

BIOGRACE II

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



User manual for the **BioGrace greenhouse gas calculation tool for electricity, heating and cooling**

Final version – 09-05-2015

This support document is designed to assist the economic operators to understand and use the BioGrace Greenhouse gas (GHG) calculation tool for electricity, heating and cooling from biomass. The main questions that arise concerning the tool are presented below, with 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 Rules¹.**

<u>Functions of the tool</u>	This chapter details the different ways of using this tool. You will find why this tool was developed and what it can do.
<u>How does the tool work?</u>	This chapter explains how the tool is designed and the general principles of the calculations.
<u>How to understand and pilot the results?</u>	This part describes how the result module, in head of each pathway, works. It also explains how to choose between disaggregated default value and actual default value.
<u>How can I use the tool to calculate my own actual value?</u>	These chapters allow you to make the best use of the tool depending on your personal objective.
<u>How can I use the tool to understand the default values?</u>	
<u>How can I create a new pathway with the tool?</u>	
<u>How to use the LUC sheet?</u>	A step by step tutorial may help you to declare a land use change in one of your pathways.
<u>How to use the Esca sheet?</u>	Information about “Improved agricultural management” can help you take into account carbon stock changes related to improved practices.
<u>How to use the N₂O emissions GNOC sheet?</u>	A step by step tutorial may help you to calculate the N ₂ O emissions of your pathway using the Global Nitrous Oxide Calculator (GNOC).
<u>How to use the N₂O emissions IPCC sheet?</u>	A step by step tutorial may help you to calculate the N ₂ O emissions of your pathway using the IPCC TIER 1 methodology.
<u>How to use the Calculate efficiency sheet?</u>	A step by step tutorial may help you to use this sheet.
<u>How to use the Co-digestion sheets?</u>	A step by step tutorial may help you to calculate new default values for co-digestion of several substrates in a biogas plant.
<u>How to use the Final conversion only sheet?</u>	A step by step tutorial may help you to understand the purpose of this sheet.
<u>Glossary</u>	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.

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1 Functions of the tool

Access and understanding of GHG calculations for electricity, heating, and cooling from biomass should be available to all involved or interested actors; this can cover a very large and diversified public. For this reason Excel was used to set up the BioGrace-II GHG calculation tool. The calculations done in the Excel tool and presented in this document use the methodology as given in the following three documents (further referred as “the EC reports”):

- Commission Staff Working Document - State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU [SWD(2014) 259];
- Report on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling [COM/2010/11];
- JRC scientific report on the default and input values for GHG emissions of biomass [Report EUR 27215 EN] – further referred as the JRC report.

Please note!: The BioGrace-II GHG calculation tool also contains bioliquid pathways for the production of pure vegetal oil. These pathways follow the calculation rules from the RED and not SWD(2014)259. So, for more information on the calculation rules applicable to these pathways, please read the **BioGrace-I calculation rules** document related to the BioGrace I GHG calculation tool for biofuels.

The present document gives insight on how to understand and use this tool.

Three main functions have been identified when developing the tool:

1. **Give details on EC reports default value calculations:** the calculation sheets have been developed to detail the exact and comprehensive methodology applied to calculate default values presented in the JRC report.
2. **Adapt existing pathways for actual value calculations:** adapting some input numbers of the calculation sheet allows easy calculation of own actual GHG results. Own standard values (or conversion factors - see **part 3.3**, definition in the glossary **part 7**) may also be inserted in the calculations (for example, adding a specific chemical input). The tool can also be used to estimate the contribution to total GHG emissions of any process or any improvement action.
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.

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

2 General presentation of the tool

2.1 First and fast navigation within the tool

The tool is organized in several Excel sheets.

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

The second sheet, “**Directory**”, shows all the links to the Excel sheets with explicit names; for instance, “Wood chips from forestry residues” is linked to the “Ch-F_r” sheet.

A		B	C	D	E	F
		BIOGRACE II		Harmonised Greenhouse Gas Calculations for Electricity, Heating and Cooling from Biomass		www.biograce.net
1						
2		Directory of pathways				Version 3.
3						
4						
5	1	Wood chips from forest residues		15		Pure plant oil from rapeseed
6	2	Wood chips from short rotation coppice (Eucalyptus)		16		Pure plant oil from sunflower seed
7	3	Wood chips from short rotation coppice (Poplar)		17		Pure plant oil from soybean
8	4	Wood chips from stemwood		18		Pure plant oil from jatropha seed
9	5	Wood chips from industry residues		19		Pure plant oil from palm oil
10	6	Wood briquettes or pellets from forest residues		20		Waste cooking oil
11	7	Wood briquettes or pellets from short rotation coppice (Eucalyptus)		21		Animal fats from animal waste
12	8	Wood briquettes or pellets from short rotation coppice (Poplar)		22		Biogas from wet manure
13	9	Wood briquettes or pellets from stemwood		23		Biogas from maize
14	10	Wood briquettes or pellets from wood industry residues		24		Biogas from biowaste
15	11	Agricultural residues		25		Biomethane from wet manure
16	12	Pellets from straw		26		Biomethane from maize
17	13	Pellets from bagasse		27		Biomethane from biowaste
18	14	Palm kernel meal				
19						
20		Calculation of direct land use change (LUC)				
21		Calculation of Improved Agricultural Management				
22		Calculation of N₂O field emissions according to IPCC Tier 1				
23		Calculation of N₂O field emissions with GNOC				
24		Calculation of net heat and electricity efficiencies				
25		Calculation of default values for co-digestion				
26		Calculation of actual values for co-digestion (biogas)				
27		Calculation of actual values for co-digestion (biomethane)				
28		Final conversion only				
29		Final conversion only (with heat at different temperature levels)				
30						
		Start		Version management		About
		Directory		LUC		Esca
		N ₂ O emissions IPCC		N ₂ O emissions GNOC		Bg-

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.
- **N₂O emissions GNOC** sheet estimates N₂O emissions in accordance with the Global Nitrous Oxide Calculator (GNOC).
- **N₂O emissions IPCC** sheet estimates N₂O emissions in accordance with the IPCC TIER 1 methodologies².
- **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.
- **Calculation efficiencies** sheet is used to calculate net heat and electricity efficiencies.
- **Final conv. only** and **Final conv. only (mult. Heat)** sheets enable 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.

²: See the [BioGrace calculation rules](#) document for explanations on why this model is recommended.

BIOGRACE II

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

Production of electricity and/or heat, or cooling from wood chips from forestry residues

Version 2 - for Compliance

Overview Results

Energy carrier (including emissions from the fuel in use)				Default values		Final energy		Allocation factors & references	
All results in g CO _{2,eq} / MJ wood chips	Non-allocated results	Total (allocated results)	Actual/Default	JRC report		Electricity	Heat	Allocation factors	
Cultivation e _{pc}				0,0		All results in g CO _{2,eq} per MJ as indicated		Production chain	
Feedstock is a residue				0,00		Allocation factor	Allocation factor	100,0% to energy carrier	
Processing e _p				1,9		Allocated results	Allocated results	0,0% to co-product(s)	
Forest residues collection				1,86		#DIV/0!	#DIV/0!	CHP	
Forest residues seasoning				0,00		per MJ chips	per MJ chips	#DIV/0! to electricity	
Chipping				0,38		#DIV/0!	#DIV/0!	#DIV/0! to heat	
Transport e _{td}				22,8		per MJ electr.	per MJ heat	Fossil fuel references	
Transport of forestry residues				0,00				186 g CO _{2,eq} /MJ _{electricity}	
Transport of wood chips				22,77				80 g CO _{2,eq} /MJ _{heat}	
Emissions from the fuel in use e _f				0,5				47 g CO _{2,eq} /MJ _{cooling}	
CH ₄ and N ₂ O emissions at final conversion				0,50					
Land use change e _l									
Bonus or e _{sca}									
e _{ccr} + e _{ocs}				0,0					
Totals				25,1					

General settings

Main output <input type="checkbox"/> Electricity <input type="checkbox"/> Heat <input type="checkbox"/> Cooling (including heat and / or electricity) <input checked="" type="checkbox"/> Electricity and heat	Conversion efficiencies Electrical efficiency Thermal efficiency Temp of useful heat (°C)	Pathway configuration Transport distance (chips): above 10 000 km	! When using this GHG calculation tool, the BioGrace calculation rules must be respected. The rules are included in the zip file (containing the complete tool) and also at www.BioGrace.net
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Calculation per phase

Values calculated from complete pathway		
Overall yield per MJ input	0,9268	MJ _{wood chips} / MJ _{fuel input}

Chipping	Quantity of product	Calculated emissions	Info per kg chips
Yield		Emissions per MJ wood chips	
Wood chips	0,976 MJ _{wood chips} / MJ _{fuel}	g CO ₂	
Moisture content	30%	g CH ₄	
Energy consumption		g N ₂ O	
Diesel	0,0040 MJ / MJ _{wood chips}	g CO _{2,eq}	
CH ₄ and N ₂ O emissions from use of diesel (chipping)			
		Total	
		Result g CO _{2,eq} / MJ _{wood chips}	

The two sheets: “user defined standard values” and “standard values” present the generic data necessary for the calculations.

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

The “user defined standard values” sheet can be used in case the user wants to use conversion values that are not included in the list of standard values (see [paragraph 3.3](#) detailing how to use the tool for this specific use). Please note that BioGrace has formulated rules on when own standard values can be used, these rules can be found in the [BioGrace-II Calculation Rules](#).

4	User Defined Standard Values		GHG emission coefficient					
	parameter:	Comments	gCO ₂ /kg	gCH ₄ /kg	gN ₂ O/kg	gCO _{2-e} /kg	gCO ₂ /MJ	gCH ₄ /MJ
5	unit:							
6								
7	User defined standard values							
8	Example 1 (diesel from standard values)						93,95	0,0000
9	Example 2 (methanol from standard values)						97,74	0,3036
10	Example 3 (Urea ammonium nitrate (UAN))		3906,3	6,79	6,2289	5906,25		
11						0		
12						0		
13								

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.

2.2 Colour-coding of Excel cells in calculation sheets

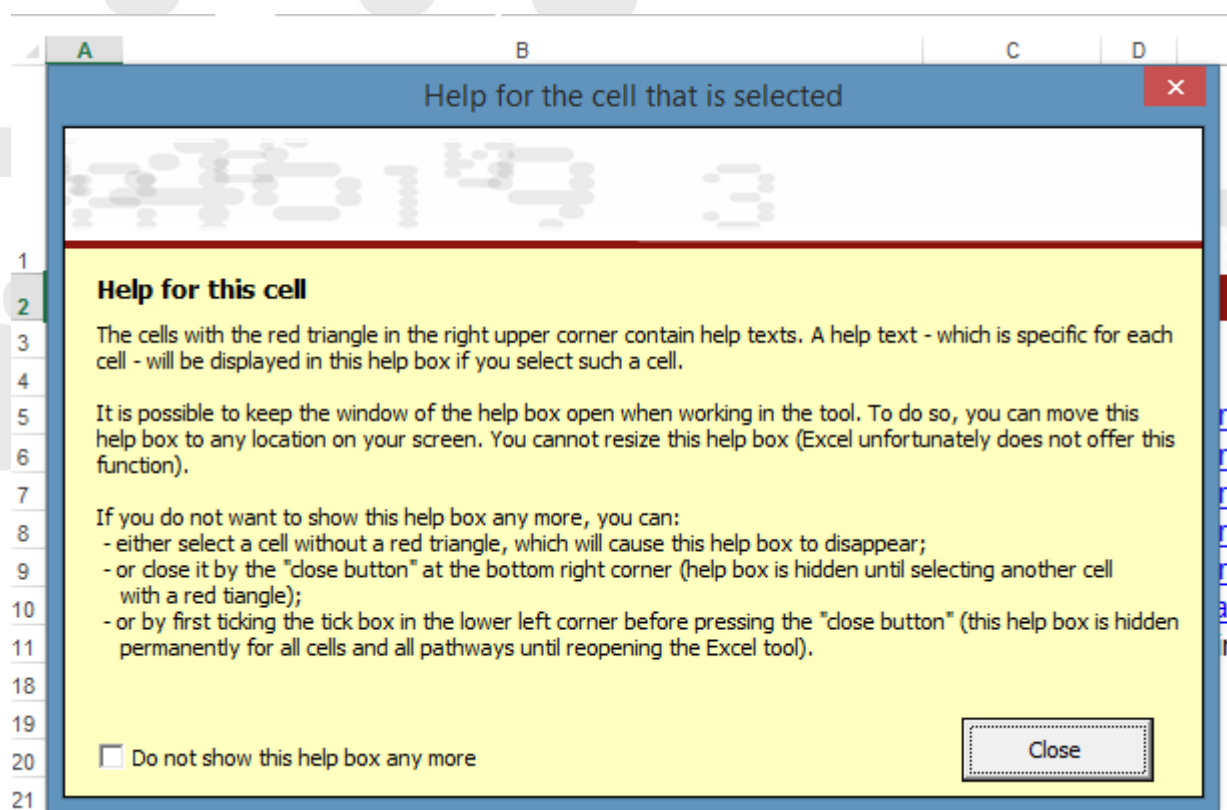
Generalities: The tool is built on a very simple colour-code for cells.

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

Please note!: in case a calculation is made that will be used to show the GHG performance of a bioenergy as part of fulfilling the sustainability criteria of the EC reports, the function “track changes” should be turned 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.

2.3 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 are helpful to understand:

- how the calculations for the JRC report default value were made,
- the purpose of some intermediate calculations made in the tool,
- how to use the tool properly, following 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. More information on the management of the help box is provided in the above figure.

2.4 How GHG calculations are made within this tool

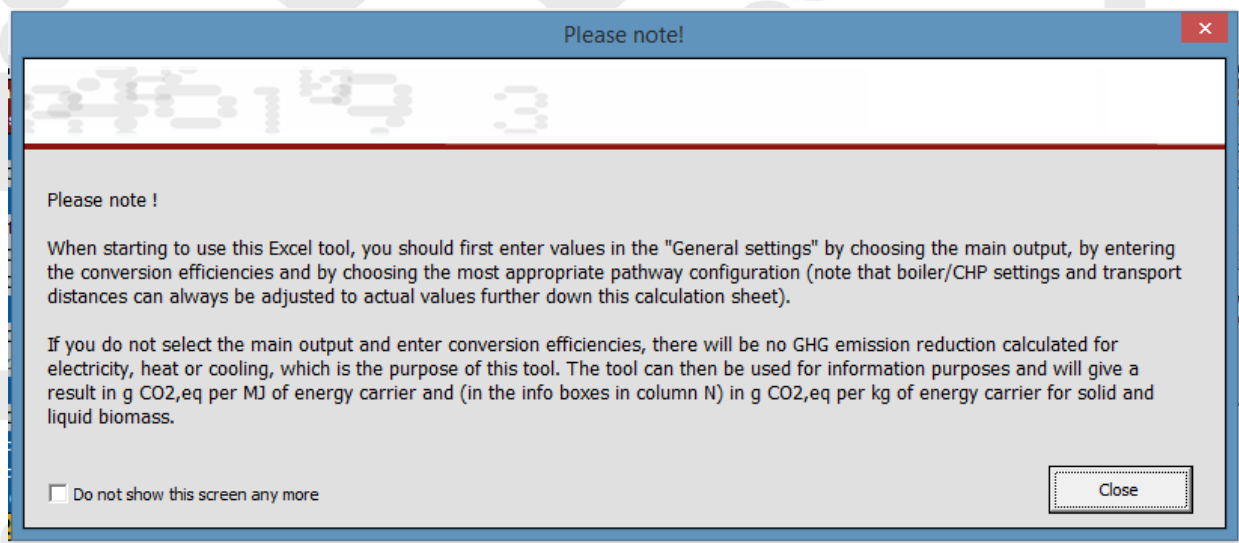
2.4.1 General principles

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, CH₄ and N₂O emissions are calculated.
- A module gathers the inputs' consumptions and calculates the emissions of the three main gases contributing to climate change (CO₂, CH₄, and N₂O). 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 summarized to obtain the GHG emission of the whole pathway. Details of the modules aggregated under each of the JRC report defined step are given under *2.4.6 Presentation of the Overview Results* module .
- Detailed calculation formulas can be seen by clicking each cell in the sheet. Methodological rules can be understood either from looking at the formula calculated or by reading the “help boxes” attached to some specific cells (whenever available). All the different rules cannot be defined here. For more details, please refer to the EC reports, and to the **BioGrace-II Calculation Rules**.

2.4.2 Presentation of the “General settings” box

Each pathway is composed of 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 information regarding the type of final energy produced (called Main output), its characteristics (called Conversion efficiencies) and, for some pathways, about the general features of the pathway (called Pathway configuration). 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 CO₂ emissions in MJ final energy”.

Finally, the “Track change” button, presented in paragraph 2.2 Colour-coding of Excel cells in calculation sheets, is part of the “General settings” box.

2.4.3 Presentation of the “Values calculated from complete pathway” box

In each pathway, calculations start with a box called “Value calculated from complete pathway”. This box contains either one or two values, depending on the pathway. These values correspond to the overall yield (for two different units, in case of two values) for the total pathway. These values are used in the calculations to convert “MJ feedstock” into “MJ final energy carrier”.

	A	B	C	D	E	F	G	H	I	J	K	L	M
33													
34													
35													
36													
37													
38													
39													
40													

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 cells C37 and C38 (more detailed information on copying rows or steps are provided in paragraph 3 “Function 1: Adapting pathways to calculate an actual value”).

2.4.4 Presentation of 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.

160													
161													
162													
163													
164													
165													

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.

Help for the cell that is selected

Consistency check

This consistency check is especially useful when new steps are inserted into the pathway or when steps are deleted from the pathway. Such actions require adaptation of the top section (in which the results are calculated) and in the parts where an allocation is made (if any).

In this check, the unallocated and allocated results from the top section (where the overall results are given) are compared with the two values in the two rows above (which also need to be recalculated when steps are deleted and/or inserted). If the value in this cell is “Yes” then the two results (calculated in a slightly different way) give the same value. If the value in this cell is “No” then an error is still made somewhere.

This consistency check does not say anything about whether the calculations WITHIN steps are correctly made, there is no way to make such a check. As a result, actual calculations should be checked by verifiers who should look at all modifications made in the tool (which are marked when the option “Track changes” is left to “ON”).

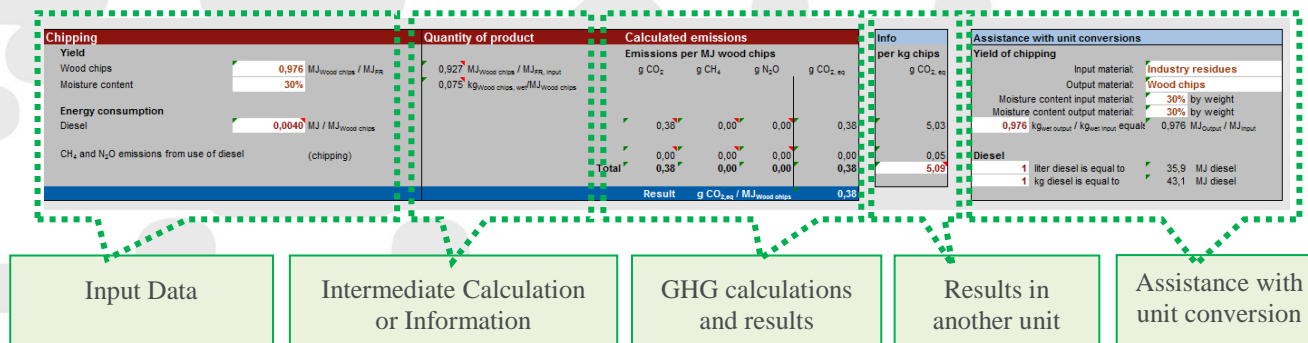
Please note: if you have chosen to use one or more disaggregated default values, by changing one or more of the A’s in column E in the “Overview results” section into D’s, then the result of this consistency check will always be “NO” (the pathway is not consistent). If you would like to make this check, then turn the D’s back into A’s, then check if the pathway is consistent and finally turn the Ds back into A’s to complete your calculation.

☐ Do not show this help box any more

Close

2.4.5 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. No co-product mentioned means that this step doesn't have any co-product.
 - Energy consumption** (electricity, heat and diesel consumption): Heat or electricity can either be bought or come from a boiler or a CHP. In such cases, more complex calculations are made to calculate the GHG emissions, with if necessary, allocations. The use of boilers and CHPs is further explained in paragraph 2.4.9.
 - Other inputs** such as chemical, transports, etc.
- Units: this is the key information to take into account. Beware that the units are often given per MJ of products. As explained in paragraph 2.4.7, units used in the tool should not be changed. To help the user of the tool to convert his input data into the correct unit, "Assistance with unit conversions" boxes are provided (see paragraph below).

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 (in MJ wood chips per MJ forest residues) and intermediate yield data appear.

Finally, some modules dealing with specific issues can be found at the right of each calculation sheet. Indeed, some agricultural practices or local conditions also need to be taken into account within the EC reports methodology, for instance no tillage, or carbon storage. Issues like "Land-Use-Changes", "CO₂ storage", "Improved agricultural management", have been added to specifically address and take into account these subjects in each calculation sheet.

15

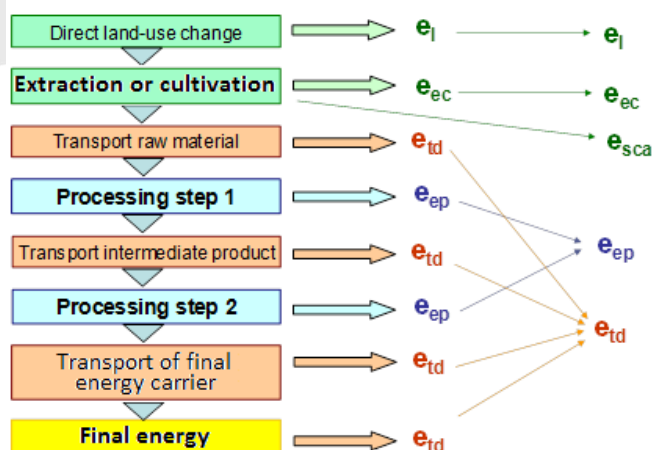
The first lines of each Excel sheet present the results synthetically for the pathway calculated in this Excel sheet. It is made of 5 main parts:

Detailed results: this first part gives the step by step results before and after allocation. The aggregated results written in white text correspond to the disaggregated results provided in the JRC report (see the box below). Several calculation modules can contribute to each step. This part also provides information on CO₂ emissions caused by the CH₄ and N₂O emissions at final combustion (e_u).

Box 2: Basis for assessing the GHG emission savings of solid and gaseous biomass

The assessment of GHG emission savings of biomass carried out by JRC for this Staff Working Document is based broadly on the simplified methodology contained in the Commission report on biomass sustainability published in 2010 (see Annex 1 of COM(2010)11), which is based on the following formula:

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

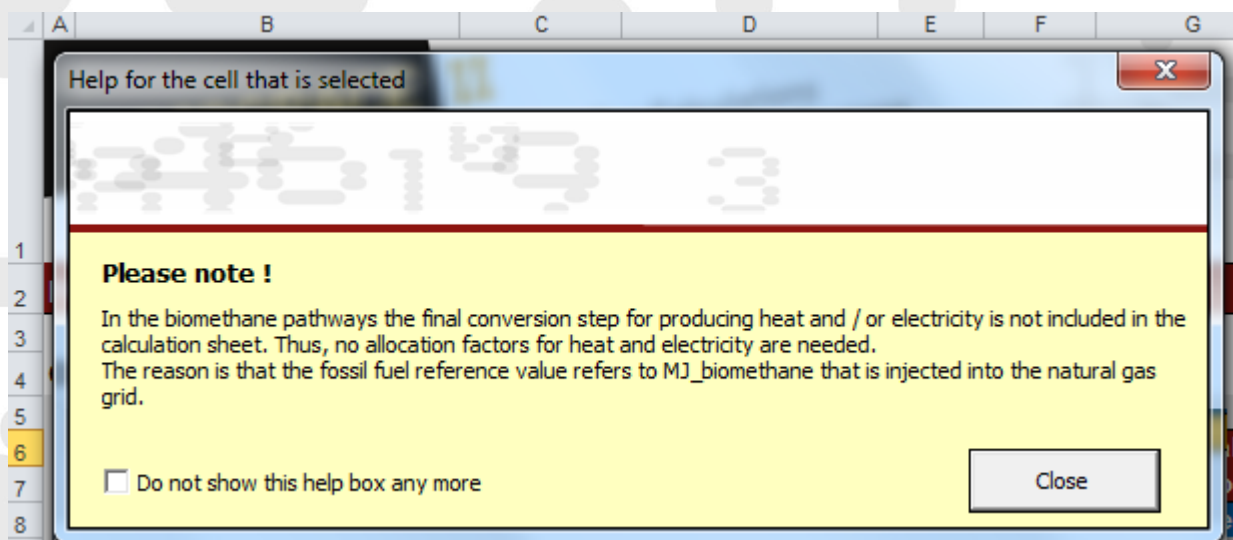


Global results to use: the first column of this part gives step by step actual results calculated for the present Excel sheet. The second column, column E, is very important to calculate final GHG emissions for this pathway. It enables using a mix of both disaggregated default value and disaggregated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

JRC report **default values:** column G gives a clear and direct comparison with the default values taken from the JRC report.

Final energy & GHG emission reduction: this part brings important information to the user. The main one is the GHG emission reduction achieved with this bioenergy pathway as compared to fossil fuel. This data is to be used to show that the sustainability criteria on GHG savings are met (or not). According to the final energy selected in the general settings box (see 2.4.2 Presentation of the “General settings” box), final results are presented in g CO₂,eq per MJ of cooling, electricity and/or heat.

Note that for biomethane pathways, the final energy part is different because the biomethane is injected into the natural gas grid without final conversion (see figure below).



Allocation factors & references: this part provides two 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 2.4.2).

The second information is the fossil fuel references used to calculate the GHG emission factors (see next paragraph).

Please note!: You will find in column E of the result module very important checkboxes. They are here for implementing the possibility left by the EC reports, to assess GHG emission from a mix between disaggregated defaults values given in the JRC report, and disaggregated actual values. The “A” of the checkbox 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 JRC report disaggregated default value (presented in column G).

For instance, if you want to use for the cultivation step e_{ec} the disaggregated default value of the JRC

report and only for this part, than you should choose the letter “D” from the checkbox list of line 8. The letter on rows 10 and 12 of the same column E should stay positioned on “A” to get back actual values calculated in the modules below of the BioGrace tool.

Please, also refer to [BioGrace-II calculation rules](#) for more explanation on the methodological rules for applying such possibility.

2.4.7 Presentation of the final conversion module

In all pathways (at the exception of the production of biogas and biomethane), the last module of pathway is the final conversion (see figure below). In this module N₂O and CH₄ emissions caused by the combustion of the final energy carrier into the final energy are calculated. More information on the CO₂, CH₄ and N₂O emissions due to the final conversion can be found in the help box associated with these emissions (see red triangles in the figure below).

When making actual calculations, the “Factor from typical to default values” should be “1”. The CH₄ and N₂O 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 no calculation will be done and the user should provide by himself the CH₄ and N₂O emissions related to his process using the “User defined standard value” sheet (see explanation provided in the help box of cell “Include following emissions”).

	A	B	C	D	E	F	G	H	I	J	K	L
119												
120		Final conversion (CH₄ and N₂O emissions only)										
121		Type of fuel used in end conversion	Wood chip						Emissions per MJ wood chips			
122		Type of end conversion	Boiler						g CO ₂	g CH ₄	g N ₂ O	g CO _{2,eq}
123		Factor from typical to default values	1,2									
124		Include following emissions	CH4 and N2O emissions from Wood chip Boiler						0,00	0,01	0,00	0,50
125												
126									Result		g CO_{2,eq} / MJ_{Wood chips}	
127												0,50

2.4.8 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 CO₂, CH₄ and N₂O which results in CO₂-equivalents per MJ of final energy carrier. Then the final conversion (see 2.4.7) enables to get all emissions per MJ of final energy.

To convert input data from the user specific unit into the unit used in the tool, “Assistance with unit conversions” boxes are provided (see paragraph 2.4.5).

2.4.9 Calculation details about N₂O emissions due to crop cultivation

For pathways with crop cultivation, field N₂O 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 N₂O emissions are to be calculated.

40	Cultivation of maize			Qu
41	Yield			
42	Corn/Maize whole crop	40 756	kg ha ⁻¹ year ⁻¹	241
43	Moisture content	65%		0
44				
45	Energy consumption			
46	Diesel	3 743	MJ ha ⁻¹ year ⁻¹	
47				
48	CH ₄ and N ₂ O emissions from use of diesel		(harvesting)	
49				
50	Agro chemicals			
51	Synthetic N-fertiliser (kg N)	63,2	kg N ha ⁻¹ year ⁻¹	
52	Manure	0,0	kg N ha ⁻¹ year ⁻¹	
53	Biogas digestate	123,8	kg N ha ⁻¹ year ⁻¹	
54	CaO-fertiliser (calculated as kg CaCO ₃)	458,7	kg CaO ha ⁻¹ year ⁻¹	
55	K ₂ O-fertiliser (kg K ₂ O)	24,0	kg K ₂ O ha ⁻¹ year ⁻¹	
56	P ₂ O ₅ -fertiliser (kg P ₂ O ₅)	38,5	kg P ₂ O ₅ ha ⁻¹ year ⁻¹	
57	Pesticides	6,7	kg ha ⁻¹ year ⁻¹	
58	Field CO ₂ emissions (acidification)	164,5	g ha ⁻¹ year ⁻¹	
59				
60	Seeding material			
61	Seeds- corn	25,0	kg ha ⁻¹ year ⁻¹	
62				
63	Field N₂O emissions	4,66	kg ha ⁻¹ year ⁻¹	
64	Field N ₂ O emissions can be calculated in the sheet			
65	N ₂ O emissions GNOC			

In the tool, two models are used to evaluate N₂O 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 should be used to estimate N₂O 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 should be used.

A link to the sheets “N₂O emissions GNOC” has been placed right below the cell where the information about N₂O field emissions should be provided (see figure above). Within the GNOC sheet, a link to the IPCC sheet is placed.

2.4.10 Calculation details about 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.

25
26
27
28
29
30
31
32

Pathway configuration	
Heat provision in pellet production:	
	Wood chip boiler
Natural gas boiler Wood chip boiler Wood chip CHP (heat dim.) Wood chip boiler/CHP (act. calc.) Wood pellet boiler/CHP (act. calc.)	

	A	B	C	D	E	F	G	H	I	J
109										
110		Wood pellet/briquette production			Quantity of product			Calculated emissions		
111		Yield						Emissions per MJ wood pe		
112		Pelletising efficiency	0,990	MJ _{wood pellets} / MJ _{wood chips}	0,755	MJ _{wood pellets, gross} / MJ _{FR, input}		g CO ₂		g CH ₄
113		Wood pellets	0,774	MJ _{wood pellets, gross} / MJ _{wood c}	0,755	MJ _{wood pellets, net} / MJ _{FR, input}				
114		Wood pellets	0,774	MJ _{wood pellets, net} / MJ _{wood chip}	0,058	kg _{wood pellets/MJ Wood pellets}				
115		Moisture content of wood pellets	10%							
116										
117										
118		Factor from typical to default values	1,2							
119										
120		Energy consumption								
121		Electricity (including input into boiler)	0,0499	MJ / MJ _{wood pellets, gross}	(emissions are calculated below the light grey boiler/CHP box)					
122		Diesel	0,0020	MJ / MJ _{wood pellets, gross}	(internal transport)			0,19		0,00
123		CH ₄ and N ₂ O emissions from use of diesel						0,00		0,00
124		Heat	0,1853	MJ / MJ _{wood chips to be dried}						
125										
133		<u>Wood chip boiler</u>	1	Emissions wood chip boiler included in final results				<u>Emissions from wood chip boiler</u>		
134					Click here for information on calculation strategy					
135		Thermal efficiency of wood chip boiler	85,0 %	% (MJ _{heat} / MJ _{wood chips})	Please note: not dried wood chips will lead to a lower thermal effency of the boiler					
136		Wood chips to be fired in CHP are:	dried		The chips are dried towards same moisture content as chips fed to pelletiser, requ					
137		Wood chip consumption in boiler	0,2815	MJ / MJ _{wood pellets, gross}	Amount of wood chips used for generation of heat					
138		CH ₄ and N ₂ O emissions from wood chip boiler						0,00		0,00
139		Electricity use in boiler	No input needed as the electricity use in the boiler is already included in the electricity use given above							
140										
141		Total electricity use in wood pellet production plus boiler								
142		Electricity EU mix (0.4 kV)	0,0499	MJ / MJ _{wood pellets, gross}				9,47		0,03
264										
265								Total	11,59	0,04
266										
267										
268								Result	g CO_{2,eq} / MJ_w	

2.4.11 Specific calculation points to be known

20

In this example, the agro chemicals 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 MJ of biomethane are calculated, using conversion formulas in the cells.

This calculation relies on the match between the name of the inputs (“N-fertiliser”, “K₂O-fertiliser”, etc.) and the names in the “standard values” sheet. Excel formulas are used to call the right GHG emission coefficients for each input (formula “VLOOKUP” in English³). It is therefore very important to use the appropriate name of input/output if one changes an input value in the calculation sheets. For instance, if the user wants to use an own standard value, this value has to be created in the “user defined standard values”, and the same name must be used in the calculation sheet.

³ or “VERT.ZOEKEN” in Dutch, or “RECHERCHEV” in French, or “SVERWEIS” in German language respectively

3 Function 1: Adapting pathways 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 values for existing inputs ;
- Adding new input in the process ;

3.1 Modifying input data only

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 turning on “Track changes”. 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.

3.2 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 6.5 “How to use the Final Conversion Only sheet?”).

Specific calculation rules have been written in the document [BioGrace-II calculation rules](#). These rules should be followed while using the result from previous and partial GHG calculations.

General information and requirements when doing such modifications:

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

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

- One or more unallocated results for individual steps.
- One result for multiple steps.

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

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 N for the corresponding step.
- **Step 2:** In the result section of the pathway, it shall be indicated in column E that an “individual result from a previous calculation” has been inputted, causing the result line(s) (columns A-G) for the individual step(s) in question to become orange-coloured.

2. One result for multiple steps.

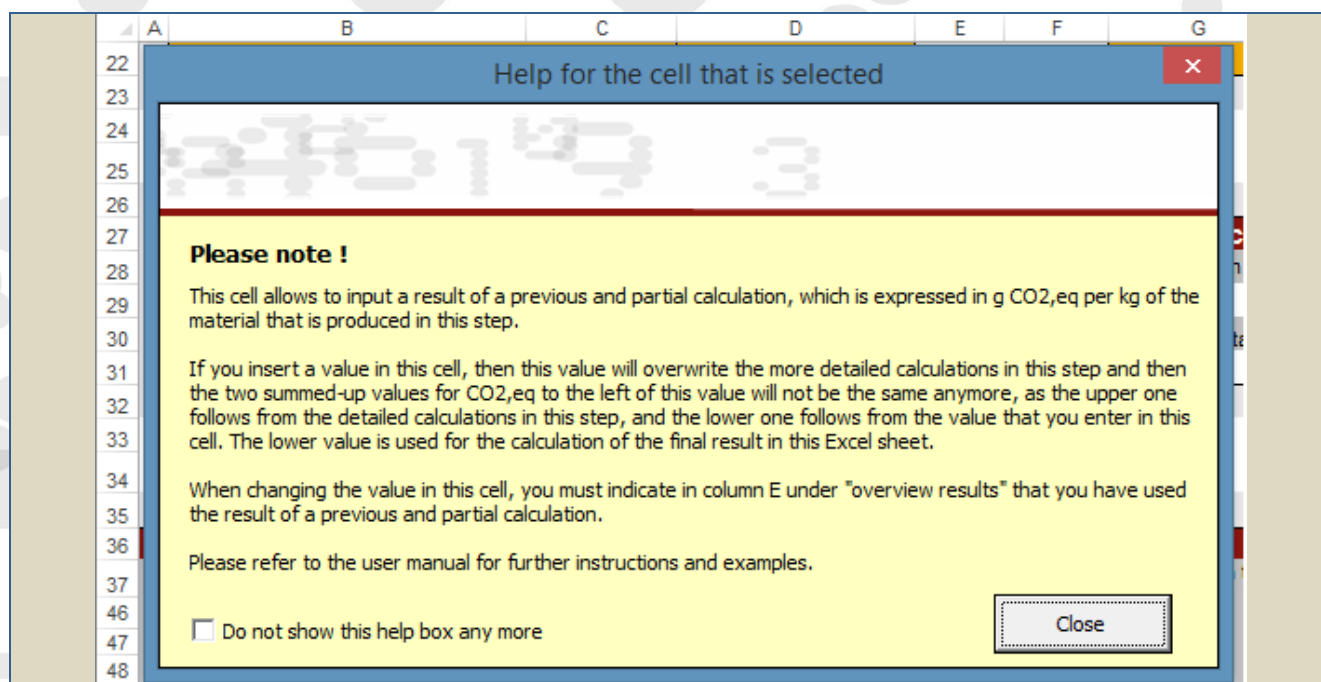
- **Step 1:** One combined result for more than one step shall be entered in the cells with white background colour in column N for the last step in the combined result (so the combined result

- **Step 2:** In the cells with white background colour in column N for the previous steps that are included in the combined result, the value “0” shall be entered.
- **Step 3:** In the result section of the pathway, it shall be indicated in row E 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-G) for these steps to become orange-coloured. If needs be, 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.

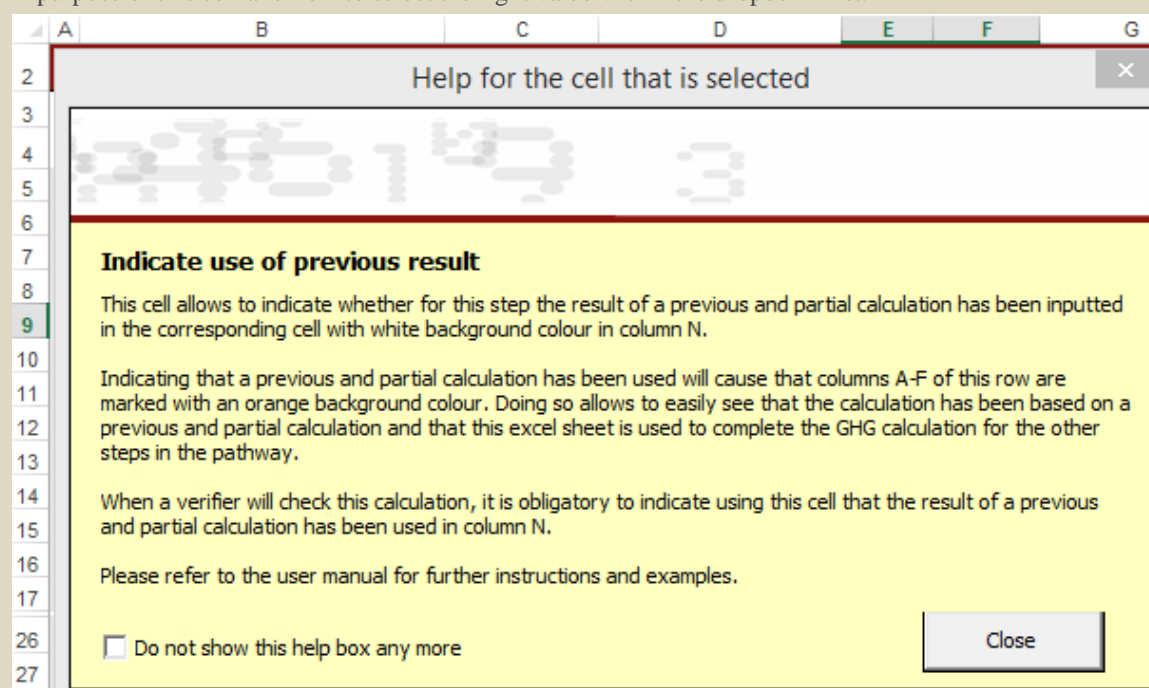
This example explains how to use the result from an individual calculation for “cultivation and harvesting of stemwood” step in the “wood pellets/briquettes from stemwood” pathway in the BioGrace-II calculation tool. The unit of the result provided is in g CO_{2,eq} per kg of stemwood. This could happen 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.

- **Step 1:** The result for the “cultivation and harvesting of stemwood” step shall be entered in cell N51.

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



- **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.



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

Production of electricity and/or heat, or cooling from wood pellets/briquettes from						
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 JRC report		
Cultivation e _{ec}		1,0	A	1,1		
Cultivation and harvesting	1,05	1,05	Individual result of previous calculation	1,05		
Processing e _p		31,1		31,1		
Chipping	0,39	0,39	Individual result of previous calculation	0,39		
Wood pellet/briquette production	30,73	30,73	Combined result of previous calculation	30,72		
Transport e _{td}		9,4	A	9,4		
Transport of stemwood	0,00	0,00		0,00		
Transport of wood chips	1,02	1,02		1,02		
Transport of wood pellets	8,34	8,34		8,35		
Emissions from the fuel in use e _{fu}		0,3	A	0,3		
CH ₄ and N ₂ O emissions at final conversion	0,30	0,30		0,30		
Land use change e _l	0,0	0,0				
Bonus or e _{sca}	0,0	0,0				
e _{pcr} + e _{ocs}	0,0	0,0				
Totals	41,8	41,8		42		

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 kg 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 N for the step “Transport of wood chips” (i.e. cell N95), since it is the last step in the combined result.

A	B	C	D	E	F	G	H	I	J	K	L	M	N
83													
84	Transport of wood chips												
85	Wood chips	1,000	MJ _{Wood chips} / MJ _{Wood chips}	Quantity of product				Calculated emissions				Info per kg _{wet} wood chips	
86	Moisture content	50%		0,976 MJ _{Wood chips} / MJ _{Stemwood} 0,106 kg _{Wood chips, wet} / MJ _{Wood pellets}				Emissions per MJ wood pellets					
87								g CO ₂	g CH ₄	g N ₂ O	g CO _{2,eq}		
88	Transport per												
89	Truck (40 ton) for chips (and similar size)	120	km	0,0123 ton km / MJ _{Stemwood, input}				1,01	0,00	0,00	1,02	9,56	
90	Fuel	Diesel											
91	No emissions	0	km	0,0000 ton km / MJ _{Stemwood, input}				0,00	0,00	0,00	0,00	0,00	
92	Fuel	Diesel											
93	No emissions	0	km	0,0000 ton km / MJ _{Stemwood, input}				0,00	0,00	0,00	0,00	0,00	
94	Fuel	Diesel											
95								Total	1,01	0,00	0,00	1,02	9,56
96													
97								Result	g CO _{2,eq} / MJ _{Wood pellets}		1,02		

Production of electricity and/or heat, or cooling from wood pellets/briquettes from					
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 JRC report	
Cultivation e_{ec}		1,0	A	1,1	
Cultivation and harvesting	1,05	1,05	Combined result of p	1,05	
Processing e_p		31,1	A	31,1	
Chipping	0,39	0,39	Combined result of p	0,39	
Wood pellet/briquette production	30,73	30,73		30,72	
Transport e_{td}		9,4	A	9,4	
Transport of stemwood	0,00	0,00	Combined result of p	0,00	
Transport of wood chips	1,02	1,02	Combined result of p	1,02	
Transport of wood pellets	8,34	8,34	Individual result of previous Combined result of previous	8,35	
Emissions from the fuel in use e_u		0,3		0,3	
CH ₄ and N ₂ O emissions at final convers	0,30	0,30		0,30	
Land use change e_l	0,0	0,0			
Bonus or e_{sca}	0,0	0,0			
e_{ccr} + e_{ccs}	0,0	0,0			
Totals	41,8	41,8		42	

3.3 Adding specific standard values for existing input

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

In order to do so, the dedicated Excel sheet named “user defined standard values” should be used as the Excel sheet “standard values” is protected and cannot be changed.

Adding new standard value requires applying the following principles:

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

Step by step example:

The tool user wants to add a specific standard value for a specific fertiliser instead of using the N-fertiliser standard value pre-defined in the tool. The following example corresponds to the modification of the standard 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 value" sheet. This sheet is framed exactly the same as the "Standard value" sheet.

4	User Defined Standard Values									
	parameter:	Comments	GHG emission coefficient							
5	unit:		gCO ₂ /kg	gCH ₄ /kg	gN ₂ O/kg	gCO _{2-eq} /kg	gCO ₂ /MJ	gCH ₄ /MJ	gN ₂ O	
6										
7	User defined standard values									
8										
9	Example 1 (diesel from standard values)									
10	Example 2 (methanol from standard values)									
11	Example 3 (Urea ammonium nitrate (UAN))									
12			3906,3	6,79	6,2289	5906,25				
13						0				

- Step 2:** Write the name in the first available free line of the standard 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 values" sheet.
- Step 3:** Add your own values in the columns with the appropriate unit (from column E to S). If you have a unique value in g CO_{2,eq} (and not in CO₂, CH₄, N₂O), than fill out the first column in g CO₂ as the columns H and L, with unit "g CO_{2,eq}" is calculated automatically and should not be changed. Please, note that you also have to add "0" value to the two other columns (for CH₄ and N₂O) the other cells to avoid error messages in pathway calculation.

4	User Defined Standard Values									
	parameter:	Comments	GHG emission coefficient							
5	unit:		gCO ₂ /kg	gCH ₄ /kg	gN ₂ O/kg	gCO _{2-eq} /kg	gCO ₂ /MJ	gCH ₄ /MJ	gN ₂ O/MJ	
6										
7	User defined standard values									
8										
9	Example 1 (diesel from standard values)									
10	Example 2 (methanol from standard values)									
11	Example 3 (Urea ammonium nitrate (UAN))									
12	N-fertiliser - User1									
13			2400,0	0,00	0,0000	2400,0				

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

4	User Defined Standard Values									
	parameter:	Comments	GHG emission coefficient							
5	unit:		gCO ₂ /kg	gCH ₄ /kg	gN ₂ O/kg	gCO _{2-eq} /kg	gCO ₂ /MJ	gCH ₄ /MJ	gN ₂ O/MJ	
6										
7	User defined standard values									
8										
9	Example 1 (diesel from standard values)									
10	Example 2 (methanol from standard values)									
11	Example 3 (Urea ammonium nitrate (UAN))									
12	N-fertiliser - User1									
13										

- Step 5:** Go to the pathway where you want to use this modified standard value. Modify the name of the N-fertiliser input called in column B into "N-fertiliser - User1". Please note that the name must be exactly written in the same way as in the "user defined standard value" sheet. Modify the quantity if needed in column C of the same line.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
49		Agro chemicals												
50		N-fertiliser - User1	63,2	kg N ha ⁻¹ year ⁻¹					1,16	0,00	0,00	1,16		3,72
51		Mamure	0,0	kg N ha ⁻¹ year ⁻¹					0,00	0,00	0,00	0,00		0,00
52		Biogas digestate	123,8	kg N ha ⁻¹ year ⁻¹					0,00	0,00	0,00	0,00		
53		CaO-fertiliser (calculated as kg CaCO ₃)	458,7	kg CaO ha ⁻¹ year ⁻¹					0,16	0,00	0,00	0,18		0,57
54		K ₂ O-fertiliser (kg K ₂ O)	24,0	kg K ₂ O ha ⁻¹ year ⁻¹					0,11	0,00	0,00	0,12		0,37
55		P ₂ O ₅ -fertiliser (kg P ₂ O ₅)	38,6	kg P ₂ O ₅ ha ⁻¹ year ⁻¹					0,33	0,00	0,00	0,35		1,11

- 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 value is not the same as the unit of the pre-defined standard value of the same product. To change formulae follow the example below (the column position to change are shown in yellow):

Initial formula in cell I51 of the previous picture = $=\$C51*\text{VLOOKUP}(\$B51;\text{'Standard values'!}\$C\$9:\$S\$275;3;\text{FALSE})/\$C\$35$

New formula in cell I50 $=\$C51*\text{VLOOKUP}(\$B51;\text{'Standard values'!}\$C\$9:\$S\$275;7;\text{FALSE})/\$C\$35$

The numbers “3” and “7” refer to the columns where the values are taken from. This number has if the unit changes from kg input material to MJ input material for example.

3.4 Adding an input in a pathway that exists in the “user defined standard value” sheet

Step by step example:

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

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

Baling of straw			Quantity of product	Calculated emissions			
Yield				Emissions per MJ straw pellets			
Straw bales	0,98	MJ _{Straw bales} / MJ _{Straw} , input	0,98 MJ _{Straw bales} / MJ _{Straw} , input	g CO ₂	g CH ₄	g N ₂ O	g CO ₂ eq
Moisture content	13,5%		0,068 kg _{Straw bales} /MJ _{Straw pellets}				
Energy consumption							
Diesel	0,0115	MJ / MJ _{Straw bales}		1,09	0,00	0,00	1,09
CH ₄ and N ₂ O emissions from use of diesel		(forestry collection)		0,00	0,00	0,00	0,01
				Total	1,09	0,00	1,10
	</						

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

38	Over	Paste Special...	because this value is included in all pathways in cell C38.
39		Insert...	
40		Delete...	
41	Feedstock is a re	Clear Contents	
42	Yield	Quick Analysis	
43	Straw	Filter	
44		Sort	
45		Insert Comment	
46		Format Cells...	
47		Pick From Drop-down List...	
48		Define Name...	
49		Hyperlink...	
50	Baling of straw		
51	Yield		
52	Straw bales		
53	Moisture content		
54	Energy consump		
55	Diesel		
56	CH ₄ and N ₂ O emiss		
57			
58			
59			
60			
61			
62			

- Step 3:** Fill in the line with the name of the input (column B), the unit used (column D), and the quantity used

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(column C). Please check that the name of the added input is the same as in the table of the "standard value" sheet. Also verify that you use the same unit as existing inputs.

49	Baling of straw		Quantity of product	Calculated emissions				Info
50	Yield			Emissions per MJ straw pellets				per kg straw b
51	Straw bales	0,98 MJ straw bales / MJ straw input	0,98 MJ straw bales / MJ straw input	g CO ₂	g CH ₄	g N ₂ O	g CO ₂ eq	g CO ₂ eq
52	Moisture content	13,5%	0,068 kg straw bales / MJ straw pellets					
53	Energy consumption							
54	Diesel	0,0115 MJ / MJ straw bales		1,09	0,00	0,00	1,09	16,10
55	Gasoline	0,0030 MJ / MJ straw bales		0,28	0,00	0,00	0,28	
56	CH ₄ and N ₂ O emissions from use of diesel	(forestry collection)		0,00	0,00	0,00	0,01	0,17
57				Total	1,37	0,00	1,38	20,39
58								
59								
60								
61				Result	g CO ₂ eq / MJ straw pellets			1,38

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

49	Baling of straw		Quantity of product	Calculated emissions				Info
50	Yield			Emissions per MJ straw pellets				per kg straw b
51	Straw bales	0,98 MJ straw bales / MJ straw input	0,98 MJ straw bales / MJ straw input	g CO ₂	g CH ₄	g N ₂ O	g CO ₂ eq	g CO ₂ eq
52	Moisture content	13,5%	0,068 kg straw bales / MJ straw pellets					
53	Energy consumption							
54	Diesel	0,0115 MJ / MJ straw bales		1,09	0,00	0,00	1,09	16,10
55	Gasoline	0,0030 MJ / MJ straw bales		0,28	0,00	0,00	0,28	
56	CH ₄ and N ₂ O emissions from use of diesel	(forestry collection)		0,00	0,00	0,00	0,01	0,17
57				Total	1,37	0,00	1,38	20,39
58								
59								
60								
61				Result	g CO ₂ eq / MJ straw pellets			1,38

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

49	Baling of straw		Quantity of product	Calculated emissions				Info
50	Yield			Emissions per MJ straw pellets				per kg straw b
51	Straw bales	0,98 MJ straw bales / MJ straw input	0,98 MJ straw bales / MJ straw input	g CO ₂	g CH ₄	g N ₂ O	g CO ₂ eq	g CO ₂ eq
52	Moisture content	13,5%	0,068 kg straw bales / MJ straw pellets					
53	Energy consumption							
54	Diesel	0,0115 MJ / MJ straw bales		1,09	0,00	0,00	1,09	16,10
55	Gasoline	0,0030 MJ / MJ straw bales		0,28	0,00	0,00	0,28	
56	CH ₄ and N ₂ O emissions from use of diesel	(forestry collection)		0,00	0,00	0,00	0,01	0,17
57				Total	1,37	0,00	1,38	20,39
58								
59								
60								
61				Result	g CO ₂ eq / MJ straw pellets			1,38

3.5 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 value in the "User defined standard value", then insert your new input in the biofuel-pathway you are working on.

4 Function 2: Using the tool to have details on default value calculations

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

The list of the pathways can be found in the “Directory” sheet with links to each pathway Excel sheet. All calculations are presented step by step, following the well to wheel approach.

Looking in detail at a calculation sheet gives a lot of information on how the calculations were made and on how the EC reports methodology 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 JRC report 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 JRC report 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 values used for calculating default values**, like LHV, the GHG emission for producing one MJ of natural gas, etc.;
- **How energetic allocations are made** (see the allocation module for this as well as the calculation rules);
- **How energy surplus is taken into account** (see the energetic calculation in each pathway with energy surplus for detail examples);
- **Intermediate calculations**, in column E, where all the yields are expressed;
- **GHG emissions** as calculated from the input numbers, in columns I, J and K, respectively for CO₂, CH₄ and N₂O;

- **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 look at the “About” sheet in the Excel tool or in box 3 of the Commission Staff Working Document [SWD(2014) 259];
- **Specific emissions calculated** in modules at the end of each Excel sheet: annualised emissions from carbon stock changes caused by land use change, CO₂ 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 JRC report, the corresponding calculation in the BioGrace-II tool gives a result that comes very close (deviation less than 0.1 g CO_{2,eq}/MJ).

5 Function 3: 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.

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

- **Step 1:** Copy an existing pathway and rename it. 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 necessary. Make sure to keep the result overview box at the top of your pathway, the “Overall yield per MJ input” in cell “C38” (see 2.4.3 Presentation of the “Values calculated from complete pathway” box) and the 4 last generic modules (“Final conversion (CH₄ and N₂O emissions only)” -except for biogas or biomethane injection-, “Improved Agricultural Management”, “CO₂ capture and replacement”/“CO₂ 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. Beware of adding allocation modules (when needed) right after the separation step of the co-products.
- **Step 4:** Fill in the new frame with appropriate inputs and outputs into column B, with the associated input numbers in column C. The 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 value in the “standard value” sheet.
- **Step 5:** Add new standard values if needed (for more detail, please refer to "adding new standard value" part in the previous section "Adapting pathways").
- **Step 6:** Adapt the formulas of the columns I to L when needed (see "adding a new input" part in previous section "Adapting pathways" for more details).
- **Step 7:** Add, if necessary, add comments or intermediate calculations in columns F to H.
- **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.

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). The Annex I point 9 of the COM(2010)11 refers to the methodology described in 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.

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. Make sure that "macro" is authorised to operate (this is the case when the text in the LUC module changes into the appearance of the figure below).
- **Step 2:** Value and text called from the LUC Excel sheet then appear.

- **Step 3:** Go to the LUC sheet. You will there find a framework for calculating the carbon stock changes from reference situation to actual utilisation. The annual GHG emissions that need to be added to your pathway will be calculated from that.
- **Step 4:** Select the type of calculation you want to use. Three kinds of calculation are possible according to the type of the soil and the information collected:
 - 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).
 - If you have your own value for carbon stocks calculated according to the guidelines in the same Commission Decision (called actual calculation).
 - 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: Default calculation with mineral soils:** First, you need to have with you the "Commission Decision of 10 June 2010 on guidelines for the calculation of land use carbon stocks for the purpose of Annex V of Directive 2009/28/EC" where all formula and data are available. In the part dedicated to default calculation, fill the needed information and data in the white cells. These cells are not using a pre-defined list. You should refer to the information given in column L to find the tables from the Commission decision. Please, use the same wording than the one used in the communication paper of the Commission. Note that cells in light red are automatically filled from other cells. For that, begin by filling the "actual land use" part. In the below example, 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.

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Calculation of direct land use change (LUC)

Actual land use		Reference land use	
Climate region	Cool temperate - Wet	Cool temperate - Wet	
Vegetation/crop (land use)	Perennial crops (poplar / willow)	Grassland	
Above and below ground vegetation			
Ecological zone (if relevant)	-	-	There are two w
Continent (if relevant)	-	-	- or you can use
C_{VEG}	43,2 ton C / ha	6,8 ton C / ha	- or you should c
Carbon stock in mineral soil			
Climate region	Cool temperate - Wet	Cool temperate - Wet	Determine using
Soil type	High activity clay	High activity clay	Determine using
Soil management	No till	No till	Determine using
Input	Medium	High with manure	Determine using
SOC_{ST}	95 ton C / ha	95 ton C / ha	Loop up in Table
F_{LU}	0,69	0,69	Look up in Table

- The resulting LUC is calculated right below this part by applying the RED methodology. A negative value shows an increase in the carbon stock from the reference situation.

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Calculation of direct land use change (LUC)

SOC_{ST}	95 ton C / ha	95 ton C / ha	Loop up in Table
F_{LU}	0,69	0,69	Look up in Table
F_{MG}	1,15	1,15	Look up in Table
F_i	1	1,44	Look up in Table
Resulting carbon stock			
$CS_A =$	118,6 ton C / ha	$CS_R =$	115,4 ton C / ha
Resulting land use change			
$e_l =$	-0,59 ton CO ₂ ha ⁻¹ year ⁻¹	Please, note tha	

- Step 5: Actual calculation:** Fill in the white cells of the “Actual calculation” part. You should refer to the information required in column B, and to information given in column L. First, general references for your actual value 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 methodology is then used to get the annual carbon changes.

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Calculation of direct land use change (LUC)

Type of data use
More detail information

Example : If model : name of
If measurements
For all : details ab

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 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_4a_GLP_4a.pdf

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

climate	
soil type	
land cover	
land management and inputs.	

Resulting carbon stock in soils $SOC_A =$ ton C / ha $SOC_R =$ ton C / ha Please, fill these c

Resulting carbon stock in vegetation $C_{veg-A} =$ ton C / ha $C_{veg-R} =$ ton C / ha Please, fill these c

$CS_A =$ 0,0 ton C / ha $CS_R =$ 0,0 ton C / ha

Resulting land use change $e_l =$ 0,0 ton CO₂ ha⁻¹ year⁻¹ Please, note that

- **Step 6: Organic soils calculation:** for organic soil, actual calculations must be made for the evaluation of the SOC, but actual calculations or default values can be used for the evaluation of C_{VEG}.
- **Step 7:** Check in the last line that the proper value is called. If this is not the case, get back to step 4 and choose the appropriate calculation type.

	A	B	C	D	E	F	G	H	I	J	K
1	<p>BIOGRACE II Harmonised Greenhouse Gas Calculations for Electricity, Heating and Cooling from Biomass</p>										
2	<p>Calculation of direct land use change (LUC)</p>										
84											
85											
86	<p>LUC : value that will be used in calculations : Option 1. Default calculation (no actual and accurate data are available) -0,59 ton CO₂ ha⁻¹ year⁻¹</p>										

- **Step 8:** Check in the bioenergy production pathway where you need to declare a Land Use Change that the LUC value is there. Please, also check that no Improved agricultural management is declared in the module right below (See the next section for more information).

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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. Please have a look at the LUC section to have a step-by-step tutorial.



The main difference comes from the fact that only carbon stock in soil is taken into account. Please also note that e_{sca} has a different sign than e_l : a positive e_{sca} means that carbon stocks are improving in your soil, and thus that the GHG result of the pathway should decrease, whereas a positive e_l means carbon stock losses. This difference comes from the formula of box 2 of the EC report [SWD(2014) 259] that defines e_{sca} has a carbon stock accumulation from which the feedstock produced should take some advantages.

Please note that if you have also a change in the above ground carbon stock due to a change in land use type, then you 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” should be used to estimate N_2O field emissions for all the types of crops available in the GNOC (see the list of crops in the online tool - <http://gnoc.jrc.ec.europa.eu>).

This sheet 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 website (see Figure 1 below) and used in the cultivation module of the pathway after making a unit conversion (see 2.4.9).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
1	 Harmonised Greenhouse Gas Calculations for Electricity, Heating and Cooling from Biomass www.biograce.net  <small>Co-funded by the Intelligent Energy Europe Programme of the European Union</small>													
2	Calculation of N₂O field emissions with the Global Nitrous Oxide Calculator (GNOC) Version 3.0.2 - draft in progress													
3	The calculation of N₂O field emission													
4														
5	Please note!													
6	For the calculation of the N ₂ O field emissions the GNOC model has to be used for all crops that are listed in the model. Only for those crops not listed in the model, the IPCC methodology may be used.													
7	1) Go to the GNOC model (http://gnoc.jrc.ec.europa.eu/) and check whether your crop is included.													
8	2) If your crop is included, calculate the field emissions and enter the value in the spreadsheet. To assist the verification of your calculation enter the data below that are asked for in GNOC.													
9	3) If your crop is not included, use the sheet N₂O emissions IPCC													
10														
11														
12	Information needed in GNOC													
13														
14	The GNOC model can be found at http://gnoc.jrc.ec.europa.eu/													
15														
16	Coordinates of place (x; y)			x	These coordinates can be copied from GNOC after selecting the place of the cultivation on the interactive map									
17				y										
18	Crop													
19	Soil type													
20	Irrigation													
21	Fresh yield			kg ha ⁻¹ year ⁻¹										
22	Synthetic N-fertiliser (kg N)			kg N ha ⁻¹ year ⁻¹										
23	Manure			kg N ha ⁻¹ year ⁻¹										
24														
25														
26	Result from GNOC model to be used in BioGrace Excel tool													
27														

The GNOC evaluates direct and indirect N₂O 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 model, the minimum information required is (see Figure 1): the location of the field or forest, 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.

Figure 1: screenshot of the homepage GNOC website (<http://gnoc.jrc.ec.europa.eu>)

Once the user has provided all relevant information, the website provides the result total N₂O emissions (see figure below). **Note that the calculation gives results in kilogram N (as part of N₂O) per hectare per year. These are converted into the unit "kilogram N₂O per hectare per year" as this unit is used throughout this Excel tool.** Therefore you should take the result (2.2523 in the example below) and multiply it by 1.53743⁴ to get the result in the proper unit (which is kg N₂O/hectare) to report in your pathway.

Result: Total N ₂ O Emissions	
Location ID	2147 - 500
Country name	FRANCE
Total soil N ₂ O emissions [kg N ₂ O-N ha ⁻¹]	2.2523
Total soil N ₂ O emissions [g CO ₂ eq MJ ⁻¹ crop]	7.1726

Result details - values are given in [kg N₂O-N ha⁻¹] unless

Direct N₂O emissions from fertilizer application N₂Oeq

⁴ 44/28=1.57143 kg N₂O/(kg N in N₂O)

6.4 How to use the N₂O emissions IPCC sheet?

For crops that are not covered by the GNOC, a specific module in the sheet “N₂O emissions IPCC” is dedicated to this calculation.

The sheet “N₂O emissions IPCC” of the BioGrace-II tool follows IPCC guidelines 2006 for N₂O emission calculation as explained in chapter 11 “N₂O emissions from managed soils and CO₂ emissions from lime and urea application” (see the “**BioGrace-II Calculation Rules**” document for specific recommendations about the use of this method). At the beginning of the “N₂O 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 N₂O emission sources that occur during the agricultural step: direct N₂O emissions from the field, indirect N₂O emissions due to leaching and runoff and indirect N₂O emissions due to NH₃ and NO_x volatilization.

Step by step example:

For field N₂O 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.

Please enter the data for your crop in the blue cells

General information

Crop name

Crop yield (fresh matter)

Humidity(%)

Crop yield (dry matter)

kg_{ow}/ha/year

kg_{dm}/ha/year

0

Is the soil water saturation high?

Not known

Abbreviation glossary :

Fresh matter = fm
Dry matter = dm
Tonne = t
N mass in N₂O = N2O_N

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

Table 1: Crops covered in this tool and their LHV

Crop	Eucalyptus	Poplar	Corn
LHV	19	18,5	

- Step 2:** To calculate N₂O emissions for a crop that is not listed in Table 1, then enter the name of the crop in Table 1 and fill in Table 4 of this module. More information on how to fill in Table 4 is available in IPCC 2006 chapter 11, Table 11.2.

	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH
33														
34														
35														
36														
37														
38														
39														
40														
41														
42														
43														
44														
45														
46														

Table 4

	N _{AS}	slope	intercept	AG _{DMNT}	(AG _{DMNT} *1000+Crop(T))/Crop(T)	R _{AG(T)}	R _{BO-#(O/T)}	N _{BO}	R _{BO(T)}	BG _{DMNT}	LHV (MJ/kg)	sources
Corn/maize whole crop	0,0060			1,00	#DIV/0!	#DIV/0!	0,2200	0,0070	#DIV/0!	#DIV/0!	16,90	IPCC 2006, chap 11
New crop1												
New crop2												
New crop3												
New crop4												

EQUATION 11.6

N FROM CROP RESIDUES AND FORAGE/PASTURE RENEWAL (TIER 1)

$$F_{CR} = \sum_T \left[\left(R_{AG(T)} \cdot N_{AG(T)} \cdot \left(1 - F_{RAC_{Renew}(T)} \right) + R_{BO(T)} \cdot N_{BO(T)} \right) \right]$$

Table 5

Glossary for the Table 2, 3 and 4

See IPCC 2006, chapter 11 on N₂O emissions, for more details

- 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 D29. Go to sections 6.1 and

6.2 of this manual to know how to use these sheets. When the Esca sheet is used to calculate C losses due to change in agricultural management, please note that only when negative results are obtained, C losses are actually occurring. In this case you should change the sign of the result and insert the obtained value in cell D29.

27	Specific information in case of Land Use Change or modified management practices		
28	What type of land use change is it?	Forest to arable	Use "arable to arable land" in case of modified practices
29	Carbon loss due to land use change	0	Please, calculate this value by using the LUC sheet or the Esca sheet for modified practices
30		t/ha/year	

- **Step 4 - Calculation of direct N₂O emissions from managed soils.** Two more input data are needed for direct N₂O emissions calculations: the quantities of N synthetic fertilizer and N organic fertilizer applied. Intermediate calculations are shown in Tables 2, 3, 4 and 5 and the total of direct N₂O emissions are found at the bottom of the box.
- **Step 5 - Calculation of indirect N₂O emissions from managed soils.** Automatic calculations are made using previous input data. Intermediate calculations for N₂O indirect emissions due to NH₃ + NO_x volatilization and leaching are shown in Tables 6 and 7 (resp.).

59	Indirect N ₂ O emissions from managed soils (Tier1)				See Tables at right side of this sheet			
60			average	min	max			
61								
62	Quantity of NH ₃ volatilized (IPCC Tier 1):	NH ₃ -N (kg)	0,0	0,0	0,0			
63	Quantity of nitrate leaching (IPCC Tier 1):	NO ₃ -N (kg)	0,0	0,0	0,0			
64								
65	Emission factor for NH ₃ volatilization (IPCC Tier 1):	EF ₄ (%)	1,0%	0,2%	5,0%			
66	Emission factor for Nitrate leaching (IPCC Tier 1):	EF ₅ (%)	0,75%	0,1%	2,5%			
67								
68								
69								
70								
71	N ₂ O from atmospheric deposition of N volatilised:	N ₂ O(ATD)-N	0,00	0,000	0,00	0,00	0,00	0,00
72	Emission of N ₂ O from nitrate leaching effect:	N ₂ O(L)-N	0,00	0,000	0,00	0,00	0,00	0,00
73								
74								

Table 6
F _{SN}
F _{ON}
Frac _{QABH}
Frac _{QABF}
NH ₃ &NO _x
EF ₄
source: from

- **Step 6:** The total N₂O emissions are given in yellow at the bottom of the sheet.

	B	C	D	E	F	G	H	I	J
74	TOTAL N ₂ O EMISSIONS (Direct + Indirect N ₂ O) from managed soils (Tier1)								
75									
76									
77									
78									
79									
80									
81									
82									
83									
84									

6.5 How to use the Final Conversion Only sheet?

This sheet should 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.

In fact, there are 2 sheets available in the tool to calculate the GHG emission reduction, each one with a specific use:

- “Final conv. Only” sheet: should be used by companies which produce no heat or only one type of useful heat (i.e. all the useful heat produced has got the same temperature);
- “Final conv. only (mult. heat)” sheet: should be used by companies which produce useful heat at several temperature.

Both sheets work in the same way. The following step by step example uses the “Final conv. Only” sheet but is relevant for both.

To be able to use this sheet the companies should 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:.

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Calculation on final conversion

GHG emissions of biomass

Explanation

This sheet can be used by the company that has bought the biomass energy carrier. Certain calculation rules apply that must be respected. These rules can be found in the document "BioGrace-II calculation rules". The most important rules are:

1. The GHG value of the biomass energy carrier is either a default value or has been calculated using BioGrace-II
2. In case of an actual GHG calculation result, a verifier has verified the GHG calculations
3. If the energy carrier was delivered at a harbour, the inland transport via truck, ship or train has to be calculated and added to the GHG emissions of the energy carrier. The calculation can be done on the corresponding calculation sheets in this tool by adapting the final transport step.
4. The emissions from final conversion shall either be included in the GHG calculation for the biomass energy carrier (in which case cell C37 below can be set to "Yes") or shall be added in this calculation (which is done automatically if cell C37 is set to "No" and the values in cells C38, C39 and C40 are filled in according to the actual end use).
5. The above claims 1., 2. and 3. can be substantiated by documentation such as delivery notes and verification statements, which are accessible to the verifier which performs the verification of the calculation on this sheet.

Results

Final energy

CH₄ and N₂O emissions at final c 0,5 g CO₂

Electricity

All results in g CO_{2,eq} per MJ energy carrier

Allocation factor	Allocated results	Allocated factor
100,0%	50,5	100

per MJ energy carrier

168,3 g CO_{2,eq} per MJ electr.

GHG emission of biomass feedstock ("energy carrier")

Type of energy carrier: give description

GHG emission reduction

Electricity	Heating
9%	

- **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.

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GHG emission of biomass feedstock ("energy carrier")

Type of energy carrier: give description

GHG emission of energy carrier 50,00 g CO_{2,eq}/MJ_{energy carrier}

GHG emission reduction

Electricity	Heating
9%	

- **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.

- **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- Fill in the description of 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.

Combination of default GHG values for codigestion						
Feedstock type	Maize	Wet manure	Biowaste			
Final energy carrier	Bioogas					
Energy provision in digestion	Electricity and heat from CHP					
Digestate storage	Closed digestate					

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

Actual feedstock share						
Share (M)	10000	20000	5000	kg _{wet mass}		
Moisture content	65%	85%	62%	%		
Calculated value						
Feedstock share in energy content (S)	55,11%	19,68%	25,21%	%		
Calculated emission factor	g CO _{2,eq} per MJ biogas			40,63		

- **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.

General settings (only for biogas pathways)	
Main output <input type="checkbox"/> Electricity <input type="checkbox"/> Heat <input type="checkbox"/> Cooling (including heat and / or electricity) <input checked="" type="checkbox"/> Electricity and heat	Conversion efficiencies Electrical efficiency Thermal efficiency Temp of useful heat (°C)

- **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 the same 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.

Therefore, the step by step description below will focus on the first steps of these sheets for calculation of GHG emissions from upstream and from transport of substrates.

Step by step description of the use of this sheet:

- Step 1: Describe the upstream GHG emissions related to non-waste feedstock:** the description includes 5 types of information: the type of substrate, the amount of substrate, the upstream GHG emissions per kg of substrate, the moisture content, and the LHV.

	A	B	C	D	E	F	G	H	I	J	K	L
39												
40		Upstream emissions										
41		Upstream emissions (cultivation or point of generation of waste/residue)										
42												
43			Total amount	Upstream emissions	moisture	LHV _{dry}	Total amount	Feedstock share		Upstream emissions		
44		Type of substrate	kg _{wet} / year	g CO _{2,eq} / kg _{wet}	content	MJ / kg _{dry}	MJ / year	% (energy basis)		g CO _{2,eq} / MJ		
45							0	#DIV/0!		0,0000		
46							0	#DIV/0!		0,0000		
47							0	#DIV/0!		0,0000		
48							0	#DIV/0!		0,0000		
49							0	#DIV/0!		0,0000		
50							0	#DIV/0!		0,0000		
51							0	#DIV/0!		0,0000		
52							0	#DIV/0!		0,0000		
53							0	#DIV/0!		0,0000		
54							0	#DIV/0!		0,0000		
55		Total input	0 kg _{wet} / year				0 MJ / year					
56		Manure credit (only for manure share)										
57			Total amount ma	moisture	LHV _{dry}	Total amou	Feedstock share	Manure credit (per MJ manure)				
58			kg _{wet} / year	content	MJ / kg _{dry}	MJ / year	% (energy basis)	g CO ₂	g CH ₄	g N ₂ O	g CO _{2,eq}	
59		CH ₄ and N ₂ O emission credits for manure				0	#DIV/0!	0,00	-1,47	-0,03	-45,05	
60												
61		Total upstream emissions (including manure credit)										
62		Average upstream emissions (per MJ input)									#DIV/0! g CO _{2,eq} / MJ _{input}	
63		Average upstream emissions (per MJ biogas)									#DIV/0! g CO _{2,eq} / MJ _{biogas}	
64												
65		Biogas yield										
66		Overall biogas yield										
67												
68		Specific biogas yield										
69												
70												
71												

- Step 2:** Calculate the CH₄ and N₂O emission credits for the use of manure, if relevant (see figure above).
- Step 3:** Provide the overall biogas yield (see figure above).
- Step 4:** 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).

	A	B	C	D	E	F	G	H	I	J	K	L
66		Transport of substrates										
67		Transport emissions (transport of substrates as given in step above)										
68			Total amount	Total amount	Type of truck			Transport		Transport emissions		
69		Type of substrate	kg / year	MJ / year	Select truck type from dropdown list			distance (km)		g CO _{2,eq} / year		
70												
71		0	0	0	Truck (40 ton) for manure (Diesel)					0,0		
72		0	0	0	Truck (40 ton) for dry product (Diesel)					0,0		
73		0	0	0						0,0		
74		0	0	0						0,0		
80		Total input										
81												
82		Total emissions (per year)								0,0 g CO _{2,eq} / year		
83		Average transport emissions (per MJ input)								#DIV/0! g CO _{2,eq} / MJ _{input}		
84		Average transport emissions (per MJ biogas)								#DIV/0! g CO _{2,eq} / MJ _{biogas}		
85												
86												
87												

- Step 4:** Complete the rest of the sheet like for any other pathway for the production of biogas and

biomethane.

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 2.4.2) 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
Fossil fuel (oil)	36,0	500	0%	5000
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	Internal usage electricity	Electricity losses	Net electricity production		
[MWh]	[MWh]	[MWh]	[MWh]		
3000	100	5	2895		
Gross heat production	Internal usage heat	Heat losses	Heat quality (average)	Net heat production	
[MWh]	[MWh]	[MWh]	[C]	[MWh]	
6000	500	50	100	5450	
600	0	6	170	594	
500	0	5	250	495	
270	0	3	300	267	
Total nett heat production				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.

	A	B	C	D	E	F
22						
23						
24						
25						
26						
27						
28						
29						
30						
31						
32						
33						

Results	[%]	Heat quality
η_e Efficiency electricity	19,6	(average)
η_{h1} Efficiency heat (100°C)	36,9	100
η_{h2} Efficiency heat (170°C)	4,0	170
η_{h3} Efficiency heat (250°C)	3,3	250
η_{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 that your land enters into one of the two categories of land described in point 8, of annex I of the COM(2010)11, you can add an extra bonus of 29 g eCO₂/MJ to your pathway.

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

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Land use change, including bonus for production on non-agriculture or degraded land				
Land use change				
Does land use change occur? <input type="text" value="no"/>				
Resulting land use change 0,00 ton CO ₂ ha ⁻¹ year ⁻¹				
Emissions per MJ Wood pellets				
	g CO ₂	g CH ₄	g N ₂ O	g CO ₂ eq
	0,00	0,00	0,00	0,00
				0,00
Bonus (eB)	-29,00	0,00	0,00	-29,00
				-29,00
Result g CO ₂ eq / MJ _{Wood pellets}				-29,00

7 Glossary

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

Standard value: data needed to convert input numbers (given in kg, kWh, etc) into GHG emissions. Examples are Lower Heating Values and values to convert 1 kg N-fertiliser or 1 MJ of natural gas into CO₂, CH₄ and N₂O emissions. They are sometime also called "conversion factors".

Default values: default values are the GHG emissions given in the JRC report. There are step by step default values and one global value for the whole pathway. They are derived from the typical value by adding an extra 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 EC reports.

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

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

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

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

GHG: Greenhouse gases, responsible for global warming.

LHV: Lower heating value

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

SWD: Staff Working Document or SWD(2014) 259 "State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU", updates the values defined in the COM(2010)11 to account for the technical and market developments in the bioenergy sector.

Harmonised GHG calculations for electricity, heating and cooling from biomass in Europe (BioGrace-II)

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