosphoric acid (H$_3$PO$_4$) (idem)		2808,91	11,3593	0,1067	3124,7		
Example 3: Inland bulk carrier 8.8 kt (diesel) (idem)					0,0		
					0,0		
					0,0		
					0,0		
					0,0		
					0,0		
					0,0		

Finally, the "**User specific calculations**" sheet is provided to keep track of all intermediate calculations made by the user of the tool, and ease the work of the verifiers in case of certification supervision. Any kind of calculation can be put in that sheet, such as conversion unit calculations.

2.1.3 Colour-coding of Excel cells in calculation sheets

The tool is built on the following simple colour–code for cells:

- Diesel | 1,494 | liter / ton$_{\text{Wood chips, wet}}$

  White cells with red text are used for input numbers. The existing values are the ones used in the JRC report. These cells can be changed by the user to test or to adapt any pathway making actual calculations.

- Fuel used in boiler or CHP | Enter the kind of fuel

  Some pathways contain yellow-coloured cells. The values in such cells **must** be filled out before the calculation can be made. These cells occur in pathway configurations for which no RED-II default values are available, for instance when selecting "Boiler/CHP on other fuel (act. calc.)" in one of the wood pellet pathways or when making an actual calculation for co-digestion in the sheet "Bg-co-dig_actual" or "Bm-co-dig_actual".

- 0,537 ton$_{\text{wood pellets,net,wet}}$ / ton$_{\text{FR,input,wet}}$
0,058 kg$_{\text{wood pellets,wet}}$/MJ$_{\text{wood pellets}}$

  Cells with grey background colour are used for calculations and information that should not be changed (except when adapting a pathway by adding new inputs or modifying the standard calculation value called (see the section on how to modify or add an input)).

- Cells with white text and green background colour as well as cells with orange background colour contain calculation results for a module or for an aggregation of modules.

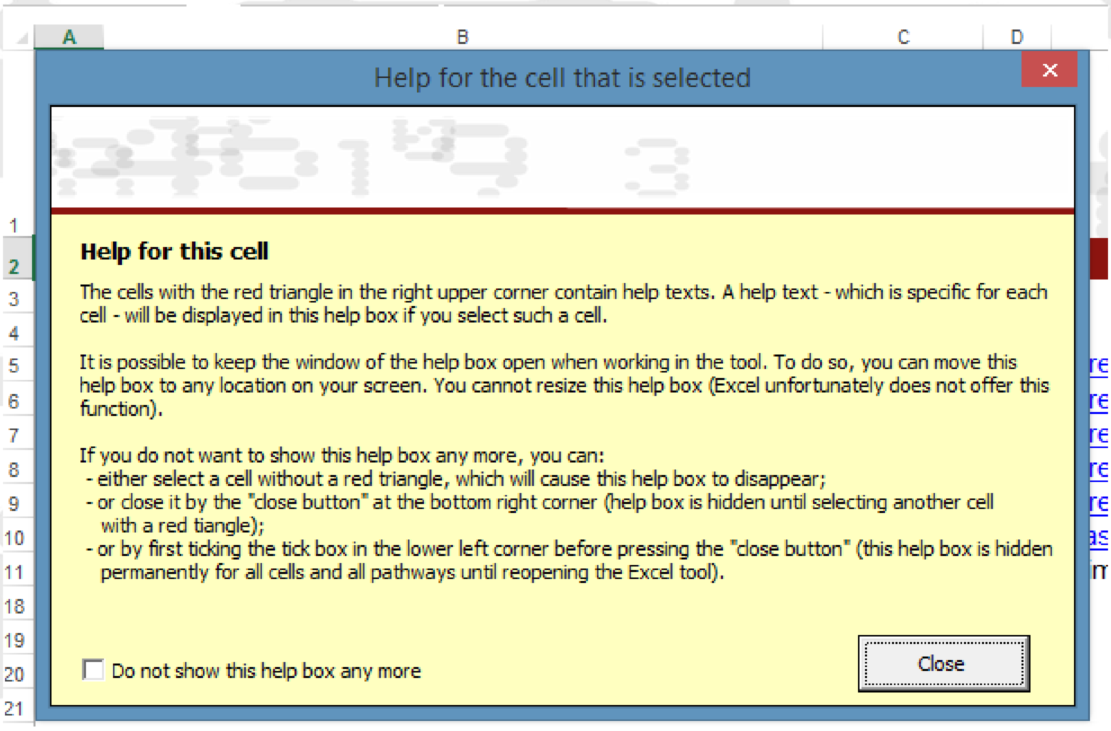
2.1.4 "Track changes" button

In case a calculation is made that will be used to show the GHG performance of bioenergy as part of demonstrating compliance to GHG emissions saving criteria, the function "track changes" must be left on. On each of the Excel sheets for the bioenergy production pathways you can find (on the right, near the top of the sheet under the general settings) an orange "button" which is named "Track changes: ON" or "Track changes: OFF". You should leave this button to "Track changes: ON" which is the standard setting when you open the tool. 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 function keeps track of changes from the original document, which will help the work of the verifiers in case of certification supervision. Please note that if the button is changed to "Track changes: OFF" it cannot be put back to "Track changes: ON" again.

Further background: At this moment of time (when writing this user manual in September 2020), the BioGrace-II GHG calculation tool is used to demonstrate compliance to sustainability criteria in Denmark and in The Netherlands. The evidence on compliance that is collected by energy companies, is audited by certification bodies. The "track changes" option is valuable for auditors when auditing actual GHG calculations made with the BioGrace-II Excel tool. In fact, an auditor is advised to not approve actual calculations that are made with the "track changes" function turned to "off", see also paragraph 2.1.2 of the BioGrace-II calculation rules.

2.1.5 Comment and help boxes in the tool

When you open the BioGrace tool, a popup box called "Help for the cell that is selected" appears (see figure below). This box gives you all needed information to understand and manage the comments included in the cells of the tool.



As explained in the help box, comments appear with the usual format of Excel comments, as a small red triangle in the right corner of the commented cells. These comments give:

- Explanations on how calculations were made, or
- Instructions on how specific cells or selection boxes can be used; and/or
- References to specific parts of this user manual or to the BioGrace-II calculation rules.

In order to make the BioGrace-II tool more user friendly, it is possible to disable this help box. In such a case, the help box will not appear anymore when selecting a cell with a comment. To be able to read the comment again, the user has to save and close the Excel tool and reopen it.

2.1.6 Changes in version 4 as compared to version 3

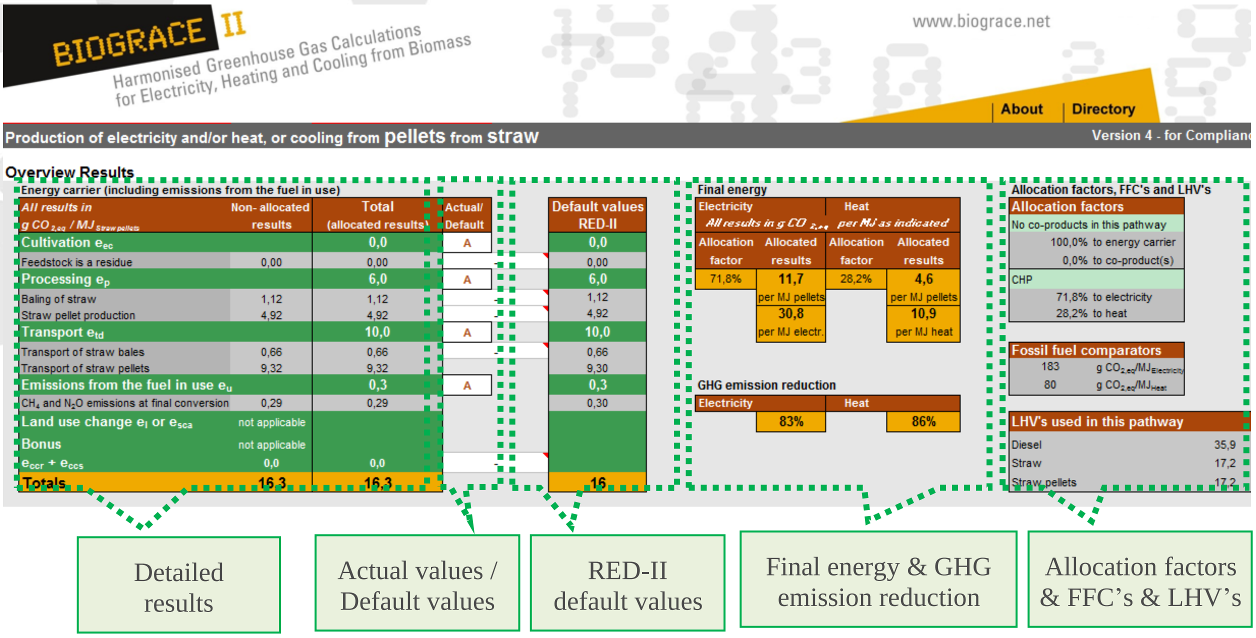
In version 4 of the tool (including “version 4 – Draft”), a number of changes have been made as compared to version 3. The most important changes are:

- The BioGrace-II Excel tool now reproduces the default value calculations from RED-II and version 2 (2017) of JRC report EUR 27215 EN, whereas the earlier versions 1, 2 and 3 of the BioGrace-II Excel tool reproduced the values from the report SWD(2014)259 and version 1a (2015) of JRC report EUR 27215 EN.
- In version 4, the calculations are first made on the basis of tons of biomass, allowing to give inputs in units familiar to biomass producers and owners of conversion installations such as pellet mills. In a second step the tool converts calculated emissions per ton of biomass to the unit grams of $CO_{2\text{-equivalent}}$ per MJ of biomass, and in the top section the emission per MJ of heat and/or electricity is calculated.
- Version 4 of the BioGrace-II Excel allows the user to create a version of the tool with a limited amount of pathways, either by hiding pathways or by deleting pathways (also causing that the file

becomes smaller, *i.e.* less MB). See the screen-copy of the Directory page in paragraph 2.1.2 and try by pressing the orange fields “Hide pathways” or “Delete pathways” in the Directory page of the Excel tool itself.

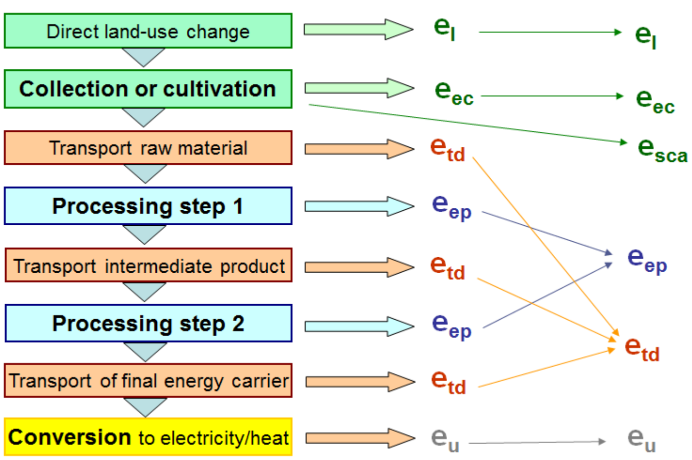
2.2 Top part of the calculation sheets

2.2.1 Overview Results



The upper part of each Excel sheet presents the results of the calculations performed in that sheet. <u>This upper part contains 5 main sections</u>:

Detailed results: this section gives the step by step results before and after allocation. The aggregated results in white text on green background correspond to the disaggregated default values from Annex VI.C of the RED-II (or Annex V.D in case of bioliquids).



Several steps in the Excel calculation can fall under one disaggregated default value. For instance, in the pathway “wood briquettes/pellets from forestry residues” the three steps “Transport of forestry residues”, “Transport of wood chips” and “Transport of wood pellets” step fall under the disaggregated default value for “Transport & Distribution”. This is illustrated in the figure above.

Actual values / default values: Column E enables using a mix of disaggregated default values and actual values for the remaining parts of the pathway. More information is provided in the textbox below.

RED-II **default values** and JRC report **calculation results:** column G gives the (disaggregated) default values from Annex VI of the RED-II and the calculation results for each individual step from the JRC Excel databases (see the sheet “About” in the Excel tool for details on the sources). The RED-II default values were calculated from these JRC calculation results.

Final energy & GHG emission reduction: this part includes the GHG emission reduction achieved with this bioenergy pathway as compared to the fossil fuel reference. This allows demonstrating that the sustainability criteria on GHG savings are met. According to the final energy selected in the general settings box (see 2.2.2 General settings), final results are presented in gram CO_2,eq per MJ of electricity and/or in gram CO_2,eq per MJ of heat.

Please note that for biomethane pathways, the GHG emission savings can only be calculated when someone takes the biomethane from the grid and produces heat and/or electricity from it.

Allocation factors & FFC’s and LHV’s: this part provides important data. The first information is on the allocation factors for the whole production chain and/or for the CHP, if any. The allocation factor for the whole production chain is only relevant for stakeholders that generate co-products during the production chain. In such a case, the emissions of processing steps up to this separation point are split between the main product and the co-product based on their yield and energy content.

The allocation factor for the CHP is only relevant for stakeholders that produce electricity and heat as a final energy, i.e. users that have selected “Electricity and heat” as main output in the General settings box (see paragraph 2.2.2).

The second information is the fossil fuel references used to calculate the GHG emission factors (see next paragraph). The last information is the lower heating values (LHV’s) that are used for making calculations in the pathway.

Please note: Use of disaggregated default values

Column E of the result module contains a number of selection boxes. They are here for implementing the possibility provided for in article 31 of the RED-II, to assess GHG emission from disaggregated defaults values (as given in Annex VI.C of the RED-II) of part of the bio-energy pathway, and actual values for the rest of the pathway. The “A” of the selection box list means that the value used for this step in column D is coming from the Excel sheet actual calculation. The letter “D” means that the value used for this step in column D is coming from the disaggregated default values in the RED-II which are presented in column G.

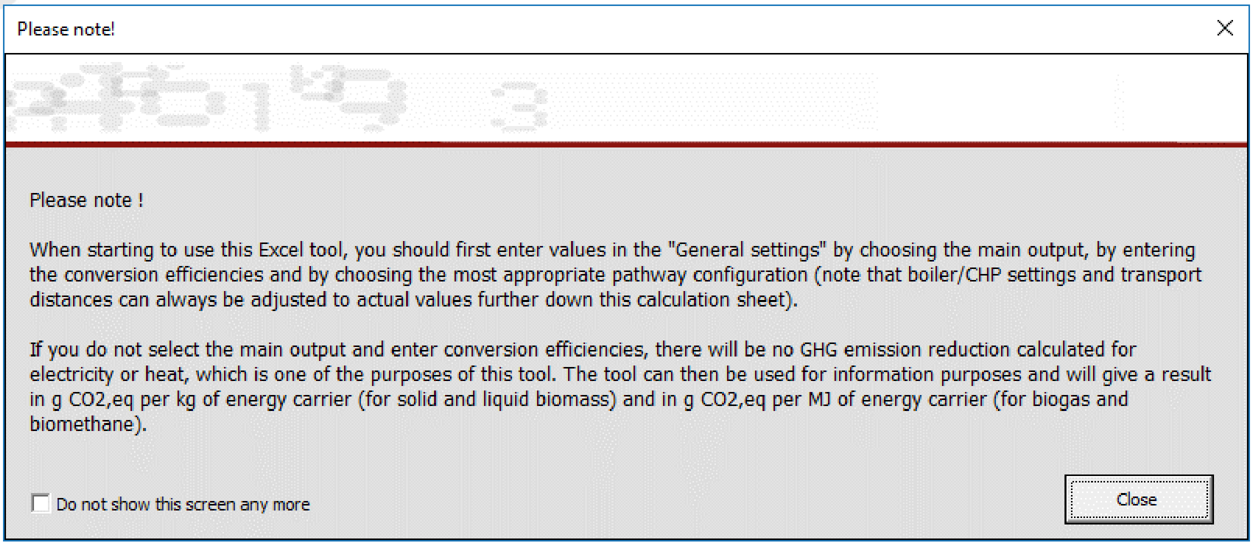
For instance (and with reference to the screenshot of the BioGrace-II Excel tool at the start of this paragraph 2.2.1): if you want to use the disaggregated default value from RED-II for the cultivation step e_{ec}, then choose the letter "D" from the selection box list in cell E8 which is the first red-coloured "A" of four shown in the screenshot above. The other red-coloured "A's" should stay positioned on "A" to get back actual values calculated in the modules below of the BioGrace Excel tool.

Please also refer to paragraph 2.4 in the BioGrace-II calculation rules and paragraph 4.6 for some further explanation on this choice between disaggregated default values and actual values.

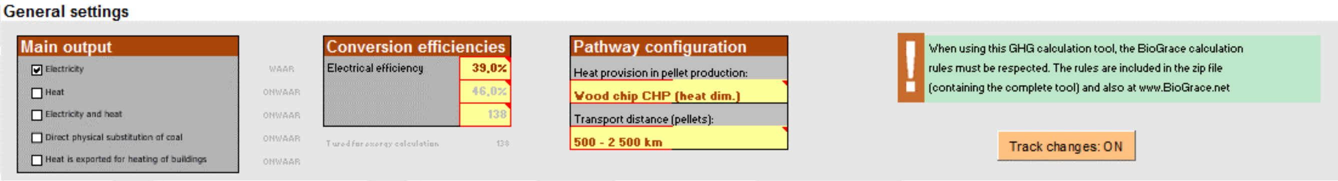
Please also note that for bioliquids in the BioGrace-II GHG calculation tool (a) there is no disaggregated default value for "Emissions from the fuel in use e_u", and (b) the disaggregated default value for transport is relatively high as it contains emissions from fuel distribution (at fuel distribution pumps) for biofuels which do not occur in the bioliquids pathways. This is a consequence of the fact that RED-II Annexes V and VI do not include disaggregated default values for bioliquids.

2.2.2 General settings

Each pathway contains a "General settings" box. When a user opens a sheet for the first time, a comment box called "Please note!" appears (see below) to explain the purpose of the "General setting" box.



As explained in the comment box, in order to calculate GHG emission reductions, the user must provide the type of final energy produced ("main output"), the conversion efficiencies and, for some pathways, also some further pathway configurations such as the type of boiler or CHP that provides heat for drying the wood chips before these are pelletised, and the overall transport distance between the wood chip/pellet producer and the end user. The conversion efficiencies can be calculated using the "Calculate efficiencies" sheet (see paragraph 6.7 How to use the Calculate efficiencies sheet?). As explained in the comment box, the most appropriate pathway configuration should be selected, but these configurations can also be adapted with actual values further down the calculation sheet.



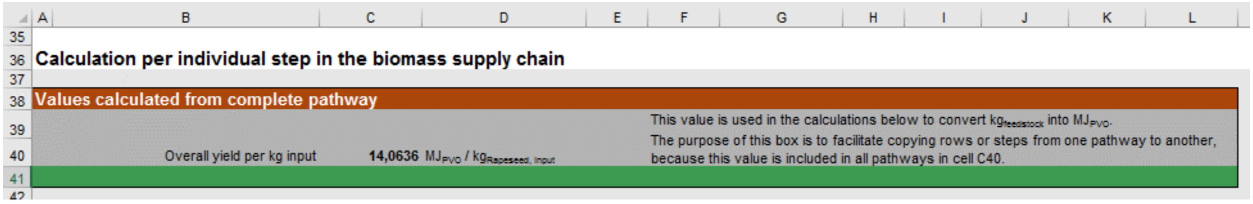
Providing information on the final conversion (main output, efficiency of the process, etc.) makes it possible to calculate the CO_2 emissions in the unit "MJ final energy" and to calculate an emission reduction percentage.

Finally, also the "Track changes" button is part of the "General settings" box. The "Track changes" button is presented in paragraph 2.1.4.

2.3 The "body of the calculation sheets: how the GHG calculations are made

2.3.1 The "Values calculated from complete pathway" box

In each pathway, calculations start with a box called "Value calculated from complete pathway". This box contains a number that corresponds to the overall yield for the total pathway. This number is used in the calculations to convert "MJ feedstock" into "MJ final energy carrier".

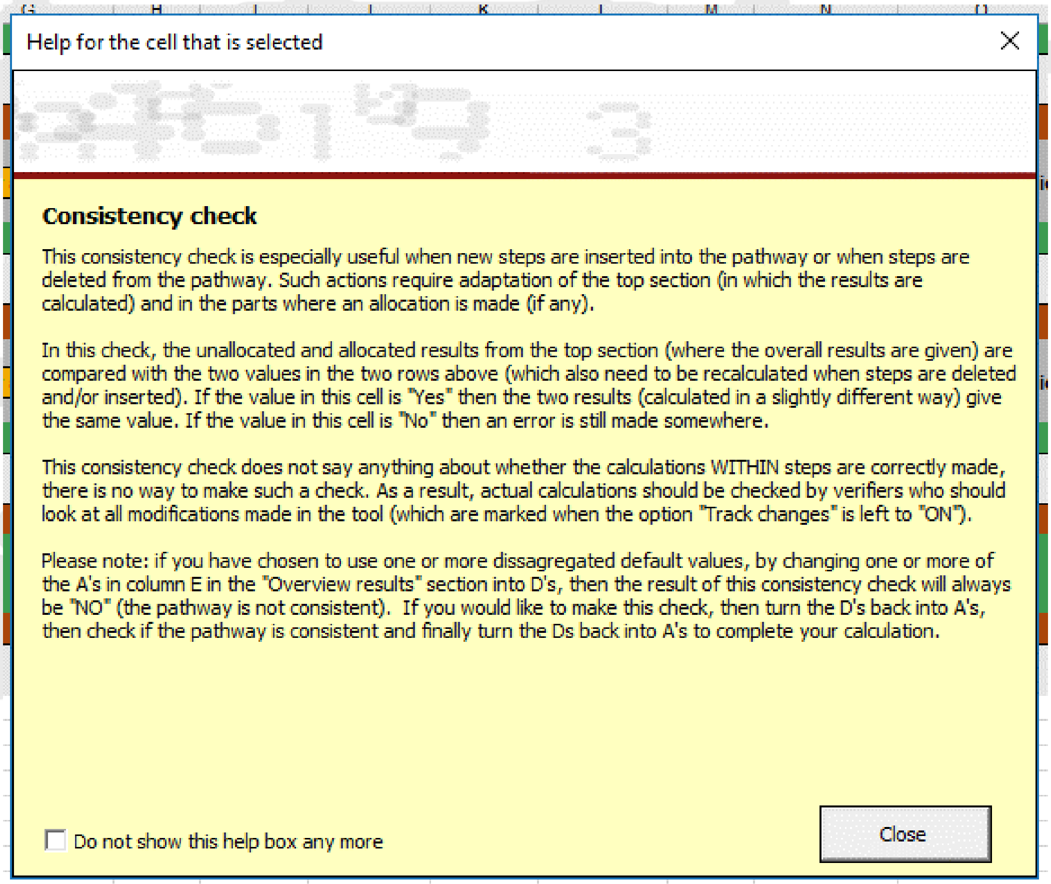


As explained in the box, the purpose of this box is to facilitate copying rows or steps from one pathway to another because these values are included in all pathways in cell C40 (more detailed information on copying rows or steps are provided in chapter 3 "Function 1: Using the tool to learn how default values were calculated".

2.3.2 The "Consistency check" box

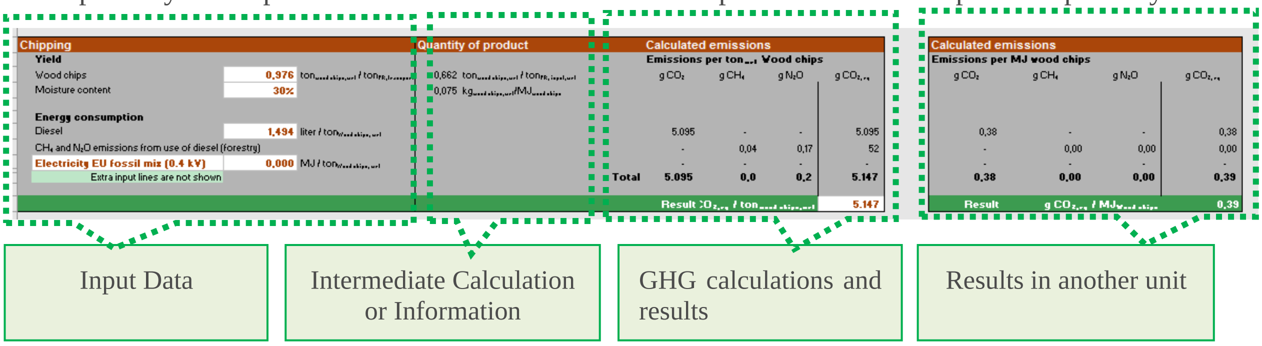
Each pathway ends with a "consistency check" box. This box aims at checking that calculations have been made properly when the pathways have been changed. In the tool, the addition of results of individual steps is made in two different ways. The check will result in "no" – which is a warning that something is wrong – in case these two different ways lead to different results. Both the calculation of unallocated emissions and the calculation of allocated emissions is checked.

A comment box explaining the purpose of this consistency box is provided in the "Yes" or "No" cell placed at the bottom right corner of the box.



2.3.3 Presentation of a module

Each pathway is composed of several modules which correspond to different steps of the pathway.



A module contains the following data (see figure above):

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. If no co-product is mentioned then this means

that this step does not have any co-product. In the calculations, the **moisture content** of the material is taken into account.

  - **Energy consumption** (for instance electricity, heat and diesel consumption). Heat or electricity can either be provided from external sources or come from a boiler or a CHP to be included in the calculation. In case a boiler produces surplus heat and/or electricity, emissions will be allocated to the surplus heat and/or electricity. Such calculations on boilers and CHPs are further explained in paragraph 2.3.7.
  - **Other inputs** such as chemical, transports, etc.

- Units: this is key information to take into account. Beware that the units are given either in kg, MJ or (for diesel) in litre of products. As explained in paragraph 2.3.5, units used in the tool should not be changed.

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 parts of the tool. In this example the quantity of product (*e.g.* in ton wood chips per ton forest residues) and intermediate yield data appear. The first factor (e.g. ton wood chips per ton forest residues) is the so-called "Feedstock factor" as defined on page 4 of the European Commissions' document "Note on the conducting and verifying actual calculations of GHG emission savings, version 2.0".

GHG Calculation and results: the right side of the tool is the calculation part. The global warming potentials for the three main gases are taken from the "Standard calculation values" sheet. In this part the results are expressed in the unit g $CO_{2,eq}$ per ton of intermediary product (including moisture).

Results in another unit: the results are recalculated in the unit "gram $CO_{2,equivalent}$ per MJ of energy carrier (such as wood chips, wood pellets or Pure Vegetable Oil) as this is the unit required for a comparison with the RED-II disaggregated and total default values.

2.3.4 Final conversion (production of electricity and/or heat)

In all solid biomass and bioliquid pathways the last module of the pathway is the final conversion (see figure below). In this module N_20 and CH_4 emissions caused by the combustion of the final energy carrier into the final energy are calculated.

When making actual calculations, the "Factor from typical to default values" should be "1". The CH_4 and N_2O emissions are already provided for some combinations of "type of fuel in end conversion" and "type of end conversion". If a combination is not provided, then the calculation will result in an error ("#N/B", this can be different in different language versions of Excel). If so, the user must define the CH_4 and N_2O emissions related to his process using the "User defined standard calculation values" sheet. Further explanation is provided in paragraph 4.3 of this user manual.

138	Final conversion (CH_4 and N_2O emissions only)						
139	Type of fuel used in end conversion	Wood chip		Emissions per MJ wood chips			
140	Type of end conversion	Boiler		g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
141	Factor from typical to default values	1,2					
142	Include following emissions	CH4 and N2O emissions from Wood chip Boiler		0,00	0,01	0,00	0,50
143							
144			g $CO_{2,eq}$ / $ton_{wood\ chips,wet}$	6.601	Result	g $CO_{2,eq}$ / $MJ_{Wood\ chips}$	0,50

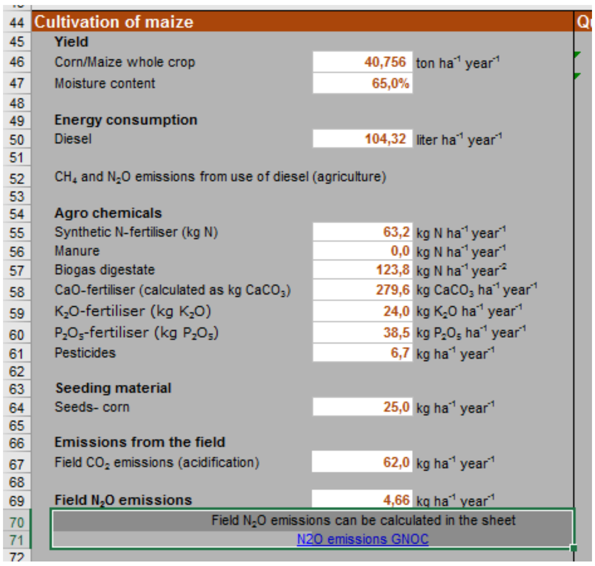
2.3.5 Units used

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 should 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 final energy carrier. This quantity is then multiplied by the global warming potentials for CO_2, CH_4 and N_2O which results in CO_2-equivalents per MJ of final energy carrier. Then the final conversion (see paragraph 2.3.4) enables to get all emissions per MJ of final energy.

In the previous version 3 of the BioGrace-II GHG calculation tool, "Assistance with unit conversions" boxes were provided. In the current version of the tool these boxes are no longer available as the tool has been set-up with a different functional unit (tons instead of MJ) which will strongly reduce the need for unit conversions when entering actual data.

2.3.6 N_2O emissions due to crop cultivation

For pathways with crop cultivation, field 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.



44	**Cultivation of maize**		
45	**Yield**		
46	Corn/Maize whole crop	40,756	ton ha^{-1} year^{-1}
47	Moisture content	65,0%	
48			
49	**Energy consumption**		
50	Diesel	104,32	liter ha^{-1} year^{-1}
51			
52	CH_4 and N_2O emissions from use of diesel (agriculture)		
53			
54	**Agro chemicals**		
55	Synthetic N-fertiliser (kg N)	63,2	kg N ha^{-1} year^{-1}
56	Manure	0,0	kg N ha^{-1} year^{-1}
57	Biogas digestate	123,8	kg N ha^{-1} year^{-2}
58	CaO-fertiliser (calculated as kg $CaCO_3$)	279,6	kg $CaCO_3$ ha^{-1} year^{-1}
59	K_2O-fertiliser (kg K_2O)	24,0	kg K_2O ha^{-1} year^{-1}
60	P_2O_5-fertiliser (kg P_2O_5)	38,5	kg P_2O_5 ha^{-1} year^{-1}
61	Pesticides	6,7	kg ha^{-1} year^{-1}
62			
63	**Seeding material**		
64	Seeds- corn	25,0	kg ha^{-1} year^{-1}
65			
66	**Emissions from the field**		
67	Field CO_2 emissions (acidification)	62,0	kg ha^{-1} year^{-1}
68			
69	**Field N_2O emissions**	4,66	kg ha^{-1} year^{-1}
70	Field N_2O emissions can be calculated in the sheet		
71	N2O emissions GNOC		

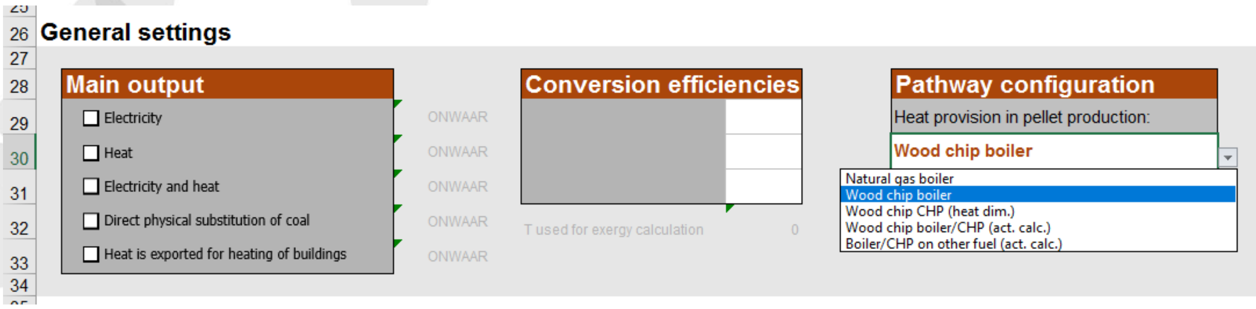
In the tool, two models are used to evaluate N_2O field emissions: the Global Nitrous Oxide Calculator, GNOC (see paragraph 6.3) and the IPCC TIER 1 methodology (see paragraph 6.4). A specific sheet has been provided for each method of calculation.

The GNOC is an online calculator (http://gnoc.jrc.ec.europa.eu) developed by JRC, that shall be used to estimate N_2O field emissions for all the types of crops available in the model (see the list of crops in the online tool). For other types of biomass such as jatropha, energy grass and short rotation forestry (poplar and eucalyptus in the tool), calculations following the IPCC TIER 1 methodology shall be used. See also paragraph 3.1 in the BioGrace-II calculation rules.

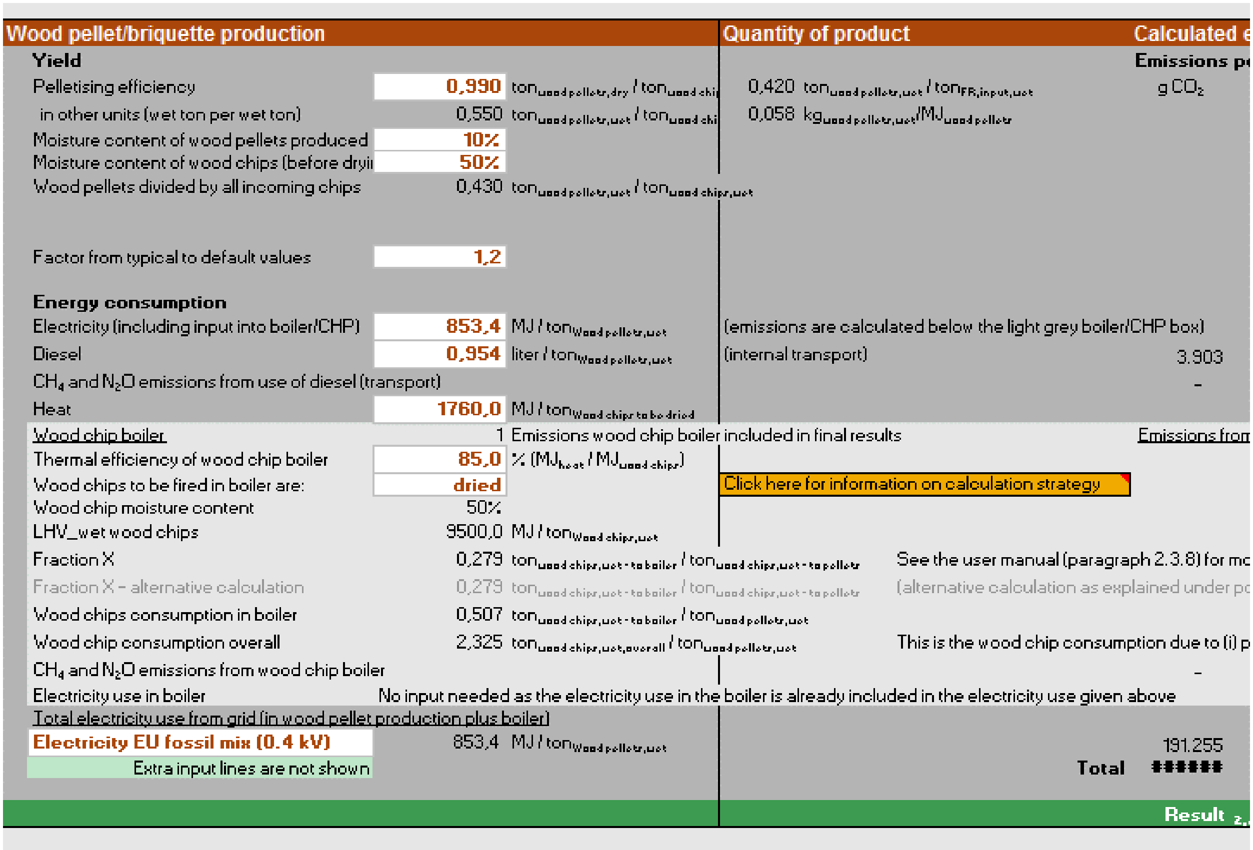
A link to the sheets "N₂0 emissions GNOC" has been placed right below the cell where the information about N_2O field emissions should be provided (see figure above). Within the GNOC sheet, a link to the IPCC sheet is placed.

2.3.7 GHG emissions from boilers and CHP

For pathways using heat in their process (e.g. most pellets production pathways) several configurations regarding the source of heat can be selected by the user of the tool. For pellet pathways, the user can choose between five configurations (see figure below) according to the process (boiler or CHP), the type of fuel (wood chip or wood pellet) and the possibility to make actual calculations.



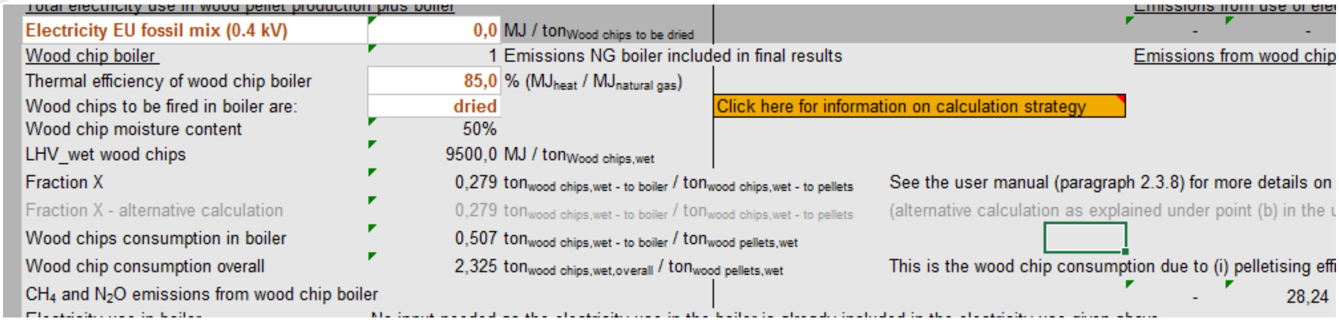
When the user selects a configuration, the related processing step (e.g. Wood pellet/briquette production) is be automatically adjusted to fit the selection. The part of the process that is specific to the configuration selected is coloured in light grey in the process (see figure below).



Information on the calculation strategy can be found in the orange box or in the document BioGrace-II calculation rules.

In the pellet/briquettes production pathways, the pathway configuration allows to choose between three different configurations. Configuration 1 is when the incoming wet wood chips (moisture content of 50%) are dried using heat generated in a natural gas boiler. Configurations 2 and 3 are when the incoming wet wood chips are dried with heat (and electricity) generated in a wood chip boiler or CHP. The BioGrace-II Excel tool further allows to choose "Wood chip boiler/CHP (act. calc.)" which is different from configurations 2 and 3 as it allows to alter the dimension of the boiler or CHP which in configurations 2 and 3 is given (the boiler/CHP is then dimensioned to the heat demand of the wood chip dryer). The remainder of this paragraph is on configurations 2 and 3. It describes the calculation for a wood chip boiler (configuration 2), the calculation is the same for a wood chip CHP (configuration 3).

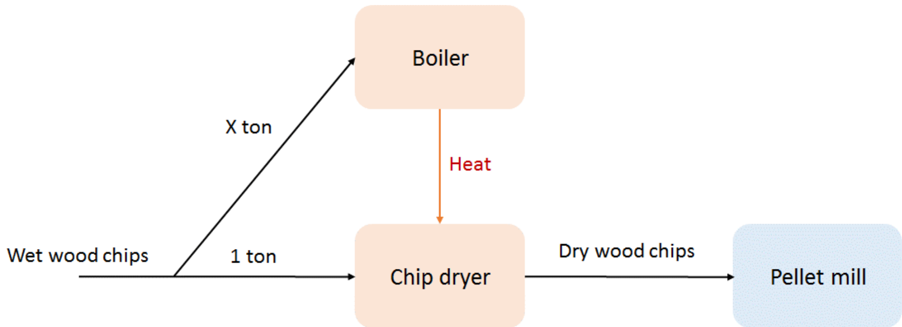
In configuration 2, part of the wood chips are combusted in the boiler to generate heat for drying the wood chips before they are pelletised. This makes the calculation somewhat more complicated. Therefore, this paragraph of the user manual explains how the "fraction X" (see screenshot below) is calculated for two situations: (i) the wood chips to the boiler are not dried, and (ii) the wood chips to the boiler are dried together with the wood chips to be fed into the pelletiser.



Electricity EU fossil mix (0.4 kV)	0,0	MJ / ton$_{Wood\ chips\ to\ be\ dried}$		-	-
Wood chip boiler	1	Emissions NG boiler included in final results		Emissions from wood chip	
Thermal efficiency of wood chip boiler	85,0	% (MJ$_{heat}$ / MJ$_{natural\ gas}$)			
Wood chips to be fired in boiler are:	dried		Click here for information on calculation strategy		
Wood chip moisture content	50%				
LHV_wet wood chips	9500,0	MJ / ton$_{Wood\ chips,wet}$			
Fraction X	0,279	ton$_{wood\ chips,wet\ -\ to\ boiler}$ / ton$_{wood\ chips,wet\ -\ to\ pellets}$	See the user manual (paragraph 2.3.8) for more details on		
Fraction X - alternative calculation	0,279	ton$_{wood\ chips,wet\ -\ to\ boiler}$ / ton$_{wood\ chips,wet\ -\ to\ pellets}$	(alternative calculation as explained under point (b) in the u		
Wood chips consumption in boiler	0,507	ton$_{wood\ chips,wet\ -\ to\ boiler}$ / ton$_{wood\ pellets,wet}$			
Wood chip consumption overall	2,325	ton$_{wood\ chips,wet,overall}$ / ton$_{wood\ pellets,wet}$	This is the wood chip consumption due to (i) pelletising effi		
CH_4 and N_2O emissions from wood chip boiler				-	28,24

The boiler or CHP requires an additional demand for wood chips as compared to case 1 (natural gas boiler). How much wood chips are extra required depends on the efficiency of the boiler, which on its turn depends on whether the boiler is fed with dry, or with wet wood chips. Therefore the BioGrace-II Excel tool allows to make both calculations, which are explained in some more detail:

i) Wood chip boiler on wet wood chips

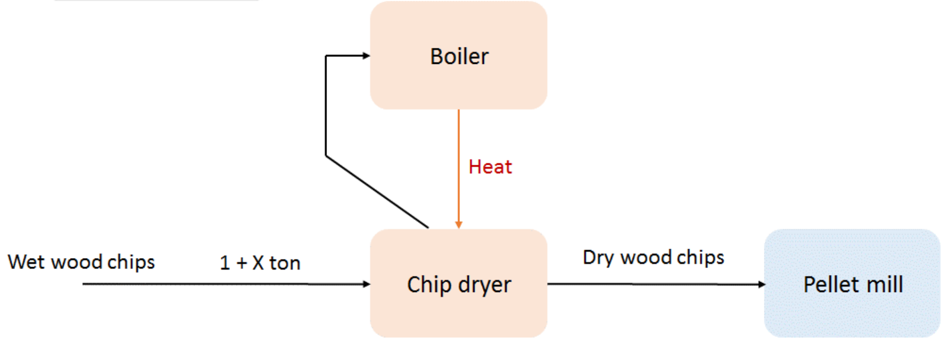


In the calculation, the fraction of extra wood chips needed for drying (as compared to 1 ton of wood chips entering the dryer) is calculated from the amount of heat required to dry 1 ton of wet wood chips (H, in MJ$_{heat}$ / ton$_{wood\ chips\ to\ be\ dried}$), the efficiency of the wood chip boiler (η_{boiler} in

$MJ_{heat}/MJ_{heat\ content\ of\ wood\ chips\ combusted}$) and the heat content of wood chips ($LHV_{wood\ chips}$ in $MJ_{heat\ of\ wood\ chips\ combusted}$ / $ton_{wood\ chips\ combusted}$). In this case, the calculation is simple:

Fraction X = H / (η_{boiler} * $LHV_{wood\ chips}$), with unit $ton_{wood\ chips\ combusted\ in\ boiler}$ / $ton_{wood\ chips\ to\ be\ dried}$.

ii) Wood chip boiler on dry wood chips



This is a more complex calculation, as also the X ton wood chips that are combusted in the boiler are first dried in the chip dryer. There are two ways in which the fraction X can be calculated.

a) By considering that the amount of heat required for the drying now becomes (1 + X)*H.

   This will give the formula X = (1 + X) * H / (η_{boiler} * $LHV_{wood\ chips}$).
   This can be rewritten into Fraction X = H / (η_{boiler} * $LHV_{wood\ chips}$ - H).

b) By considering – if the extra amount of wet pellets to dry 1 ton of wet wood pellets is H / (ηboiler * LHVwood chips) – that then the same formula needs to be applied to this amount too, because this amount needs to be dried as well. This will require an extra amount of wet wood pellets of (H / (ηboiler * LHVwood chips))^2. However, this extra amount needs to be dried too, which requires an extra extra amount of wet chips of (..)^3, etc., etc.

   So the amount of wood chips that are needed for the drying is (..) + (..)^2 + (..)^3 + (..)^4 .. etc.

The two solutions (a) and (b) above give the same numerical outcome, as is shown in the Excel tool.

Please also note that:

1. The thermal efficiency η_{boiler} will probably be higher in case (ii) when the wood chips are first dried as compared to case (i) when wet wood chips are burned in the boiler.
2. In this calculation there is no need to define the moisture content of the dried wood chips. For increasingly wet wood chips an increasingly high H is needed. In the calculation, both H as well as the moisture content of the incoming wood chips and the moisture content of the produced wood pellets need to be entered. These values need to be consistent.

Last but not least, the user can also select to make a calculation for either “Wood chip boiler/CHP (act. calc.)” or “Boiler/CHP on other fuel (act. calc.)”. In that case the calculation can only be completed if the user adds two rows of values in the sheet "user defined standard calculation values". If for instance the user indicates in the tool that the boiler/CHP fuel is "bark", then the user must include in the sheet "User defined standard calculation values" the three emission factors for provision of bark (in g CO_2 / MJ bark, g CH_4 / MJ bark and in g N_2O / MJ bark) and values for the CH_4 and N_2O emission from a bark-fired boiler or CHP. Not adding these numbers will cause that the tool indicates that an error is found as the corresponding standard calculation values for "Bark" and "CH_4 and N_2O emissions from Bark" cannot be found. See also the paragraph below on how these numbers are found in the tool.

2.3.8 Using standard calculation values through the Excel function "VLOOKUP"

Cultivation of maize			Quantity of product	Calculated emissions			
Yield				Emissions per ton_{wet} Maize whole crop			
Corn/Maize whole crop	40,756	ton ha^{-1} $year^{-1}$	1,00 $ton_{Maize\ whole\ crop,\ Input}$ / $ton_{Maize\ whole\ crop,\ Input}$	g CO_2	g CH_4	g N_2O	g $CO_{2,\ eq}$
Moisture content	65,0%		0,268 $kg_{Maize\ whole\ crop}$ / MJ_{Biogas}				
Energy consumption							
Diesel	104,32	liter ha^{-1} $year^{-1}$		8.729	-	-	8.729
CH_4 and N_2O emissions from use of diesel (agriculture)			241068,79	-	0	0	89
Agro chemicals							
Synthetic N-fertiliser (kg N)	63,2	kg N ha^{-1} $year^{-1}$		6.015	3	3	7.094
Manure	0,0	kg N ha^{-1} $year^{-1}$		-	-	-	-
Biogas digestate	123,8	kg N ha^{-1} $year^{-2}$		-	-	-	-
CaO-fertiliser (calculated as kg $CaCO_3$)	279,6	kg $CaCO_3$ ha^{-1} $year^{-1}$		254	0	0	268
K_2O-fertiliser (kg K_2O)	24,0	kg K_2O ha^{-1} $year^{-1}$		245	-	-	245
P_2O_5-fertiliser (kg P_2O_5)	38,5	kg P_2O_5 ha^{-1} $year^{-1}$		512	-	-	512
Pesticides	6,7	kg ha^{-1} $year^{-1}$		1.844	2	0	1.976

In this example, the agrochemicals needed for the cultivation step of maize are shown on the left, in kg per hectare and per year. On the right part the emissions of greenhouse gas per wet ton of maize are calculated, using conversion formulas in the cells.

This calculation relies on the match between the name of the inputs ("Synthetic N-fertiliser (kg N)", "K_2O-fertiliser (kg K_2O)", etc.) and the names in the "Standard calculation values" sheet. Excel formulas are used to call the right GHG emission coefficients for each input (formula "VLOOKUP" in English[3]). It is therefore required 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 calculation value, this value has to be created in the sheet "User defined standard calculation values", and the same name must be used in the calculation sheet. Moreover, it is important to make sure that the units of the input values are the same as the units of the standard calculation value. Please note that – were in the tool emissions are calculated for diesel use - a conversion from liter to MJ is included in the formula's.

[3] or "VERT.ZOEKEN" in Dutch, or "RECHERCHEV" in French, or "SVERWEIS" in German language respectively

3 Function 1: Using the tool to learn how default values were calculated

The BioGrace-II tool makes transparent how the RED-II default values 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 the pathway sheets. All calculations are presented step by step, following the well to wheel approach.

Looking in detail at a calculation sheet provides information on how the calculations were made and on how the methodology from RED-II Annex VI.B was applied. 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-II default value calculations:
  - The different steps encompassed and the way they are modelled (e.g. has the transport of bagasse pellets been taken into account in the RED-II default value?);
  - 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, distance, 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 calculation values used for calculating default values**, like LHV, the GHG emission for producing and using one MJ of natural gas, etc.;
- **How energetic allocations are made** (see the allocation module for this as well as the calculation rules);
- **How surplus electricity and/or heat is taken into account** (see the exergy calculations for detail examples);
- **Intermediate calculations**, in column E, where all the yields are expressed;
- **GHG emissions** as calculated from the input numbers, in columns I, J and K, respectively for CO_2, CH_4 and N_2O;
- **The difference between typical and default values**: default values correspond to conservative estimations of GHG emissions which are calculated by multiplying typical values by a factor (1.2 or 1.4 depending on the pathway considered). For more details please consult the "About" sheet in the Excel tool;
- **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.

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

For most of the default values listed in the RED-II, the corresponding calculation in the BioGrace-II tool gives a result that comes very close (deviation less than 0.05 g $CO_{2,eq}$/MJ).

4 Function 2: Using the tool to calculate an actual value

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

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 calculation values for existing inputs ;
- Adding new input in the process ;

4.1 Modifying input data

Calculation sheets of the BioGrace-II 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-II calculation rules which includes a specific chapter "Use of starting values in the BioGrace GHG calculation tool". Complying with these rules, **you can modify the value of all white cells**.

In order to keep track of these changes, we recommend to keep "Track changes" turned to "on". On each of the Excel sheets for the bioenergy production pathways you can find (on the right, near the top of the sheet under the results) an orange "button" which is named "Track changes: ON" or "Track changes: OFF". For calculations performed as part of a scheme you should keep this button to "Track changes: ON" (see the document BioGrace-II calculation rules). 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.

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.

Two examples of making actual calculations are:

1. The screenshot below demonstrates how actual values for energy input and efficiencies have been used to make an actual calculation for a pellet mill located in The Netherlands. The energy input values stem from actual readings from the pellet mill site (they are the annual electricity and natural gas use, divided by the annual production of pellets in ton_{wet}). Please note that – in order to be allowed to make an actual calculation – also the input values in the step "Chipping" in this pathway "Pe-Fr" must be replaced by actual input values. In this example, the user of the tool did not know the actual amount of heat, and has therefore inserted the text "Heat (value is overwritten by NG value below)". The amount of natural gas in the boiler was measured by the user, this value was entered. In this

configuration (a natural gas boiler) this is an appropriate solution. However, in case of a wood chip boiler or wood chip CHP, the amount of heat is also needed to calculate other numbers, and in such a case the user must calculate the amount of heat generated by the boiler or CHP from its fuel input and its efficiency.

Wood pellet/briquette production			Quantity of product	Calculated emissions			
Yield				Emissions per ton_{wet} Wood pellets			
				g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Pelletising efficiency	0,982	$ton_{Wood\ pellets,dry}$ / $ton_{Wood\ chi}$	0,560 $ton_{Wood\ pellets,wet}$ / $ton_{Fr,Input,wet}$				
in other units (wet ton per wet ton)	0,574	$ton_{Wood\ pellets,wet}$ / $ton_{Wood\ chi}$	0,058 $kg_{Wood\ pellets,wet}$ / $MJ_{Wood\ pellets}$				
Moisture content of wood pellets produced	11,0%						
Moisture content of wood chips (before dr	48,0%						
Wood pellets divided by all incoming chips	0,574	$ton_{Wood\ pellets,wet}$ / $ton_{Wood\ chips,wet}$					
Factor from typical to default values	1,0						
Energy consumption							
Electricity (including input into boiler/CHP)	855,2	MJ / $ton_{Wood\ pellets,wet}$	(emissions are calculated below the light grey boiler/CHP box)				
Diesel	0,000	liter / $ton_{Wood\ pellets,wet}$	(internal transport)	-	-	-	-
CH_4 and N_2O emissions from use of diesel (transport)				-	-	-	-
Heat (value is overwritten by NG value bel	0,0	MJ / $ton_{Wood\ chips\ to\ be\ dried}$					
Natural gas boiler	1	Emissions NG boiler included in final results		Emissions from NG boiler			
Thermal efficiency of natural gas boiler	89,0	% (MJ_{Heat} / $MJ_{Natural\ gas}$)	Click here for information on calculation strategy				
Wood chip consumption overall	1,743	$ton_{Wood\ chips,wet}$ / $ton_{Wood\ pellets,wet}$					
Natural gas (EU-mix)	4122,2	MJ / $ton_{Wood\ pellets}$		272.067	-	-	272.067
CH_4 and N_2O emissions from NG boiler				-	10,37	4,15	1.495
Electricity use in boiler	No input needed as the electricity use in the boiler is already included in the electricity use given above						
Total electricity use from grid (in wood pellet production plus boiler)							
Grid electricity (MV) - Netherlands	855,2	MJ / $ton_{Wood\ pellets,wet}$		125.563	-	-	125.563
Additional inputs into the pellet/briquette production							
LPG	38,42	MJ / $ton_{Wood\ chips,wet}$	LPG use for internal transport	2.547	0,00	0,00	2.548
No emissions	0,00	MJ / $ton_{Wood\ chips,wet}$		-	-	-	-
No emissions	0,00	kg / $ton_{Wood\ chips,wet}$		-	-	-	-
No emissions	0,00	kg / $ton_{Wood\ chips,wet}$		-	-	-	-
Extra input lines are shown			Total	400.177	10,4	4,1	401.673
			Result g $CO_{2,eq}$ / $ton_{Wood\ pellets,wet}$				401.673

2. The screenshot below demonstrates how extra transport steps can be added. This is an example on bagasse pellets that are used at an inland location in Europe, requiring extra transport per inland bulk carrier and per truck. Please also note that the yield number of "1,000" and the names of the fuels "Diesel" and "Heavy fuel oil" have been filled out again (the values were exactly the same) as to indicate that in this case these are actual values.

Transport of bagasse pellets			Quantity of product	Calculated emissions			
Yield				Emissions per ton_{wet} Bagasse pellets			
Bagasse pellets	1,000	$ton_{Transported,wet}$ / $ton_{Bagasse\ p}$	0,770 $ton_{Bagasse\ pellets\ transported,wet}$ / $ton_{Bagasse,Input,w}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Moisture content	9,0%		0,065 $kg_{Bagasse\ pellets\ transported,wet}$ / $MJ_{Bagasse\ pellets}$				
Transport per			(Emissions are calculated for transport of 1 ton of wet bagasse pellets)				
Truck (40 ton) for liquids and pellets (Diese	265	km	265 $ton_{Bagasse\ pellets,wet}$ km / $ton_{Bagasse\ pellets,wet}$	22.013	0,97	0,43	22.165
Fuel	Diesel						
Bulk Carrier "**Supramax**" (Fuel oil) - pellets	8632	km	8632 $ton_{Bagasse\ pellets,wet}$ km / $ton_{Bagasse\ pellets,wet}$	53.329	-	-	53.329
Fuel	Heavy fuel oil						
Inland bulk carrier 8.8 kt (diesel)	365	km	365 $ton_{Bagasse\ pellets,wet}$ km / $ton_{Bagasse\ pellets,wet}$	11.247	33,95	0,15	12.139
Fuel	Diesel						
Truck (40 ton) for liquids and pellets (Dies	34	km	34 $ton_{Bagasse\ pellets,wet}$ km / $ton_{Bagasse\ pellets,wet}$	2.824	0,12	0,05	2.844
Fuel	Diesel						
Extra input lines are shown			Total	89.413	35,0	0,6	90.476
			Result $CO_{2,eq}$ / $ton_{Bagasse\ pellets,wet}$				90.476

4.2 Using the result from previous and partial GHG calculations

Calculation sheets of the BioGrace-II tool allow that GHG calculations are made for part of the bioenergy pathway and – after verification – are used as input in a new calculation for the rest of the bioenergy pathway. These inputs can take into account individual or multiple steps.

Note that the sheet “Final conv. only” has been created for companies that buy ready to use energy carriers and transform them into final energy. This sheet will allow them to calculate the GHG emission reduction (see paragraph 6.5 How to use the “Final conversion only” sheet?). Specific calculation rules for using the result of previous and partial GHG calculations are available in the document BioGrace-II calculation rules. These rules must be followed.

General information and requirements when doing such modifications:

- The results of previous calculation shall be expressed in g CO_2,eq per ton of wet feedstock.
- Changing such a value will overwrite all values and calculations in that step.
- Changes shall be made also to the result module at the top of the sheet (see examples below).

There are two different kinds of values that can be entered (see also the examples on the next page):

1. One or more unallocated results for individual steps
   - **Step 1:** Result(s) for individual step(s) shall be entered in the cells with white background colour in column L for the corresponding step.
   - **Step 2:** In the result section of the pathway, it shall be indicated in columns E and F that an “individual result from a previous calculation” has been inputted, causing the result line(s) (columns A-F) for the individual step(s) in question to become orange-coloured.
2. One result for multiple steps.
   - **Step 1:** One combined result for more than one step shall be entered in the cells with white background colour in column L for the last step in the combined result (so the combined result for cultivation, chipping and transport of chips is put into the result in column L for the step “Transport of wood chips”).
   - **Step 2:** In the cells with white background colour in column L 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, it shall be indicated in rows E and F that a “combined result from a previous calculation” has been inputted. This shall also be done for all the previous steps included in the combined result, causing the result lines (rows A-F) for these steps to become orange-coloured. Land use change (el) as well as improved agricultural management (esca) 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.
   - **Step 4:** If a co-product is formed in one of the steps included in the combined result, then in the BioGrace-II 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. This has to be done as the allocation of emissions to co-products in done when calculating the previous result, and must not repeated in the BioGrace-II Excel tool.

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 and harvesting of stemwood" step in the "wood pellets/briquettes from stemwood" pathway in the BioGrace-II calculation tool. The unit of the result provided is in g $CO_{2,eq}$ per ton of stemwood. This could happen in practice to a company responsible for transport and chipping of stemwood, which gets stemwood 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.

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

- **Step 1**: The result for the "cultivation and harvesting of stemwood" step shall be entered in cell L56.

Cultivation and harvesting			Quantity of product		Calculated emissions			
					Emissions per ton_{wet} Stemwood			
Yield								
Stemwood (Pine)	Give value	ton ha^{-1} $year^{-1}$	1,00 $tonStemwood_{wet}$ / $ton_{Stemwood,input,wet}$		g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Moisture content	50,0%		0,109 $kg_{Stemwood,wet}$ / $MJ_{Wood\ pellets}$					
Energy consumption								
Diesel	2,82	liter / $ton_{Stemwood,wet}$			9.631	-	-	9.631
CH_4 and N_2O emissions from use of diesel (agriculture)		(harvesting and chipping)			-	0,08	0,32	99
				Total	9.631	0,1	0,3	9.729
				Result	g $CO_{2,eq}$ / $ton_{Stemwood,wet}$			9.729

When selecting this cell, a help box appears (see below) which provides more details on how to use the results from previous calculations.

This cell allows to input a result of a previous and partial calculation. A value entered will overwrite the more detailed calculations in this step. Please refer to the user manual (§ 4.2) for further instructions and examples.

- **Step 2**: In the result section at the top of the pathway, the value in cell E9 should be put to "Individual result of previous calculation" using the dropdown list. When selecting cell E9, a help box appears to explain the purpose of this cell and how to select the right value within the dropdown list.

Help for the cell that is selected

Indicate use of previous result

This cell allows to indicate whether for this step the result of a previous and partial calculation has been inputted in the corresponding cell with white background colour in column L in the section "Calculation per individual step in the biomass supply chain" below.

Indicating that a previous and partial calculation has been used will cause that columns A-F of this row are marked with an orange background colour. Doing so allows to easily see that the calculation has been based on a previous and partial calculation and that this excel sheet is used to complete the GHG calculation for the other steps in the pathway.

When a verifier will check this calculation, it is obligatory to indicate using this cell that the result of a previous and partial calculation has been used in column L.

Please refer to the user manual for further instructions and examples.

The line should then become orange-coloured (see figure below).

1					
2	Production of electricity and/or heat, or cooling from **wood pellets/briquettes** from fo				
3					
4	**Overview Results**				
5	Energy carrier (including emissions from the fuel in use)				
6–7	*All results in g $CO_{2,eq}$ / MJ $_{Wood\ pellets}$*	Non- allocated results	Total (allocated results)	Actual/ Default	Default values RED-II
8	Cultivation e_{ec}		1,1	A	1,1
9	Cultivation and harvesting	1,06	1,06	Individual result of pre	1,06
10	Processing e_p		30,0	Individual result of previou / Combined result of previou	29,8
11	Chipping	0,39	0,39		0,39
12	Wood pellet/briquette production	29,58	29,58	-	29,37
13	Transport e_{td}		9,5	A	9,5
14	Transport of stemwood	0,00	0,00	-	
15	Transport of wood chips	1,07	1,07	-	1,03
16	Transport of wood pellets	8,44	8,44		8,41
17	Emissions from the fuel in use e_u		0,3	A	0,3
18	CH_4 and N_2O emissions at final conversion	0,30	0,30		0,30
19	Land use change e_l or e_{sca}	0,0	0,0	-	
20	Bonus	0,0	0,0	-	
21	e_{ccr} + e_{ccs}	0,0	0,0	-	
22	**Totals**	**40,8**	**40,8**		**41**
23					

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 at the "cultivation and harvesting of stemwood" step until the "transport of woodchips" step (also included), in the "wood pellets/briquettes from stemwood plantation" pathway. The unit of the result provided is in g CO_2,eq per ton of wood chips. This could happen in practice to a company which produces pellets from wood chips. To make the calculations, the following steps must be performed:

- **Step 1:** The value must be put into the result in column L for the step "Transport of wood chips" (i.e. cell L118), since it is the last step in the combined result. In this example a value of 17.380 g CO2,eq/ton of woodchips is entered, this value is the sum of the emissions for cultivation and harvesting, transport of stemwood, chipping and transport of wood chips.

	B	C	D	E–G	H	I	J	K	L
93	Extra input lines are not shown				Total	3.639	0,0	0,1	3.677
94									
95						Result g $CO_{2,eq}$ / ton$_{Wood\ chips,wet}$			3.677
96									
97									
98	Transport of wood chips			Quantity of product		Calculated emissions			
99	Yield					Emissions per ton$_{wet}$ Wood chips			
100	Wood chips	1,000	ton$_{Wood\ chips,wet}$ / ton$_{Wood\ chip}$	0,976 ton$_{Wood\ chips,wet}$ / ton$_{Stemwood,input,wet}$		g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
101	Moisture content	50,0%		0,106 kg$_{Wood\ chips,wet}$ / MJ$_{Wood\ pellets}$					
102									
103	Transport per			(Emissions are calculated for transport of 1 ton of wet wood chips)					
104	Truck (40 ton) for liquids and pellets (Diesel)	120	km	120 ton$_{Wood\ chips,wet}$ km / ton$_{Wood\ chips,wet}$		9.968	0,44	0,19	10.037
105	Fuel	Diesel							
116	Extra input lines are not shown				Total	9.968	0,4	0,2	10.037
117									
118						Result g $CO_{2,eq}$ / ton$_{Wood\ chips,wet}$			17.380
119									

- **Step 2**: A "0" is put into the cells with a white background colour in column L for all the previous steps that are included in the combined result: i.e. cells L56 for "Cultivation and harvesting", cell L77 for "Transport of stemwood", and cell L95 for "Chipping" of stemwood.
- **Step 3**: In the result section of the pathway, the value in cells E9, E11, E14, and E15 should be put to "combined result from a previous calculation" using the dropdown list. The lines become orange-coloured (see next figure). Also for e_l and for e_{sca} it shall be indicated in cell E19 that a "combined result from a previous calculation" has been inputted, as to indicate that land use change was already included in the calculation (even if it did not occur, the value for land-use change was then "0").

Production of electricity and/or heat, or cooling from wood pellets/briquettes from f

Overview Results

Energy carrier (including emissions from the fuel in use)

All results in g $CO_{2,eq}$ / MJ Wood pellets	Non- allocated results	Total (allocated results)	Actual/ Default	Default values RED-II
Cultivation e_{ec}		**0,0**	A	**1,1**
Cultivation and harvesting	0,00	0,00	Combined result of pre	1,06
Processing e_p		**29,6**	A	**29,8**
Chipping	0,00	0,00	Combined result of pre	0,39
Wood pellet/briquette production	29,58	29,58	-	29,37
Transport e_{td}		**10,3**	A	**9,5**
Transport of stemwood	0,00	0,00	Combined result of pre	
Transport of wood chips	1,85	1,85	Combined result of pre	1,03
Transport of wood pellets	8,44	8,44		8,41
Emissions from the fuel in use e_u		**0,3**	D	**0,3**
CH_4 and N_2O emissions at final conversion	0,30	0,30		0,30
Land use change e_l or e_{sca}	0,0	0,0	Combined result of pre	
Bonus	0,0	0,0	Individual result of previous	
e_{ccr} + e_{ccs}	0,0	0,0	Combined result of previou	
Totals	**40,2**	**40,2**		**41**

Please note that, as in this way you have made actual calculations for some transport steps and for one of the two processing steps, you shall also make actual calculations for the other processing steps (in this case “Wood pellet/briquette production”) and for the other transport steps (in this case “Transport of wood pellets”). For the emissions from the fuel in use e_u you can chose a disaggregated default value, like shown in the screenshot above by the value “D” In cell E17.

Please also note that the sheet “Final conv. only” should be used in case the previous GHG calculation includes the whole biomass production pathway but not yet the final conversion. It includes the last transport step to the final conversion plant. The more specific pathways (such as “wood pellets/briquettes from forestry residues” should be used if at least the final transport step was not yet included in the previous and partial GHG calculation. This is the reason that in the screen copy above no input is foreseen in cells E16/F16.

4.3 Adding specific standard calculation values for existing input

Standard calculation values are used to convert input numbers into greenhouse gas emissions. The tool applies the same Standard calculation values that the European Commission has used for calculating the default values. However, users can define their own Standard calculation values and use them in the tool. In order to do so, the dedicated Excel sheet named “User defined Standard calculation values” should be used as the Excel sheet “Standard calculation values” is protected and cannot be changed.

Adding new standard calculation values requires applying the following principles:

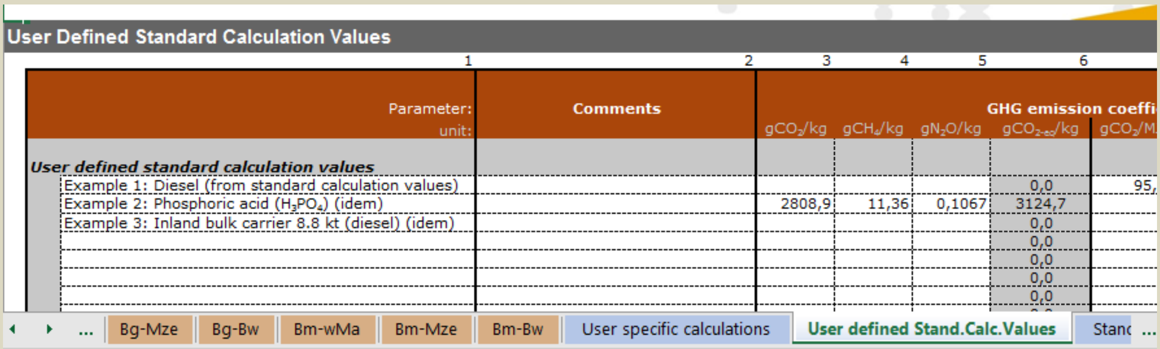
- The name given to the added input in the sheet “User defined standard calculation values” should be different from all the existing names of column C of the “Standard calculation values” sheet;
- The name of the standard calculation value, once defined, has to be written exactly in the same way in calculation sheets where it is used;
- The formulas in columns I, J and K of the calculation sheet have to be checked. In some cases the column position of the LOOKUP function must be modified to give correct calculation outcomes.
- Sources of the data shall be clearly stated (see the BioGrace-II calculation rules)

Step by step example:

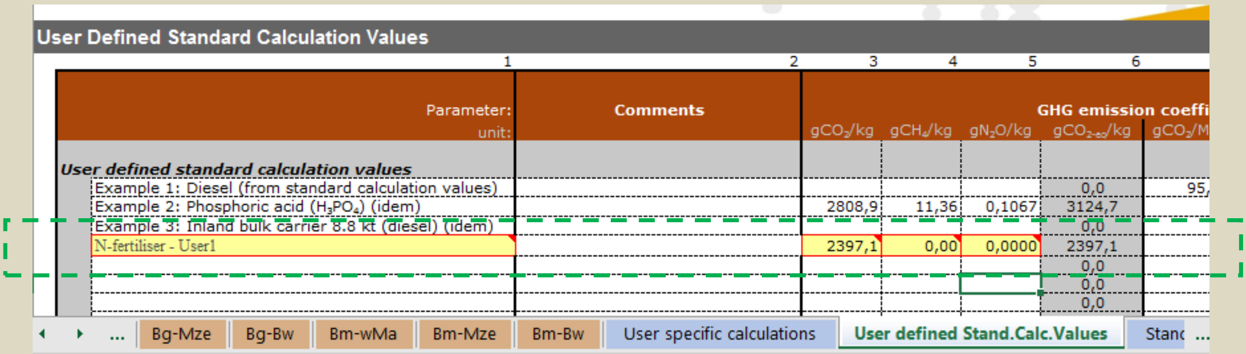
The user wants to add a specific standard calculation value for a specific fertiliser instead of using the N-fertiliser standard calculation value pre-defined in the tool. The following example corresponds to the modification of the standard calculation value used for the N-fertiliser used for the production of electricity, heat or cooling from biomethane from maize.

For that, the following steps must be performed:

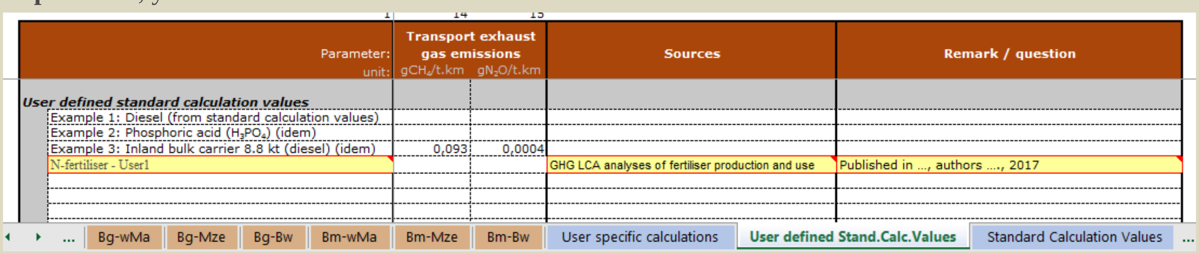
- **Step 1**: first, get to the “User defined standard calculation value” sheet. This sheet is framed exactly the same as the “Standard calculation value” sheet.



- **Step 2**: Write the name in the first available free line of the standard calculation value in column C ("N-fertiliser - User1"). Make sure that the given name is different from any other of your added values and of the "Standard calculation values" sheet.
- **Step 3**: Add your own values in the columns with the appropriate unit (from column E to Q). If you have a unique value in g $CO_{2,eq}$ (and not in CO_2, CH_4, N_2O), then fill out column E or column I in g CO_2 as the columns H and L, with unit “g $CO_{2,eq}$” are calculated automatically and cannot be changed. Please, note that you also have to add “0” to the two other columns (for CH_4 and N_2O) as to avoid error messages in pathway calculation.



- **Step 4**: Then, you need to fill in the column R and S with detailed information on the sources of these data.



- **Step 5**: Go to the pathway where you want to use this modified standard calculation value. Modify the name of the N-fertiliser input called in column B into "N-fertiliser - User1". Give the actual quantity in column C on the same line.

	A	B	C	D	E	F	G	H	I	J	K	L
43												
44	Cultivation of maize				Quantity of product				Calculated emissions			
45		Yield							Emissions per ton$_{wet}$ Maize whole crop			
46		Corn/Maize whole crop	40,756	ton ha^{-1} year^{-1}		1,00	ton$_{Maize\ whole\ crop,\ Input}$ / ton$_{Maize\ whole\ crop,\ Input}$		g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
47		Moisture content	65,0%			0,302	kg$_{Maize\ whole\ crop}$ / MJ$_{Biogas}$					
48												
49		Energy consumption										
50		Diesel	104,3	liter ha^{-1} year^{-1}					8.729	-	-	8.729
51												
52		CH_4 and N_2O emissions from use of diesel (agriculture)							-	0,07	0,29	89
53												
54		Agro chemicals										
55		N-fertiliser - User1	68,1	kg N ha^{-1} year^{-1}					4.007	-	-	4.007
56		Manure	0,0	kg N ha^{-1} year^{-1}					-	-	-	-
57		Biogas digestate	123,8	kg N ha^{-1} year^{-1}					-	-	-	-

- **Step 6**: Check and modify the formulas in columns I, J and K if they are not calling the right columns. This could be the case if the unit of your modified standard calculation value is not the same as the unit of the pre-defined standard calculation value of the same product. First, enter the new unit in column D. Then, to change the formulae follow the example below (the column position to change are shown in yellow):

  Initial formula in cell I55 of the screen copy above :

  C55*VLOOKUP(B55;'Standard calculation values'!$C$9:$Q$272;3; FALSE)/C$46

  New formula in cell I55: C55*VLOOKUP(B55;Standard calculation values'!$C$9:$Q$272;7; FALSE)/C$46

  The numbers "3" and "7"refer to the columns where the values are taken from. This number has to be 7, 8 and 9 (for the formulas in columns I, J and K, respectively) in case the input of the value in cell C55 is MJ input per ton or MJ of biomass, the numbers have to be 3, 4 and 5 if the unit of the value in cell C55 is kg input per ton/MJ biomass.

Second example on electricity from the grid:

A second example is on electricity from the grid. When making an actual calculation, emissions from using grid electricity shall be calculated using the average emission intensity for the country in which the electricity is taken from the grid. Values can be taken from the BioGrace list of additional standard calculation values, as is shown below.

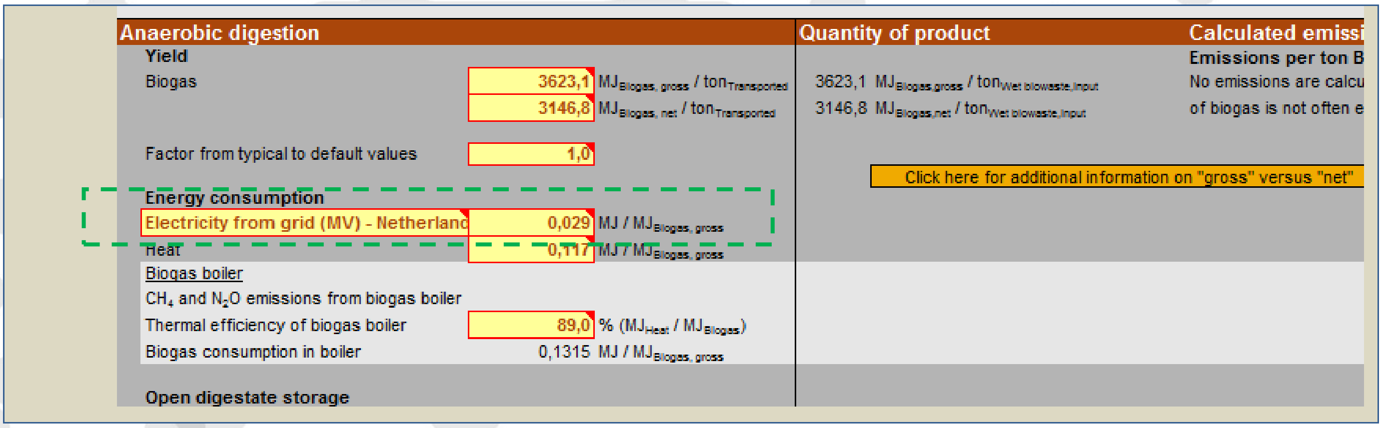
- **Step 1**: copy the information (for the country in which the electricity is taken from the grid) from the BioGrace list of additional standard calculation values into the sheet "User defined Stand.Calc.Values" of the BioGrace-II Excel tool. An example is shown below. Make sure you enter the values in columns I, J and K (with numbers 7, 8 and 9) as the unit of the electricity values is in g CO_2/CH_4/N_2O **per MJ** of electricity.

User Defined Standard Calculation Values

1	2	3	4	5	6	7	8	9	10
Parameter:	Comments	GHG emission coefficient							
unit:		gCO_2/kg	gCH_4/kg	gN_2O/kg	$gCO_{2\text{-}eq}$/kg	gCO_2/MJ	gCH_4/MJ	gN_2O/MJ	$gCO_{2\text{-}eq}$/MJ
User defined standard calculation values									
Example 1: Diesel (from standard calculation values)					0,0	95,1	0,00	0,0000	95,1
Example 2: Phosphoric acid (H_3PO_4) (idem)		2808,9	11,36	0,1067	3124,7				0,0
Example 3: Inland bulk carrier 8.8 kt (diesel) (idem)					0,0				0,0
					0,0				0,0
Electricity from grid (MV) - Netherlands					0,0	146,8	0,00	0,0000	146,8
					0,0				0,0
					0,0				0,0
					0,0				0,0
					0,0				0,0

... | PVO-Wo | Af-Aw | Bg-wMa | Bg-Mze | Bg-Bw | Bm-wMa | Bm-Mze | Bm-Bw | User specific calculations | User defined Stand.Calc.Values | Stand ...

- **Step 2**: Use this user-defined standard calculation value to make your actual calculations, as is shown below. Enter the quantity of electricity in the unit shown in the tool (here in MJ of electricity per MJ of Biogas produced in the digester).



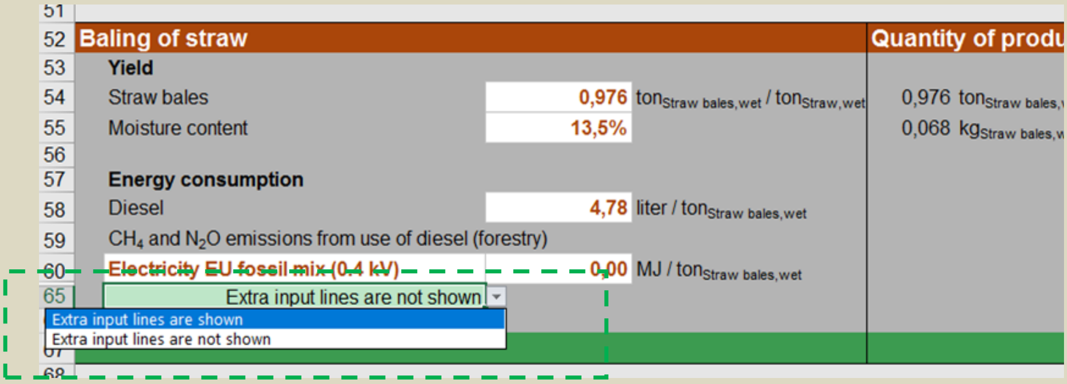
Anaerobic digestion			Quantity of product	Calculated emissi
Yield				**Emissions per ton B**
Biogas	3623,1	$MJ_{Biogas, gross}$ / $ton_{Transported}$	3623,1 $MJ_{Biogas,gross}$ / $ton_{Wet\ biowaste,input}$	No emissions are calcu
	3146,8	$MJ_{Biogas, net}$ / $ton_{Transported}$	3146,8 $MJ_{Biogas,net}$ / $ton_{Wet\ biowaste,input}$	of biogas is not often e
Factor from typical to default values	1,0		Click here for additional information on "gross" versus "net"	
Energy consumption				
Electricity from grid (MV) - Netherland	0,029	MJ / $MJ_{Biogas, gross}$		
Heat	0,117	MJ / $MJ_{Biogas, gross}$		
Biogas boiler				
CH_4 and N_2O emissions from biogas boiler				
Thermal efficiency of biogas boiler	89,0	% (MJ_{Heat} / MJ_{Biogas})		
Biogas consumption in boiler	0,1315	MJ / $MJ_{Biogas, gross}$		
Open digestate storage				

4.4 Adding additional input using additional standard calculation values

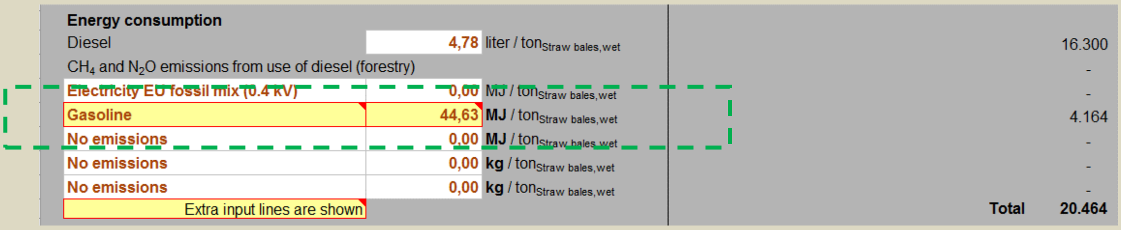
Step by step example:

If the tool user wants to add a new input in one of the pathways, 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 an input and check whether the module already contains lines for additional input. If there is a green cell with the text “Extra input lines are not shown” then the extra lines can be made visible by clicking on this cell and selecting “Extra input lines are shown”.

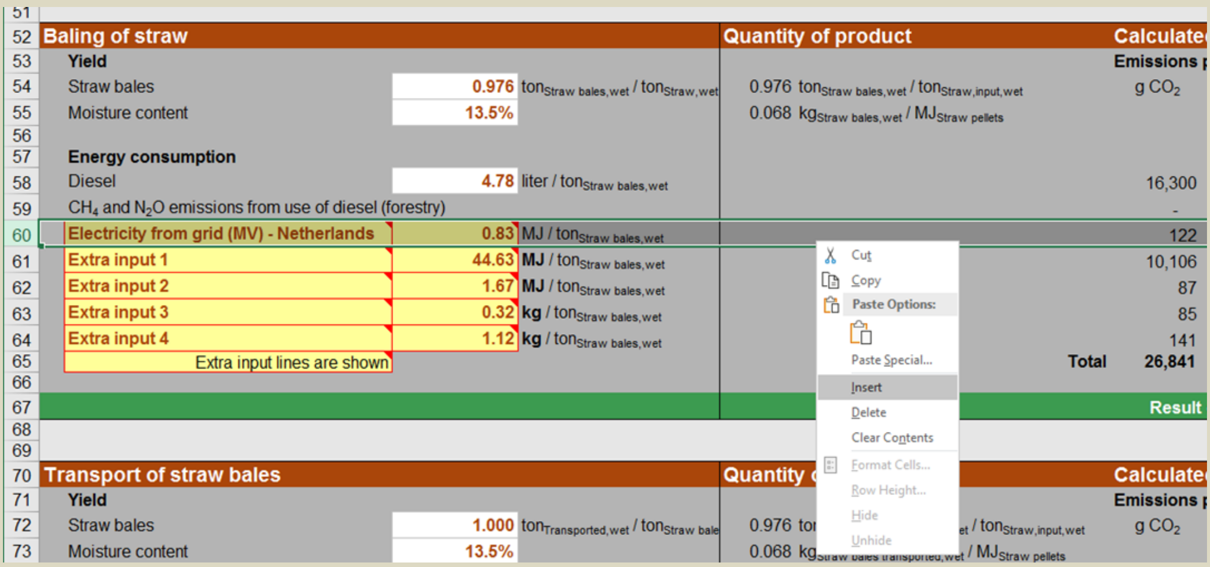


- **Step 2:** In such a case you can enter the input name and amount in the white cells, taking care to use the correct line with correct unit (either MJ or kg).

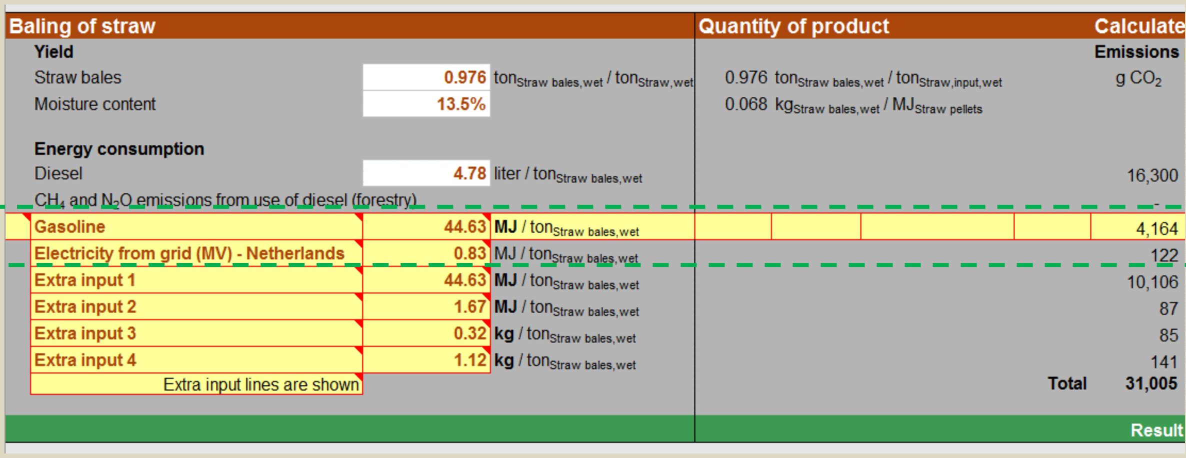


  When no extra input lines are available or when you have more extra inputs than extra input lines are available, then follow steps 3 to 6 below.

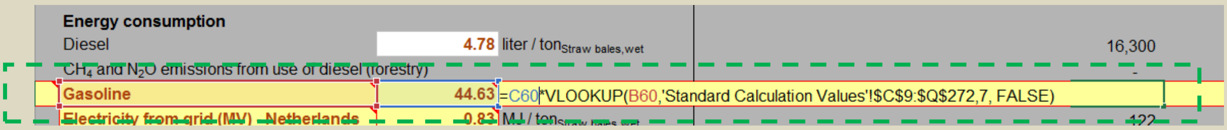
- **Step 3**: Insert a new line with the function "insert" of Excel (right click).



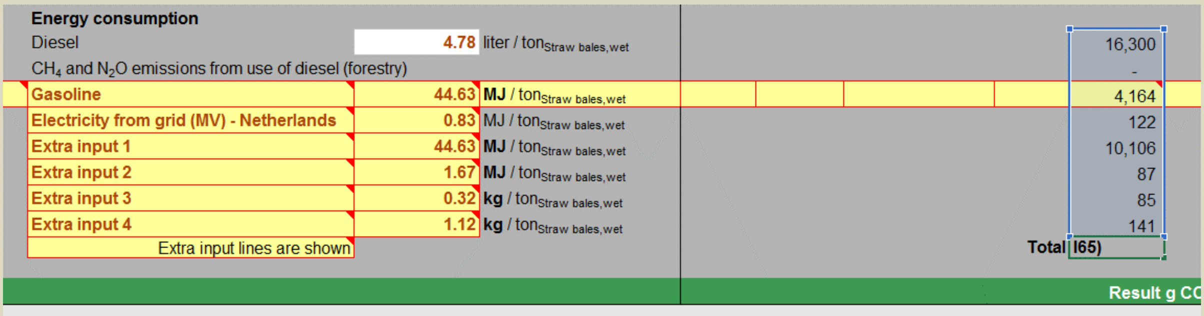
- **Step 4**: Copy the content of an entire row (for instance the row with “Extra input 1” into the new empty row. Take a row in which the unit is the same as the unit of the value that you are about to enter. Copying an entire row will copy all formula’s needed to make the calculation. Then, fill in the name of the input (column B) and the quantity used (column C). Please check that the name of the added input is the same as in the table of the "Standard calculation value" sheet. Also verify that you use the same unit as existing inputs.



- **Step 5**: On the same line, check the calculation formulas in columns I, J and K plus N, O and P. You can compare the calculations with how other calculations for inputs with the same unit are performed. If you are unsure if a formula is correct, then fill out the same input name and amount as in another row, check if the outcome is the same, and then change the input name and amount back to the new input that you want to add.



- **Step 6**: Check that the "Total" line is correctly taking into account the added input. For that, the sum in column I to K and N to P must include the added line.



4.5 Adding a new input in a pathway

Adding a new input that does not yet exist in the BioGrace-II calculation tool can be done by using the two previous step-by-step tutorials.

You will first have to add a new standard calculation value in the sheet "User defined standard calculation values", then insert your new input in the biofuel-pathway you are working on.

4.6 Using disaggregated default values

In case you want to make an actual calculation for part of the biomass production pathway, you can use disaggregated default values for other parts of the pathway. You can do so by selecting one or several "D's" in column E in the "Overview Results" section of the Excel sheet. An example is given in the screen copy below for a pathway in which only actual calculations are made under "Processing". Please note that in this case actual values must be given for all input values (cells with white or yellow background) in all steps under "Processing". See also paragraph 2.4 in the BioGrace-II calculation rules.

The disaggregated default value will overwrite the calculation, as can be seen for the transport steps below: the actual transport emissions sum up to 7.8 g $CO_{2,eq}$ per $MJ_{Wood\ pellets}$, this value is overwritten by the disaggregated default value (for this pathway and with configuration "Natural gas boiler" and transport distance "2.500 – 10.000 km") of 5.2 g $CO_{2,eq}$ per $MJ_{Wood\ pellets}$.

Overview Results

Energy carrier (including emissions from the fuel in use)

All results in g $CO_{2,eq}$ / $MJ_{Wood\ pellets}$	Non- allocated results	Total (allocated results)	Actual/ Default		Default values RED-II
Cultivation e_{ec}		0.0	D		0.0
Feedstock is a residue	0.00	0.00		-	0.00
Processing e_p		25.0	A		30.9
Forest residues collection	0.87	0.87		-	1.83
Chipping	0.55	0.55		-	
Wood pellet/briquette production	23.53	23.53		-	29.08
Transport e_{td}		5.2	D		5.2
Transport of forestry residues	0.00	0.00		-	0.00
Transport of wood chips	0.53	0.53		-	0.51
Transport of wood pellets	7.26	7.26			4.65
Emissions from the fuel in use e_u		0.3	D		0.3
CH_4 and N_2O emissions at final conversion	0.30				0.30
Land use change e_l or e_{sca}	not applicable				
Bonus	not applicable				
e_{ccr} + e_{ccs}	0.0			-	
Totals	**33.0**				**36**

Actual (A) or Default (D) value
This cell allows you to choose between using the disaggregated default value (in column G) or the result of the actual calculation from the section "Calculation per individual step" below.

A
D

Final energy

Electricity	
All results in g $CO_{2,eq}$	
Allocation factor	Allocated results
74.8%	**22.8** per MJ pellets
	54.2 per MJ electr.

GHG emission reductio

Electricity
70%

5 Function 3: Using the tool to creating a new pathway

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

In case you consider hiring an LCA/Excel expert to do the work for you, then there are two options:

1. You look for an expert yourself. The expert that you hire will make the changes with the "track changes" button left to on. It is possible to create modified pathways in this way, a number of pathways have already been modified in this way. However, the layout of such pathways will be poor due to the fact that the "track changes" button should not be turned to "off" in case the calculations will be checked by an auditor at a later moment of time.
2. It is possible that the BioGrace-I or BioGrace-II scheme holder modifies pathways or adds new pathways to the tool. These pathways will then be made publicly available without any prefilled input values and with the track change mode turned to "on". These pathways will not be integrated in the main BioGrace-I or BioGrace-II tool but published as separate files. On the BioGrace-I part of the website www.BioGrace.net some examples of such modified pathway files can be found. The three advantage of this option 2 are that (a) the modified tool will be in the same layout; (b) the modified calculations will be made and then double-checked by BioGrace scheme holders; and (c) as the modified pathway will be available through the BioGrace website, auditors will know that this version was created by or with cooperation from the BioGrace scheme holder. Please note that – just like option 1 above – such modifications can probably not be implemented for free; a contract will be needed.

Contact the BioGrace scheme holder in case you would like to investigate this option 2 further.

Below, a short tutorial is provided to highlight major steps in case you would like to make the modifications yourself:

- **Step 1:** Copy an existing pathway and rename it. Choose the pathway that is the closest to yours.
- **Step 2:** Erase all data in the white cells of column C. Erase the names of inputs and outputs in column B when they are not necessary. Also erase all values in column G (under "Default values RED-II) in the "Overview Results" section, as there are no default values nor disaggregated default values nor JRC calculation results available for pathways other than the pathways that are included in the BioGrace-II Excel tool as downloaded from the BioGrace website.

  Make sure to keep the result overview box at the top of your pathway, the "Overall yield per kg input" in cell "C40" (see 2.3.1 The "Values calculated from complete pathway" box) and the 4 generic modules ("Final conversion (CH_4 and N_2O emissions only)" - except for biogas or biomethane injection -, "Improved Agricultural Management", "CO_2 capture and replacement"/"CO_2 capture and geological storage", and "Consistency check").
- **Step 3:** The most important part is to define the frame of the new pathway, meaning the numbers of steps, the allocations when needed, etc. This frame is to be translated in independent modules. To add new lines, please use the "insert line" function of Excel by right clicking on the appropriate line. Make sure to add allocation modules right after the separation step of any co-products that are formed in your production pathway.

- **Step 4:** Fill in the new frame with appropriate inputs and outputs into column B, with the associated input numbers in column C. The user of the tool needs to pay particular attention to the units in which the input numbers are expressed. Units in column D have to be compatible with the units of the standard calculation value in the “standard calculation value” sheet.
- **Step 5:** Add new standard calculation values if needed (for more detail, please refer to "adding new standard calculation values" part in the previous paragraph 4.3 “Adding specific standard calculation values for existing input”).
- **Step 6:** Adapt the formulas of the columns I to K and N to P when needed (see "adding a new input" part in the previous paragraph 4.4 “Adding additional input using additional standard calculation values” for more details).
- **Step 7:** Add, if necessary, comments or intermediate calculations in columns E to G.
- **Step 8:** Adapt all the summing cells from the allocation module, the consistency check module and the “Values calculated from complete pathway” box.
- **Step 9:** Adapt the overview results box to your new pathway by inserting lines and linking cells to each name and results obtained. Make sure that these new results are also added in the overall result of the pathway, by checking the sums for cultivation, processing and transport. Also make sure to include the correct allocation factor in column D of the “Overview Results” section.
- **Step 10**: Make sure that in each step, the “quantity of product” number in column E is correctly calculated. It must be the product of the yield in that step, multiplied by the “quantity of product” number from the previous step.
- **Step 11**: Make sure that the number “Overall yield per kg input” in cell “C40” is calculated correctly. It has to include the yield factors in all the separate steps.
- **Step 12**: Finally, adapt the calculations in the box “Consistency check” at the bottom of the sheet. The calculations have to include the results (in column Q) from every step in the production pathway. In case there is no allocation to co-products, the two calculations are the same. In case there is allocation to co-products, please learn from other pathways (for instance “PVO from Rapeseed”) how to calculate the number “Total emissions with allocation”.

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 crop cultivation has a different carbon stock per hectare than a reference situation (e.g. conversion of non-highly biodiverse grassland land into short rotation forest). RED-II Annex VI.B point 10 (as well as RED-II Annex V.C point 10) refers to 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" to determine when and how to take these carbon changes into account. Please note that the European Commission will review these guideline by 31 December 2020, this review might result in an actualisation of the LUC and Esca sheets in the BioGrace-II Excel tool and in a corresponding actualisation of paragraphs 6.1 and 6.2 of this User manual.

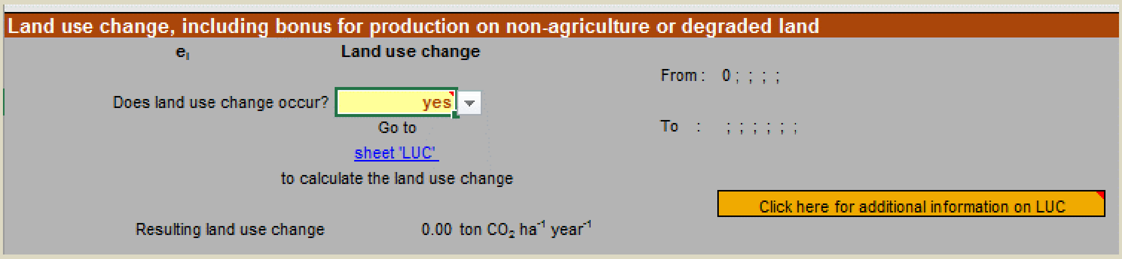
A dedicated module is available in the BioGrace-II tool near the bottom of each pathway. It will collect the emissions caused by carbon stock changes from the LUC sheet. Thus you will need to fill in this LUC sheet to calculate your actual changes in carbon stock. A declared LUC for a pathway will apply 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 short rotation forest), please use a separate copy of the BioGrace GHG calculation 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:

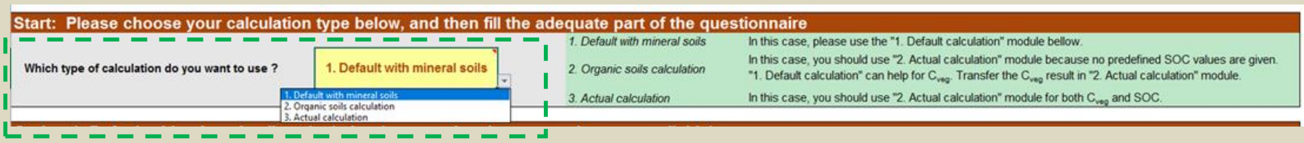
If you need to take into account a Land Use Change for a pathway (for instance it is not the case when the energy carrier is a residue), please apply the following steps:

- **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.

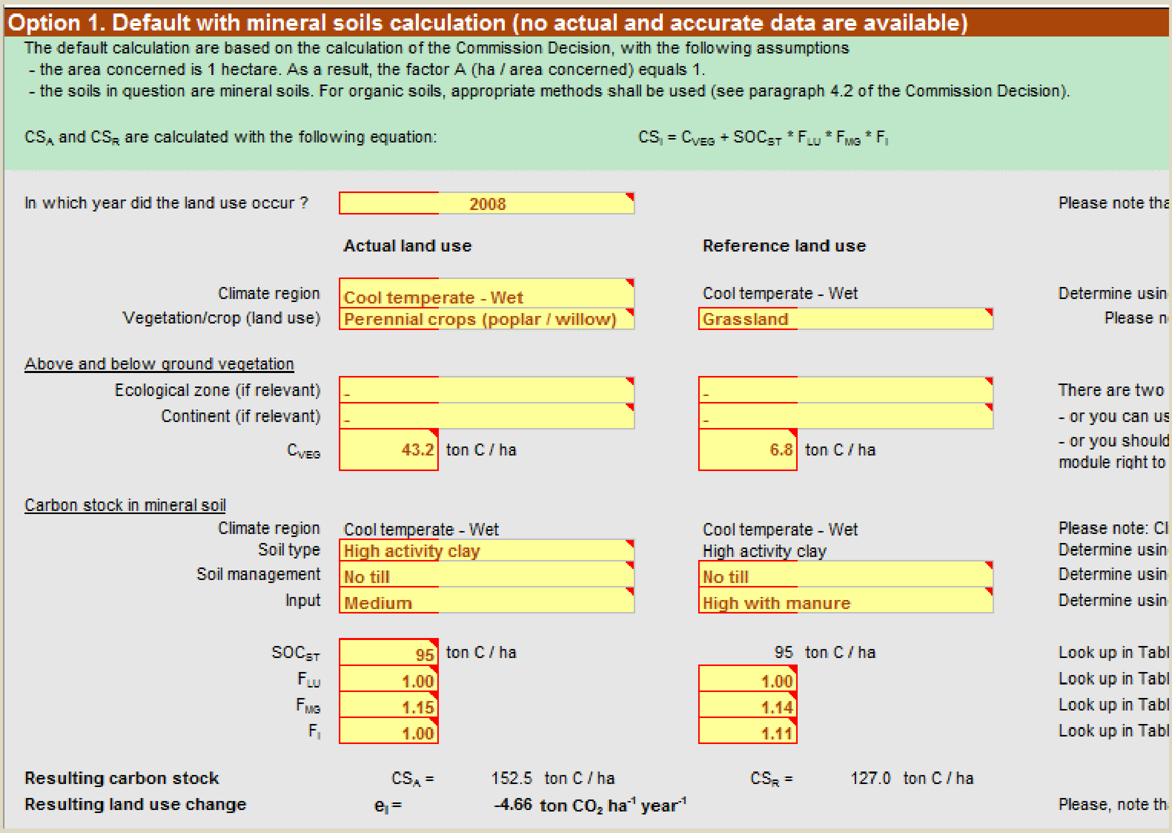


- **Step 2**: Open the document Commission Decision of 10 June 2010 on guidelines for the calculation of land use carbon stocks for the purpose of Annex V of Directive 2009/28/EC, in most cases (unless you will use another model to calculate the land use change) you will need this document.
- **Step 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. Three kinds of calculation are possible according to the type of the soil and the information collected:
  1. With mineral soils 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 with mineral soils),

2. If you have your own value for carbon stocks calculated according to the guidelines in the same Commission Decision (called actual calculation),
3. With organic soils, default values do not exist for the whole formula, so a mix of default and actual calculation can be used according to the guidelines in the same Commission Decision (called Organic soils calculation)



- **Step 5**: **Option 1 - Default calculation with mineral soils**: 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" contains Tables 1 – 18 with the numbers you need for the calculation. Look for the information matching your soil type, climate region, land use and land management, and continent (for the vegetation values). Copy these values into the white cells of the sheet "LUC" in the BioGrace-II Excel tool. These cells are not using a pre-defined list. You should refer to the information given in column L to find the correct tables from the Commission Decision. Please, use the same wording than the one used in the Commission Decision. Note that cells without a white background (as to indicate an input field) are automatically filled from other cells. For that, begin by filling the "actual land use" part. In the example bellow, the actual land use is a perennial crop (such as poplar or willow). Default values provided in the Commission Decision paragraph 8, have been used for the estimation of C_{veg} both for the actual and the reference land use.



- The resulting LUC is calculated at the bottom part of the above screen copy by applying the RED-II methodology. A negative value shows an increase in the carbon stock from the reference to the actual situation.
- **Step 6**: **Options 2 and 3 – (Partial) 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 should be added in order to keep track of the source and quality of these data. In case of methods other than measurements, you should 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 (C_{VEG}) for actual and reference uses. The formula from the RED-II

methodology is then used to get the annual carbon changes.

Organic soils
For organic soils, refer to paragraph 4.2 of the guidelines published by the Commission (see above for the link). Where carbon stock affected by soil drainage is cc
the basic methodology described by IPCC starting from the equation 2.26 on page 2.35 of http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_02_

If using data from other methods than measurements :
Please confirm that they take into account :

climate	yes
soil type	yes
land cover	yes
land management and inputs.	yes

Resulting carbon stock in soils	SOC_A =	43.2	ton C / ha	SOC_R =	6.8	ton C / ha	Please, fill these data v
Resulting carbon stock in vegetation	C_{veg-A}=	109.6	ton C / ha	C_{veg-R}=	119.1	ton C / ha	Please, fill these data v
	CS_A =	152.8	ton C / ha	CS_R =	125.9	ton C / ha	
Resulting land use change	e_l =	-4.93	ton CO_2 ha^{-1} $year^{-1}$				Please, note that positi

- **Step 7**: **Organic soils calculation:** for organic soil, actual calculations must be made for the evaluation of the SOC. For C_{VEG} you can use values from tables 9 – 18 from the Commission Decision.
- **Step 8**: Check in the last line that the proper value is called (either from "Option 1" or from "Options 2 and 3". If this is not the case, get back to step 4 and choose the appropriate calculation type.

Result of the LUC calculation

LUC value to report in your pathway : -4.66 ton CO_2 ha^{-1} $year^{-1}$ **Based on:** Option 1. Default with mineral soils calculation (no actual and accurate data are available)

- **Step 9**: Check in the bioenergy production pathway where you need to declare a Land Use Change that the LUC value is there once you have selected "yes" on the question "Does land use change occur?". Please, also check that no Improved agricultural management is declared in the module right below (See the next section for more information).

Land use change, including bonus for production on non-agriculture or degraded land

e_l	Land use change			Emissions per g CO_2
Does land use change occur?	yes	From :	Cool temperate - Wet ; Grassland ; - ; No till ; High with manure	
Go to sheet 'LUC' to calculate the land use change		To :	Cool temperate - Wet ; Perennial crops (poplar / willow) ; - ; - ; High activity clay ; No till ; Medium	
			Click here for additional information on LUC	
Resulting land use change	-4.66 ton CO_2 ha^{-1} $year^{-1}$			-21.55
			Please, note that positive value means soil carbon losses	
Bonus (eB)	0 g $CO_{2,eq}$ / $MJ_{Wood\ chips,wet}$			0.00

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, reduced 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. The paragraph above on LUC contains a step-by-step tutorial.

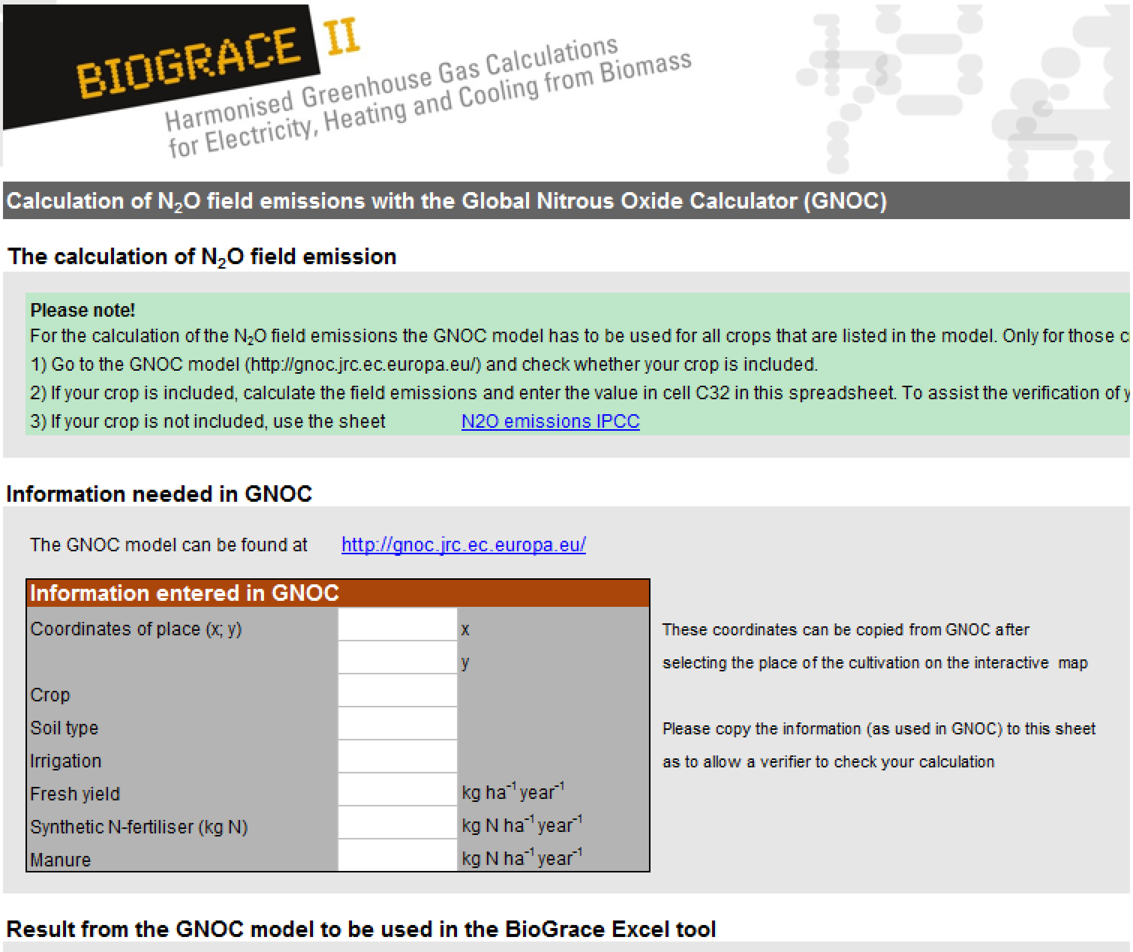
The main difference comes from the fact that only carbon stock in soil is taken into account. Please also note that e_{sca} has a different sign than e_l: a positive e_{sca} means that soil carbon stocks are increasing and thus that the GHG emissions of the pathway will decrease, whereas a positive e_l means carbon stock losses and hence increasing GHG pathway emissions. This difference is caused by the definition of soil carbon accumulation (RED-II Annex V.C.6 / VI.B.6) and the formula for land use change in RED-II Annex V.C.7 and VI.B.7.

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 should use the LUC sheet. **Do not use E_{sca} sheet if a land use change is also declared for the same final energy.**

6.3 How to use the N_2O emissions GNOC sheet?

The sheet "N_2O emissions GNOC" must be used to estimate N_2O field emissions for all the types of crops available in the GNOC tool: http://gnoc.jrc.ec.europa.eu. The tool contains a list of crops for which calculations can be made.

The sheet "N_2O emissions GNOC" in the BioGrace-II Excel tool (see screen shot below) is not meant to make any calculation, but to gather all information that has been used to make the calculations. These calculations must be done directly on the GNOC website.


BIOGRACE II
Harmonised Greenhouse Gas Calculations for Electricity, Heating and Cooling from Biomass

Calculation of N_2O field emissions with the Global Nitrous Oxide Calculator (GNOC)

The calculation of N_2O field emission

Please note!
For the calculation of the N_2O field emissions the GNOC model has to be used for all crops that are listed in the model. Only for those c
1) Go to the GNOC model (http://gnoc.jrc.ec.europa.eu/) and check whether your crop is included.
2) If your crop is included, calculate the field emissions and enter the value in cell C32 in this spreadsheet. To assist the verification of y
3) If your crop is not included, use the sheet N2O emissions IPCC

Information needed in GNOC

The GNOC model can be found at http://gnoc.jrc.ec.europa.eu/

Information entered in GNOC		
Coordinates of place (x; y)		x
		y
Crop		
Soil type		
Irrigation		
Fresh yield		kg ha^{-1} $year^{-1}$
Synthetic N-fertiliser (kg N)		kg N ha^{-1} $year^{-1}$
Manure		kg N ha^{-1} $year^{-1}$

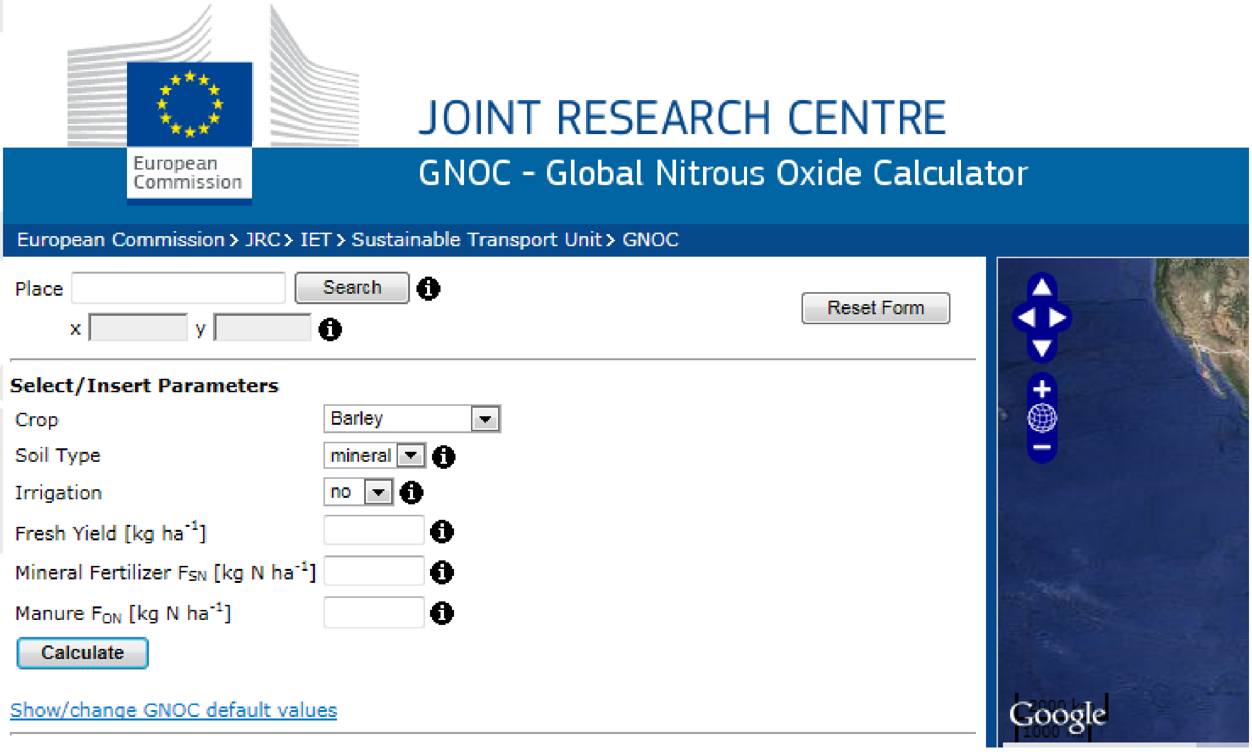
These coordinates can be copied from GNOC after selecting the place of the cultivation on the interactive map

Please copy the information (as used in GNOC) to this sheet as to allow a verifier to check your calculation

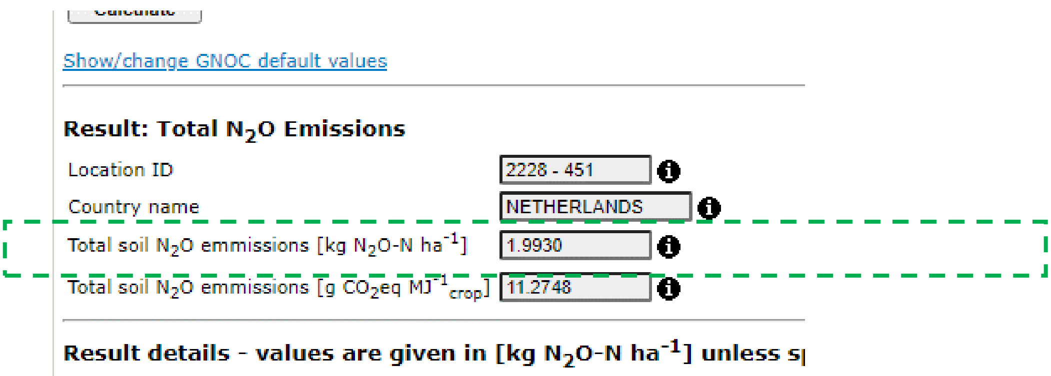
Result from the GNOC model to be used in the BioGrace Excel tool

The GNOC online tool (see screen copy below) evaluates direct and indirect N_2O field emissions combining IPCC (2006) TIER 1 and 2 approaches and the statistical model developed by Stehfest and Bouwman (2006) for direct emissions from mineral and organic fertilizers.

To use this tool, the minimum information required is (see screen copy above): the location of the field or forest, the crop type, the type of soil (organic / mineral), the use of irrigation, the fresh yield, and the amount of synthetic and organic N-fertilizers used. For actual calculations, more specific information can be used regarding the following parameters: environmental parameters, crop residue parameters, conversion factors. For more detail on the GNOC and its calculations, please refer to the GNOC website, and its online tool manual.



Once the user has provided all relevant information, the website provides the result total N_2O emissions (see figure below). Note that the calculation gives results in kilogram N (as part of N_2O) per hectare per year. These are converted into the unit "kilogram N_2O per hectare per year" as this unit is used throughout the BioGrace Excel tool. Therefore you should take the result (2.2523 in the example below) and multiply it by 1.53743[4] to get the result in the proper unit (which is kg N_2O/hectare) to report in your pathway.



[4] 44/28=1.57143 kg N_2O/(kg N in N_2O)

Please fill out both the input information as well as the result (see screen shot above) in the sheet "N_2O emissions GNOC" in the BioGrace-II Excel tool, as is demonstrated below.

Information needed in GNOC

The GNOC model can be found at http://gnoc.jrc.ec.europa.eu/

Information entered in GNOC		
Coordinates of place (x; y)	5.6573	x
	52.4493	y
Crop	Rapeseed	
Soil type	Mineral	
Irrigation	No	
Fresh yield	3372.1	kg ha^{-1} $year^{-1}$
Synthetic N-fertiliser (kg N)	142.0	kg N ha^{-1} $year^{-1}$
Manure	0.0	kg N ha^{-1} $year^{-1}$

These coordinates can be copied from GNOC after selecting the place of the cultivation on the interactive r

Please copy the information (as used in GNOC) to this s as to allow a verifier to check your calculation

Result from the GNOC model to be used in the BioGrace Excel tool

Results from GNOC to be used in the BioGrace Excel tool		
Result from GNOC website	1.9930	kg N_2O-N ha^{-1} $year^{-1}$
Result to be used in this Excel tool	3.1319	kg N_2O ha^{-1} $year^{-1}$

Please note! The value from GNOC
The difference is a fa
The value to be used

Then, you can fill out the value 3.1319 kg N_2O ha^{-1} $year^{-1}$ in the sheet "PVO-Rs" when making an actual calculation on the cultivation of rapeseed, as is shown below.

Pesticides	5.9	kg ha^{-1} $year^{-1}$	19,613
Seeding material			
Seeds- rapeseed	32.0	kg ha^{-1} $year^{-1}$	4,279
Emissions from the field			
Field CO_2 emissions (acidification)	0.0	kg ha^{-1} $year^{-1}$	-
Extra input lines are not shown			**Total 279,384**
			Result g
N_2O emissions from rapeseed cultivation		**Quantity of product**	**Calculated e** **Emissions pe** g CO_2
Field N_2O emissions	3.13	kg ha^{-1} $year^{-1}$	-
Field N_2O emissions can be calculated in the sheet N2O emissions GNOC			**Total** -
			Result g

6.4 How to use the N_2O emissions IPCC sheet?

For crops that are not covered by the GNOC, a specific module in the sheet "N_2O emissions IPCC" is dedicated to this calculation.

The sheet "N_2O emissions IPCC" of the BioGrace-II tool follows IPCC guidelines 2006 for N_2O emission calculation plus the refinements from 2019, as explained in chapter 11 "N_20 emissions from managed soils and CO_2 emissions from lime and urea application". At the beginning of the "N_2O emissions IPCC" module, a short introduction presents the methodology used with the additional hypothesis used in JRC calculations that have been incorporated in the module. This module details the calculation of the three N_20 emission sources that occur during the agricultural step: direct N_2O emissions from the field, indirect N_2O emissions due to leaching and runoff and indirect N_2O emissions due to NH_3 and NOx volatilization.

Step by step example:

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

- **Step 1**: Choose the name of the crop and the general information about your pathway in the Crop data box. You can choose between 3 different crops (Eucalyptus, Poplar, Corn/maize whole crop) or add crops (see step 2).

Crop data. See Tables at right side of this sheet

Please enter the data for your crop in the cells with white background colour

General information

Crop name	Poplar	
Crop yield (fresh matter)	28000	kg $_{fm}$/ha/year
Moisture content (%)	50%	
Crop yield (dry matter)	14000	kg $_{dm}$/ha/year

Abbreviation glossary :	
Fresh matter =	fm
Dry matter	dm
Tonne	t
N mass in N_2O	N_2O_N

Is the soil water saturation high ? No

Put "yes" when the crop is irrigated OR when rainfall in rainy season (1) minus potential evaporation is higher than soil water holding capacity. If not known, the average nitrate leakage will be applied.
(1) Rainy season: period when rainfall > 0.5 * Pan Evaporation

- **Step 2**: To calculate N_2O emissions for a crop that is not listed in Table 1, then enter the name of the crop plus the LHV value 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 chapter 11, Table 11.2.

<---------- From Table 11.1a in IPCC 2019 ----------> from tabel 11.2 in IPCC 2019 -->
<---- in case $R_{AG(T)}$ is unknown, for alternative calculation of AGDM(T),

Table 4	$N_{AG(T)}$	$N_{BG(T)}$	$R_{AG(T)}$	$RS_{(T)}$	slope	intercept	sources
Corn/maize whole crop	0.0060	0.0070	1.00	0.22	1.03	0.61	IPCC 2019, vol.4 chap.11
New crop1							
New crop2							
New crop3							
New crop4							
New crop5							
New crop6							

- **Step 3**: In case of Land Use Changes (LUC) or modified management practices, then the "LUC" or "Esca" sheets should be used to calculate the carbon loss and enter the value in cell D41. Go to paragraphs 6.1 and 6.2 of this manual for more information on these sheets.

Specific information in case of Land Use Change or modified management practices

What type of land use change is it ?	Not concerned	
Carbon loss due to land use change	0.0	t/ha/year

Use "arable to arable land" in case of modified practices
Please, calculate this value by using the LUC sheet or the ESCA sheet for modified practices (2)
(2) If the Esca sheet gives negative value then there is a C loss due to a change in management and the value obtained (with a positive sign) should be inserted here

- **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. Please note that these values have to be entered in "kilogram Nitrogen", so if the organic fertiliser gift is 10.000 kg per year and the nitrogen content is 0,4 wt%, then please enter "40 kg N". 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. Also the ***indirect*** N_2O emissions from managed soils are calculated automatically using the input data. Intermediate calculations for N_2O indirect emissions due to NH_3 + NOx volatilization and leaching are shown in Tables 6 and 7 (resp.).

- **Step 5:** The total N_2O emissions are given with orange background at the bottom of the sheet.

TOTAL N_2O EMISSIONS (Direct + Indirect N_2O) from managed soils (Tier1)

	kg N_2O_N/ha/year			kg N_2O/ha/year		
	average	min	max	average	min	max
per ha	1.18	0.08	3.05	1.85	0.13	4.80
per kg dm	0.08	0.01	0.22	0.13	0.01	0.34
per MJ of crop	0.00	0.00	0.01	0.01	0.00	0.02

Value to report in your pathway : 1.85 kg N_2O/ha/year

6.5 How to use the “Final conversion only” sheet?

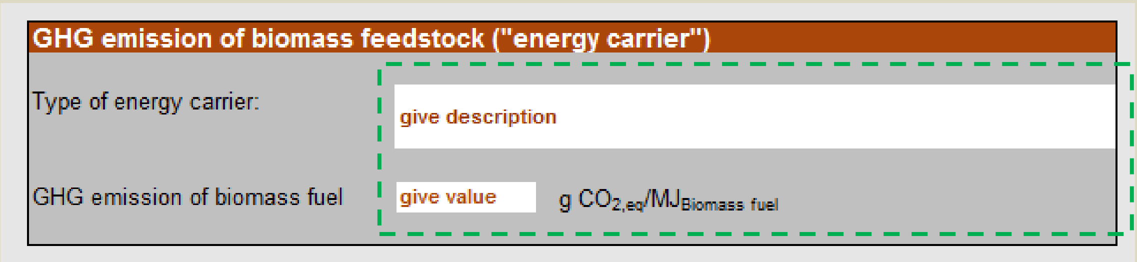
This sheet is to be used only by companies that buy ready to use energy carriers and transform it into final energy. This sheet will allow them to calculate the GHG emission reduction.

The following step by step example explains this sheet. To be able to use this sheet the companies shall get information regarding the energy carriers they bought (the methodology used for previous steps calculations, etc.) and information about the final energy it will be transformed into.

Step by step example:

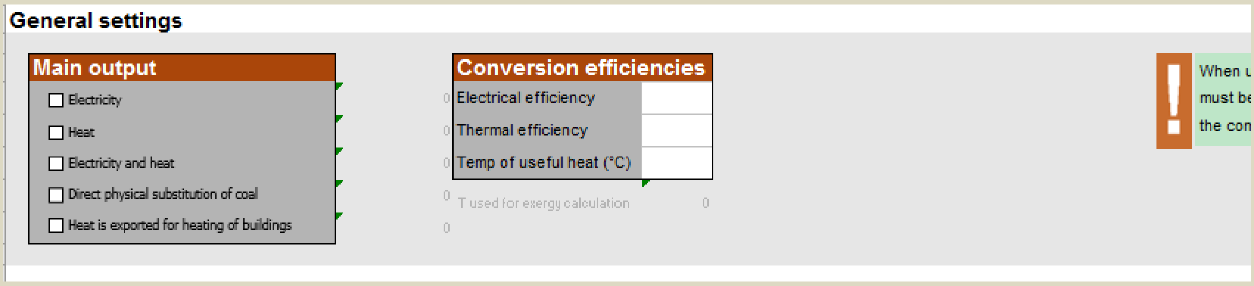
For GHG emissions calculations from a ready to use energy carrier, please apply the following steps:.

- **Step 1**: Provide information on the type of final energy carrier (give a small description) and the total GHG emissions from all previous steps of the pathway.

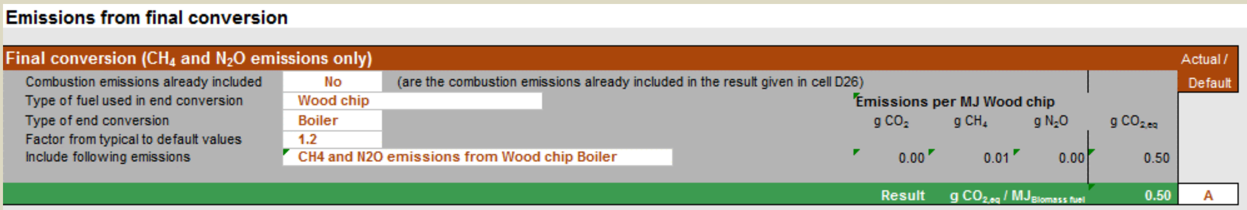


  Note: If the energy carriers (e.g. pellets or chips) arrive at a sea harbour, you will have to calculate the inland transport via truck or ship. This can be done by using the corresponding pathway sheet (e.g. pellets from forestry residues) and adapting the final transport step (e.g. transport of wood pellets). The resulting emissions per MJ energy carrier have to be added to the GHG emissions that you received together with the energy carrier.

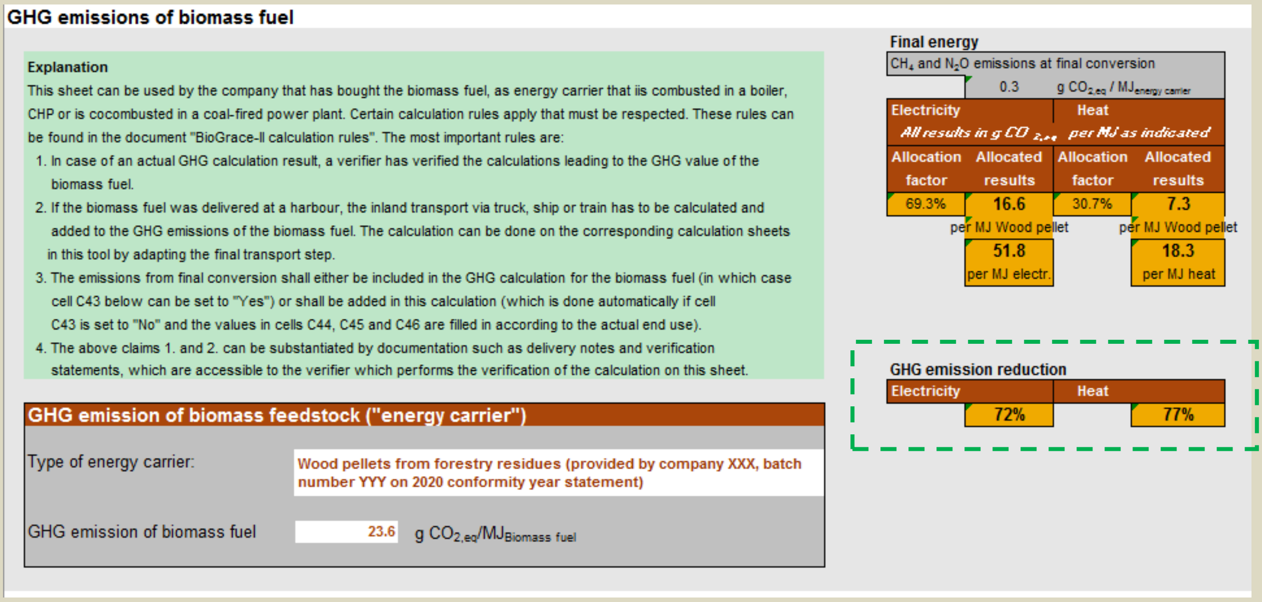
- **Step 2: Fill in the “General settings” box**. In this box the user should provide information on the final energy produced: the main type of output, and the process efficiency associated with the final conversion of the pathway.



- **Step 3**: **Fill in the “CH4 and N$_2$O emissions” box.** In this box the user should provide further information on the type of final energy carrier, and on the type of end conversion so that CH_4 and N_2O emissions related to final conversion can be estimated. Then the user can decide to use default values “D” or actual calculations “A”. For actual calculations, the emission factors related to certain combinations of fuel used and type of end conversion are provided in the tool. If, after filling the box, the value in cell L45 is an error (#N/A), then it means that no emission factor is provided for this process. Then the user can either decide to use a default value “D” (from RED-II Annex VI.C) or to provide his own estimation from a reliable source that must be mentioned.



- **Step 4**: The total GHG emission reductions are given at the bottom of the results box.



6.6 How to use the Co-digestion sheets?

There are 3 sheets in the tool for the calculation of GHG emissions related to co-digestion of biomass:

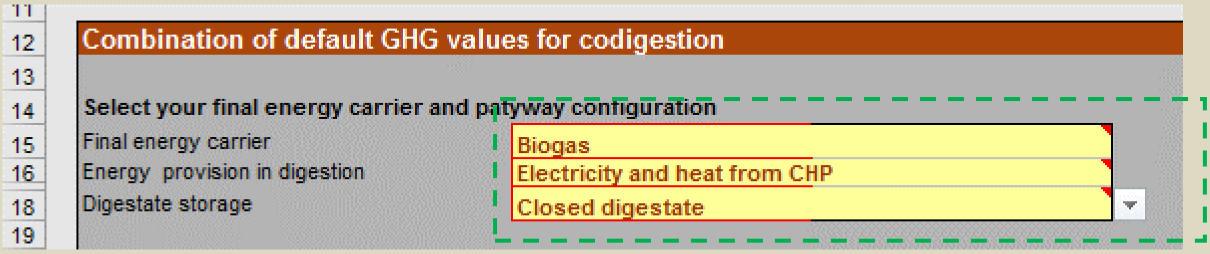
- **Co-dig_default** sheet can only be used for the purpose of calculating a new default value for the production of biogas or biomethane from codigestion of a combination of the following substrates (maize, wet manure and biowaste);
- **Bg-co-dig_actual** sheet can be used to calculate actual GHG emissions for the production of electricity and/or heat, or cooling from biogas from a combination of any biomass;
- **Bm-co-dig_actual** sheet can be used to calculate actual GHG emissions for the production of electricity and/or heat, or cooling from biomethane from a combination of any biomass.

6.6.1 How to use the Co-dig_default sheet?

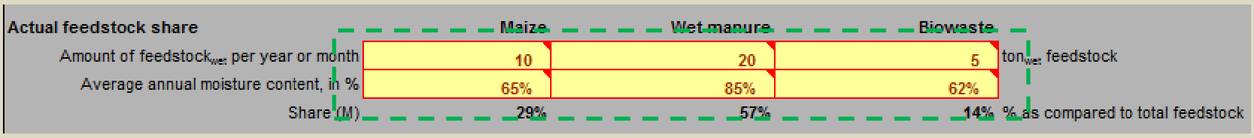
This sheet can only be used for the calculation of default values. For more information on the calculation rules related to this sheet, please have a look at the BioGrace-II calculation rules. A step by step description of the use of this sheet is presented in the table below.

Step by step description of the use of this sheet:

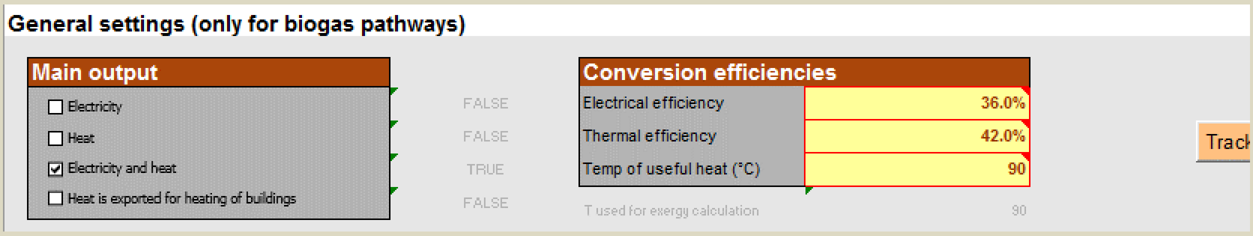
- **Step 1- Specify the process:** the description includes 3 types of information: the final energy carrier, the type and origin of the energy used in digestion (relevant if "biogas" has been chosen as final energy carrier) or the upgrade process (relevant if "biomethane" has been chosen as final energy carrier), and the type of digestate storage.



- **Step 2**: Provide information on the actual feedstock share and the moisture content of each feedstock used.



- **Step 3- In case of biogas as final energy carrier; fill in the "General settings" box**. In this box the user should provide information on the final energy produced: the main type of output, and the process efficiency associated with the final conversion of the pathway.



- **Step 4**: The total GHG emission reductions are given in the results box.

6.6.2 How to use the Bg-co-dig_actual and Bm-co-dig_actual sheets?

These sheets are built in a similar way as other pathways for the production of biogas or biomethane, except that they are especially designed to calculate actual GHG emissions from the digestion of several feedstocks. This paragraph explains the calculation in case the product is biogas (for the sheet "Bg-co-dig_actual"). The calculation for biomethane (sheet "Bm-co-dig_actual") is the same.

Many of the calculations in these two sheets are made automatically. A calculation can already be made when the limited number of yellow-marked cells is filled out, as is demonstrated below. Values must be entered in these yellow-marked cells; when this is not done, then no complete GHG calculation can be made. In addition actual input values can be entered for the values that are pre-set and have a white background colour (and which come from the JRC calculations). When these values are replaced by actual values you can also change the "Factor from typical to default values" from "1.4" to "1.0".

Before giving the step by step description, two remarks are:

1. When you open the sheets, you will see a number of error messages which appear as calculations cannot be made because some numbers are missing (and hence there is a division by zero). See

for an example the screen-copy below. These error messages disappear once you have filled out the required cells.

Calculation of actual values for co-digestion (biogas)

Overview Results

Energy carrier (including emissions from the fuel in use)

All results in g $CO_{2,eq}$ / MJ_{Biogas}	Non- allocated results	Total (allocated results)
Cultivation e_{ec}		**#DIV/0!**
Upstream emissions	#DIV/0!	#DIV/0!
Processing e_p		**#DIV/0!**
Anaerobic digestion	#DIV/0!	#DIV/0!
Transport e_{td}		**#DIV/0!**
Transport of substrates	#DIV/0!	#DIV/0!
Emissions from the fuel in use e_u		**12.5**
CH_4 and N_2O emissions at final conversion	12.49	12.49
Land use change e_l or e_{sca}	not applicable	
Bonus	not applicable	
e_{ccr} + e_{ccs}	0.0	0.0
Totals	**#DIV/0!**	**#DIV/0!**

Default values RED-II
The RED-II only gives overall default values for three combinations of manure and maize as input material For more information see the user manual, paragraph 6.6

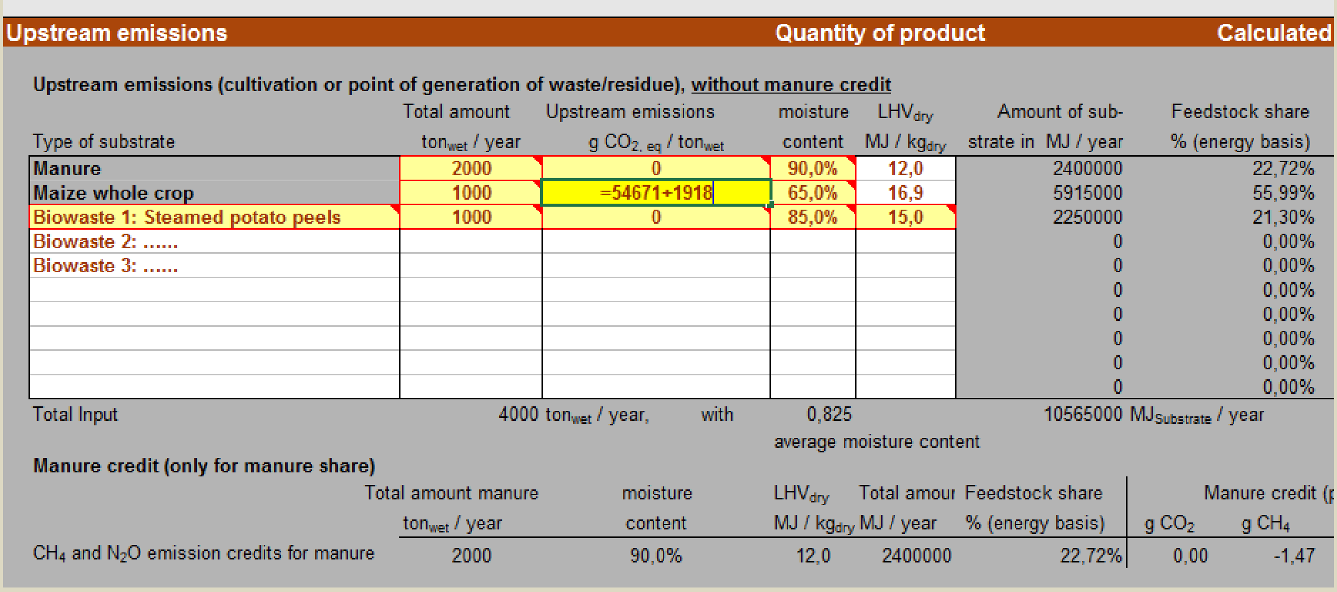
2. In these two sheets, the possibility to use disaggregated default values has been removed as the RED-II does not give disaggregated default values for co-digestion. The RED-II contains, at the end of Annex VI.D, total-pathway default values for specific combinations of co-digestion of wet manure and maize whole crop (80-20%, 70-30% and 60-40% on a fresh mass basis). These specific total-pathway defaults have not been included in the BioGrace-II Excel tool. Instead, the disaggregated default values (expressed in g $CO_{2,eq}$/ton feedstock) for wet manure, maize whole crop and/or biowaste can be filled out under "upstream emissions", see step 2 below.

The step by step description below will focus on filling the yellow-marked cells.

Step by step description of the use of this sheet:

- **Step 1: Fill out the "General settings**
  Give the main output(s), the conversion efficiencies and the pathway configuration. The example below is made with the pathway configuration "Gas-tight digestate storage" and "Electricity from grid, heat from boiler", which is an example of a digestor producing biogas that is sold to an external user. Hence in this example the heat for the digester is produced by a small boiler on-site, the biogas is transferred to the external user through a local pipeline, and at that location the biogas is combusted in a second boiler owned by the external user. The product in this case is biogas, and hence no selection is to be made for the tick boxes under "Main output".

- **Step 2: Give the upstream GHG emissions for the substrates (feedstocks) that are co-digested**
  Upstream emissions for some feedstocks can be found in the "single-feedstock" BioGrace-II pathways, see the sheets "Bg-wMa", "Bg-Mze" and "Bg-Bw". Make sure that you enter the same values for the general settings. In case you have actual values for upstream input data, then enter these first. Then, for instance, the upstream emissions for "Maize whole crop" can be found by adding the values from cells L79 and L92 in the sheet "Bg-Mze". This is shown below. For other feedstocks (*e.g.* sugar beet) you have to make the calculation yourself as – for instance - there is no sheet "Biogas from Sugarbeet" in the BioGrace-II Excel tool.
  You must enter values in all the yellow-marked cells of the sheet "Bg-co-dig_actual" and/or "Bm-co-dig_actual", and you can add more values in the white cells in case more substrates are co-digested.
  Do not replace the names "Manure" and "Maize whole crop" in the first and second line of the table. In case these are no substrates in your digester, then enter "0" in the column "ton_{wet} / year" causing these inputs to be neglected in the calculation. You must not replace these names as this will result in incorrect calculations.

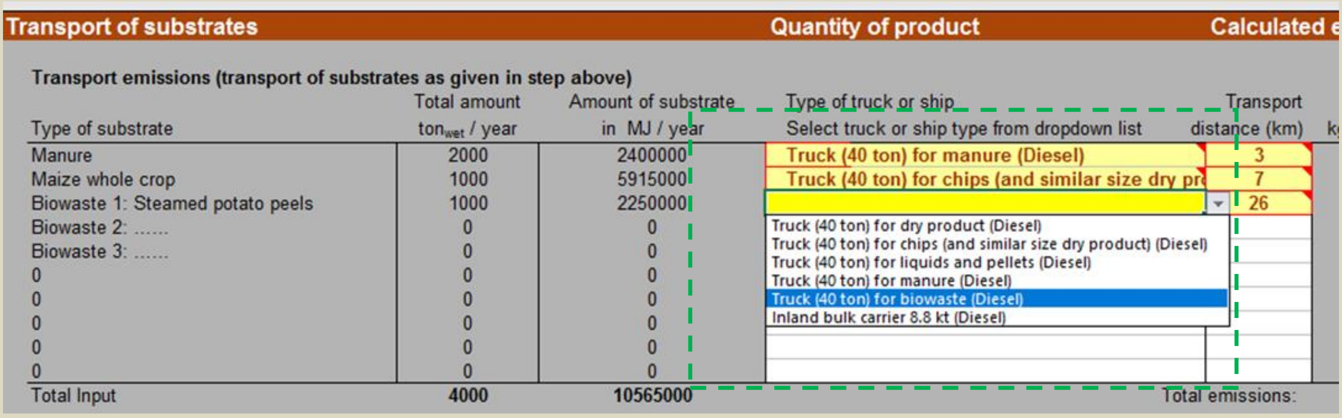


Upstream emissions			Quantity of product				Calculated
Upstream emissions (cultivation or point of generation of waste/residue), without manure credit							
Type of substrate	Total amount ton_{wet} / year	Upstream emissions g $CO_{2,eq}$ / ton_{wet}	moisture content	LHV_{dry} MJ / kg_{dry}	Amount of substrate in MJ / year	Feedstock share % (energy basis)	
Manure	2000	0	90,0%	12,0	2400000	22,72%	
Maize whole crop	1000	=54671+1918	65,0%	16,9	5915000	55,99%	
Biowaste 1: Steamed potato peels	1000	0	85,0%	15,0	2250000	21,30%	
Biowaste 2:					0	0,00%	
Biowaste 3:					0	0,00%	
					0	0,00%	
					0	0,00%	
					0	0,00%	
					0	0,00%	
					0	0,00%	
Total Input	4000 ton_{wet} / year,	with	0,825 average moisture content		10565000 $MJ_{Substrate}$ / year		

Manure credit (only for manure share)	Total amount manure ton_{wet} / year	moisture content	LHV_{dry} MJ / kg_{dry}	Total amount MJ / year	Feedstock share % (energy basis)	Manure credit g CO_2	g CH_4
CH_4 and N_2O emission credits for manure	2000	90,0%	12,0	2400000	22,72%	0,00	-1,47

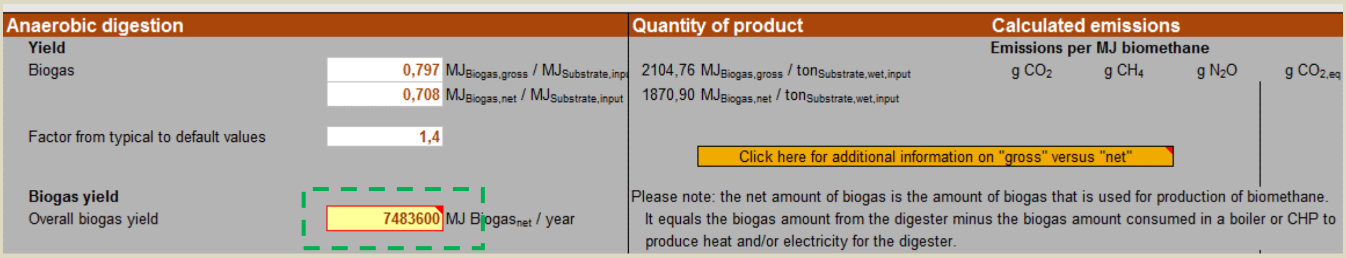
The CH_4 and N_2O emission credits for the use of manure are calculated automatically (see lower part of the screen-copy above).

- **Step 3: Provide information related to the transport of all substrates (even for waste biomass).** Select the most convenient truck type from the dropdown list and specify the distance of transport (in km).



Transport of substrates			Quantity of product	Calculated
Transport emissions (transport of substrates as given in step above)				
Type of substrate	Total amount ton_{wet} / year	Amount of substrate in MJ / year	Type of truck or ship — Select truck or ship type from dropdown list	Transport distance (km)
Manure	2000	2400000	Truck (40 ton) for manure (Diesel)	3
Maize whole crop	1000	5915000	Truck (40 ton) for chips (and similar size dry pr	7
Biowaste 1: Steamed potato peels	1000	2250000		26
Biowaste 2:	0	0	Truck (40 ton) for dry product (Diesel)	
Biowaste 3:	0	0	Truck (40 ton) for chips (and similar size dry product) (Diesel)	
0	0	0	Truck (40 ton) for liquids and pellets (Diesel)	
0	0	0	Truck (40 ton) for manure (Diesel)	
0	0	0	Truck (40 ton) for biowaste (Diesel)	
0	0	0	Inland bulk carrier 8.8 kt (Diesel)	
0	0	0		
Total Input	4000	10565000		Total emissions:

- **Step 4: Give the amount of biogas produced on a yearly basis**
  This is the total biogas production per year, when digesting the combination of all substrates entered. Please enter the net amount of biogas; in case a small boiler is used to provide heat to the digester this is the yearly amount of biogas that is produced in the digester minus the yearly amount of biogas that is combusted in the boiler to provide heat to the digester.



Anaerobic digestion		Quantity of product	Calculated emissions
Yield			Emissions per MJ biomethane: g CO_2, g CH_4, g N_2O, g $CO_{2,eq}$
Biogas	0,797 $MJ_{Biogas,gross}$ / $MJ_{Substrate,input}$	2104,76 $MJ_{Biogas,gross}$ / $ton_{Substrate,wet,input}$	
	0,708 $MJ_{Biogas,net}$ / $MJ_{Substrate,input}$	1870,90 $MJ_{Biogas,net}$ / $ton_{Substrate,wet,input}$	
Factor from typical to default values	1,4	Click here for additional information on "gross" versus "net"	
Biogas yield			
Overall biogas yield	7483600 MJ $Biogas_{net}$ / year	Please note: the net amount of biogas is the amount of biogas that is used for production of biomethane. It equals the biogas amount from the digester minus the biogas amount consumed in a boiler or CHP to produce heat and/or electricity for the digester.	

Once this value is added, the error messages in the sheet disappear.

- **Step 5**: Complete the rest of the sheet like for any other pathway for the production of biogas and biomethane. You will now have a result of your calculation in the "Overview Results" part. In case biogas is the product (see the further description under step 1 above), then only results expressed in g $CO_{2,eq}$ / MJ biogas are given. In case the biogas is converted to electricity and/or heat and you have also entered the conversion efficiencies under "General settings", then also results per MJ electricity and/or heat are given as well as emission reduction percentages.

6.7 How to use the Calculate efficiencies sheet?

This sheet aims at providing information on the thermal and/or electrical efficiency for the use of boilers or CHP. This information is needed to fill in the “General settings” box (see paragraph 2.2.2) and process modules whenever a boiler or a CHP is used in the process. In case calculations are made for verification and declaration, if several boilers or CHP are used in the pathways, this sheet should be duplicated to keep a record of the calculations made for each boiler and/or CHP. This will help the work of verification of calculations.

For more information on the calculation rules related to this sheet, please have a look at the document BioGrace-II calculation rules. A step by step description of the use of this sheet is presented in the table below.

Step by step description of the use of this sheet:

- **Step 1- Fill in the description of the annual input:** the description includes 4 types of information: the type of input fuels, the weighted average low heating value, the amount of fuel, and its water content. The amount of energy (in MWh) is then automatically calculated.

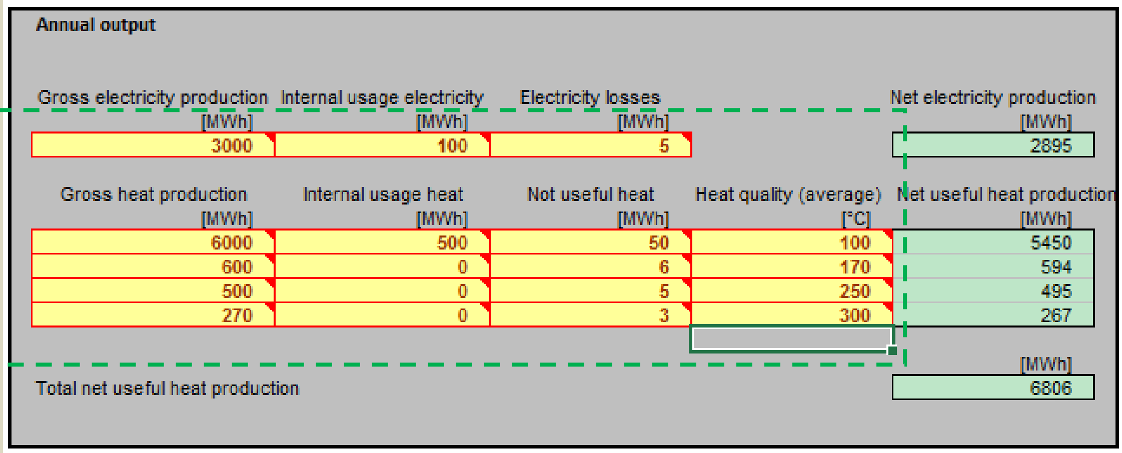
Calculate efficiencies

Annual input

Input fuels	Lower heating value (on dry basis) [MJ/kg]	Amount [ton]	Mass percentage of water [%]	Energy [MWh]
Pellets	18.0	1000	10%	4500
SRF wood chips	19.0	2000	50%	5278
Fossol fuel (oil)	36.0	500	0%	5000

	[MWh]
Total annual input of fuel	14778

- **Step 2- Fill in the description of the annual output:** To calculate the net electricity and/or heat produced, information on the gross energy production, internal use of energy and energy losses must be provided. For calculating the efficiency for heat production, information on the average heat quality (in °C) should also be given.

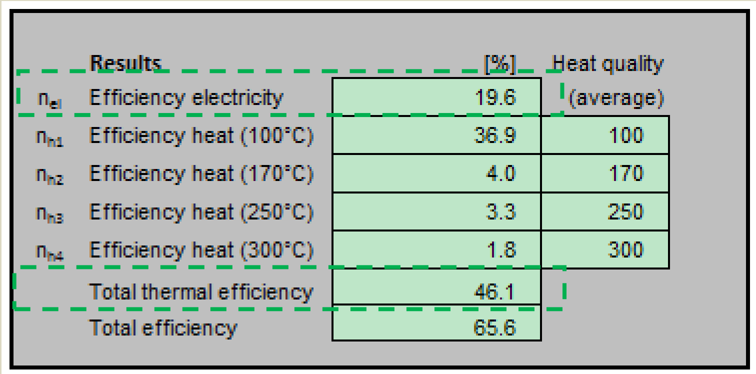


Annual output

Gross electricity production [MWh]	Internal usage electricity [MWh]	Electricity losses [MWh]		Net electricity production [MWh]
3000	100	5		2895

Gross heat production [MWh]	Internal usage heat [MWh]	Not useful heat [MWh]	Heat quality (average) [°C]	Net useful heat production [MWh]
6000	500	50	100	5450
600	0	6	170	594
500	0	5	250	495
270	0	3	300	267
Total net useful heat production				[MWh] 6806

- **Step 3- Report results in the pathways:** The results (efficiency of electricity and/or of heat) are automatically calculated and provided at the bottom of the sheet. This information as well as the heat quality should be reported in the relevant pathway.

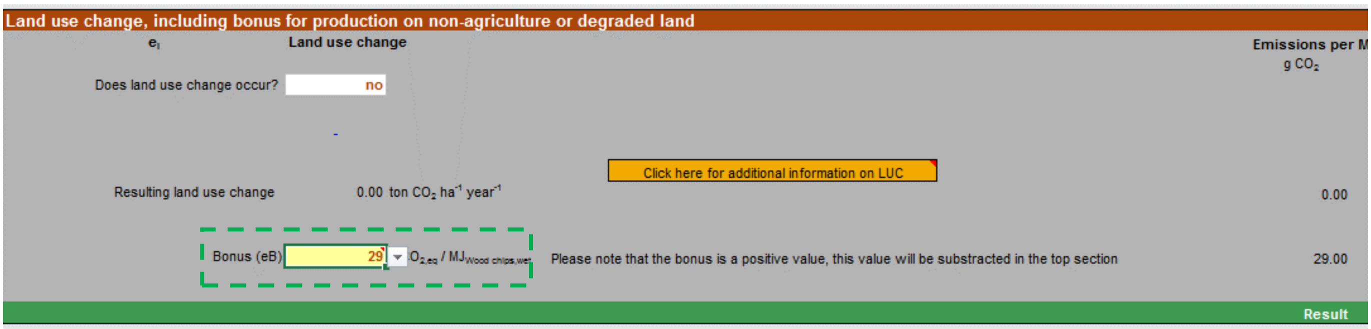


	Results	[%]	Heat quality (average)
n_{el}	Efficiency electricity	19.6	
n_{h1}	Efficiency heat (100°C)	36.9	100
n_{h2}	Efficiency heat (170°C)	4.0	170
n_{h3}	Efficiency heat (250°C)	3.3	250
n_{h4}	Efficiency heat (300°C)	1.8	300
	Total thermal efficiency	46.1	
	Total efficiency	65.6	

6.8 Declaring the 29g Bonus

If you are carrying out your own calculation and if evidence is proved that the land on which the biomass feedstock was cultivated/grown meets the conditions (a) and (b) in point 8 of RED-II Annex V.C and RED-II Annex VI.B and, then you can add an extra bonus of 29 g $CO_{2,eq}$/MJ to your pathway.

Within the BioGrace-II Excel tool the bonus can be added in the Land use change step as shown below.



7 Glossary

To use the tool, several terms have to be clearly defined. Some of these definitions and abbreviations are based on the RED-II.

CHP: Combined Heat and Power

Default values: default values are the GHG emissions given in the RED-II Annexes V and VI. There are disaggregated default values and one global value for the whole pathway. They are derived from the typical value by adding an extra 20% or 40% of energy consumption during the process stage and transport steps, depending on the pathway used. They may be used instead of actual values under certain circumstances defined in the RED-II.

$CO_{2,eq}$: GHG emissions caused by CO_2, CH_4, and N_2O, expressed as CO_2-equivalent emissions using the global warming potentials of CH_4 and N_2O as listed in the sheet "Standard Calculation Values". These values are taken over from RED-II Annex V.C.4 and VI.B.4.

Cropland: Cropland as defined by IPCC

E_{sca}: Emission reduction as a result of soil carbon accumulation.

FFC: Fossil Fuel Comparator

GHG: Greenhouse gases, responsible for global warming.

HVO: Hydrogenated Vegetable Oil

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-II GHG calculation tool. In all these cells, actual input numbers can be given to calculate an actual GHG value.

JRC: Joint Research Centre of the European Commission

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.

PVO: Pure Vegetable Oil

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

RED-II: Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (and recast of the RED, hence "RED-II")

RVO: Netherlands Enterprise Agency (in Dutch: Rijksdienst Voor Ondernemend Nederland)

Standard calculation 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".

Starting values: the input numbers that are in the BioGrace-II GHG calculation tool when it is downloaded and opened. These numbers were provided by the JRC consortium for calculating the RED-II default values.

BIOGRACE II
Harmonised Greenhouse Gas Calculations for Electricity, Heating and Cooling from Biomass

About the BioGrace GHG calculation tools

BioGrace-I

The BioGrace-I GHG calculation tool is managed by IFEU (Institut für Energie- und Umweltforschung).

The current version is version 4d from 2015.

BioGrace-II

The BioGrace-II GHG calculation tool is managed by The Netherlands Enterprise Agency (RVO).

The current version is "Version 4 – Draft" from 2020.

History

The two BioGrace GHG calculation tools were originally developed in two European projects funded under the Intelligent Energy for Europe (IEE) programme.

The BioGrace-I project lasted from 2010 to 2012 and the BioGrace-II project lasted from 2012 to 2015.

More information:

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