BIOGRACE II

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

CHP, Land use change, N_2O field emissions

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GHG calculation course for verifier trainers
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Summary

1. CHP (natural gas, lignite, straw), natural gas boiler (30 min)
2. Land use change and N2O field emissions (45 min)
3. Exercise including CHP, land use change and N2O field emissions (60 min)
4. CO2 storage or replacement + example (30 min)

GHG emissions from the production and use of biofuels

According to the methodology of the RED Directive, Annex V.C.1

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

- **E**: total emissions from the use of the fuel
- e_{ec}: emissions from the extraction or cultivation of raw materials (includes N2O field emissions)
- e_l: annualised emissions from carbon stock changes caused by land-use change
- e_p: emissions from processing (include CHP and NG boilers)
- e_{sca}: emissions saving from soil carbon accumulation via improved agricultural management
- e_{ccs}: emission saving from carbon capture and geological storage
- e_{ccr}: emission saving from carbon capture and replacement
- e_{ee}: emissions saving from excess electricity from cogeneration (CHP)

1. CHP (natural gas, lignite, straw), natural gas boiler

CHP (natural gas, lignite, straw) – General principles

What is a CHP?
→ CHP stands for Combined Heat and Power.
→ CHP integrates the production of electricity and steam simultaneously, from the same fuel (e.g. natural gas, lignite, straw).

Which steps of the biofuel production process can include CHP?
→ CHP appears in the « Processing » step.

Which emissions are considered for calculations?
→ Emissions from the fuel used at the CHP plant.
→ Emissions of CH4 and N2O from steam production in the CHP plant.
→ Emission savings for excess electricity from the CHP plant (e_{ee}).
« The excess electricity is not accounted for if the fuel for CHP is a co-product other than an agricultural crop residue », according to the RED Directive, Annex V.C.16.

CHP (natural gas, lignite, straw) – Calculation rules

What is the methodology to make calculations in BioGrace?

→ Directions from the RED Directive, Annex V.C.16 are followed:

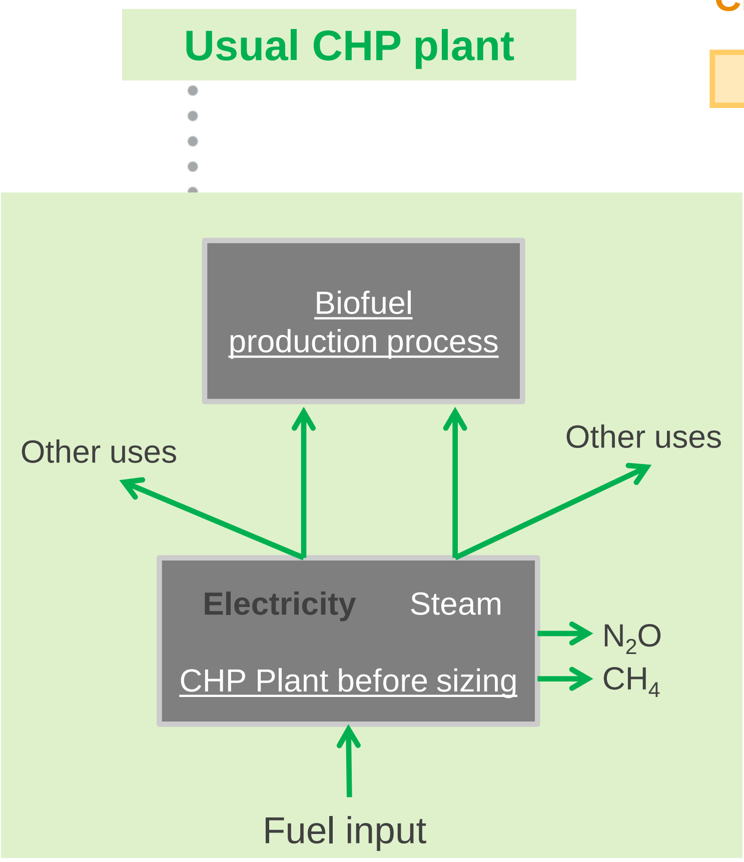
"Emission saving from excess electricity from cogeneration, e_{ee}, shall be taken into account in relation to the excess electricity produced by fuel production systems that use cogeneration except where the fuel used for the cogeneration is a co-product other than an agricultural crop residue. In accounting for that excess electricity, the size of the cogeneration unit shall be assumed to be the minimum necessary for the cogeneration unit to supply the heat that is needed to produce the fuel. The greenhouse gas emission saving associated with that excess electricity shall be taken to be equal to the amount of greenhouse gas that would be emitted when an equal amount of electricity was generated in a power plant using the same fuel as the cogeneration unit." *(in the RED Directive, Annex V.C.16)*

→ The text gives directions but no actual calculation steps.

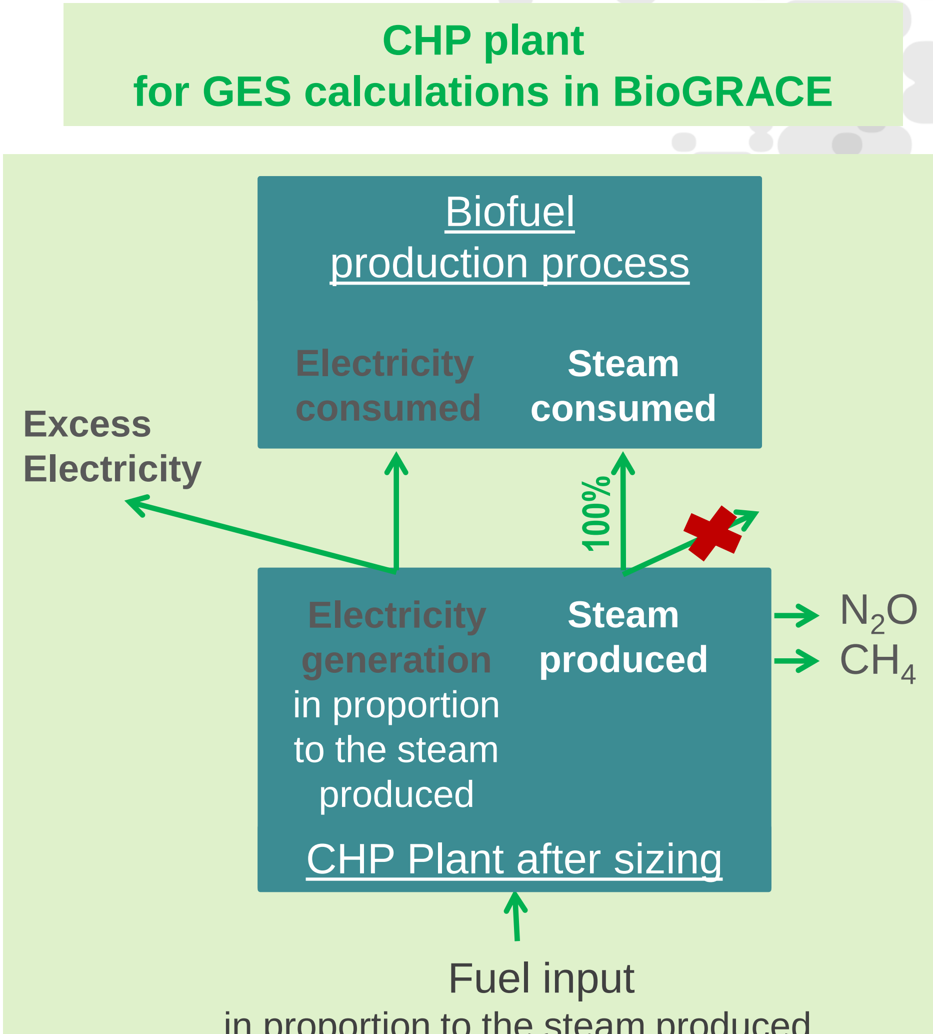
→ Direction 1: Annex V.C.16 of the RED Directive states that the excess electricity credits from CHP are calculated in proportion to the steam consumed by the production process of the biofuel:

"The size of the cogeneration unit shall be assumed to be the minimum necessary for the cogeneration unit to supply the heat that is needed to produce the fuel" *(in the RED Directive, Annex 5.C.16)*

CHP (natural gas, lignite, straw) – Calculation rules



Sizing of the CHP plant



CHP (natural gas, lignite, straw) – Calculation rules

→ Direction 2:

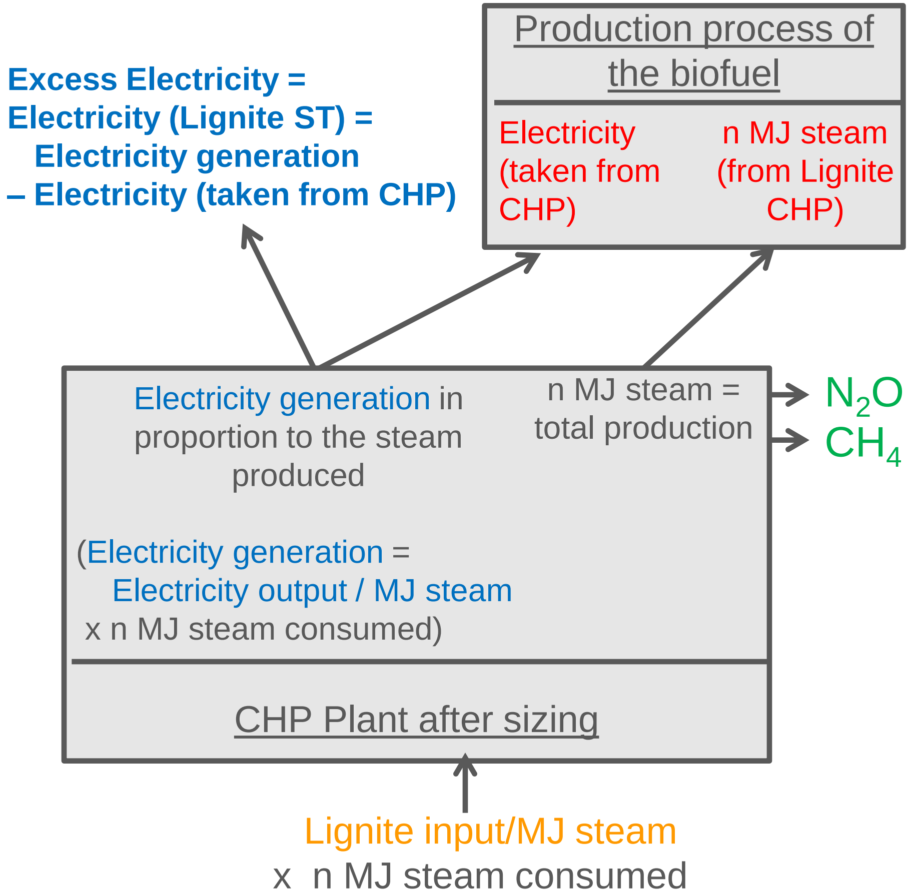
"The greenhouse gas emission saving associated with that excess electricity shall be taken to be equal to the amount of greenhouse gas that would be emitted when an equal amount of electricity was generated in a power plant using the same fuel as the cogeneration unit." in the RED Directive, Annex V.C.16

Credits for excess electricity refer to the avoided impact of the production of electricity in a plant powered with the same fuel as in the CHP plant.

→ In version 4c of the Biograce tool: the « EU mix » may not be used for electricity from the grid (i.e. an additional standard value must be defined and used for the grid average emissions for the country in which electricity is taken from the grid).

CHP (natural gas, lignite, straw) – Calculation steps

Example - Ethanol from wheat, with lignite - fuelled CHP:



Ethanol plant		
Yield		
Ethanol	0,537	$MJ_{Ethanol}$ / MJ_{Wheat}
Co-product DDGS	1,14	ton_{DDGS} / $ton_{Ethanol}$
Energy consumption		
Electricity (taken from CHP)	0,076	MJ / $MJ_{Ethanol}$
Steam (from Lignite CHP)	0,509	MJ / $MJ_{Ethanol}$
Lignite CHP		
CH_4 and N_2O emissions from Lignite CHP		
Lignite input per MJ steam	1,405	MJ / MJ_{Steam}
Lignite	0,715	MJ / $MJ_{Ethanol}$
Electricity output / MJ steam	-0,222	MJ / MJ_{Steam}
Electricity generation	-0,113	MJ / $MJ_{Ethanol}$
Electricity (Lignite ST)	-0,037	MJ / $MJ_{Ethanol}$

Natural gas boiler – Calculation steps

Which steps of the biofuel production process can include NG Boiler?

→ Natural Gas Boiler appears in the « Processing » step.

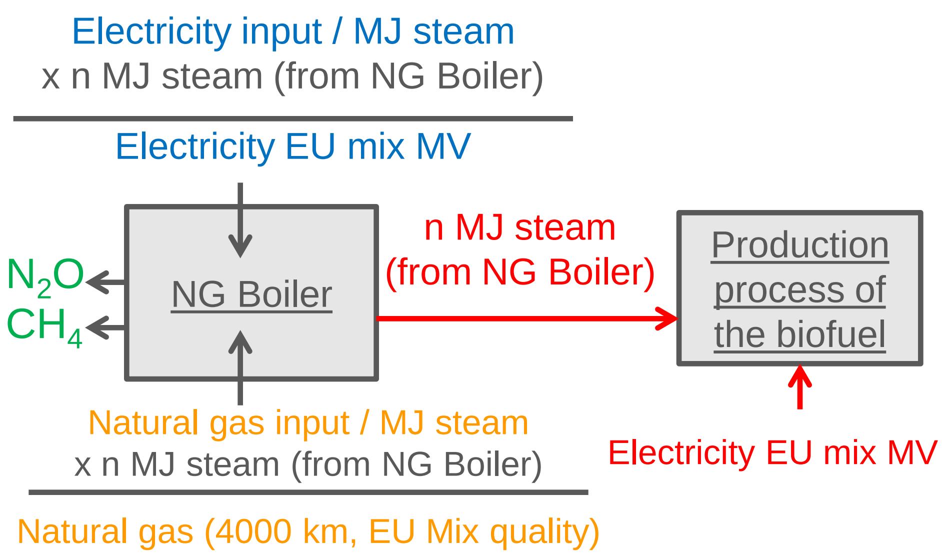
Which emissions are considered for calculations?

→ Emissions from Natural Gas input.

→ Emissions of CH_4 and N_2O from steam production.

→ Electricity consumption.

Example - ethanol from sugar beat with NG Boiler:



Ethanol plant		
Yield		
Ethanol	0,544	$MJ_{Ethanol}$ / $MJ_{Sugarbeet}$
Co-product Sugar beet pulp	0,219	$MJ_{Sugar\ beet\ pulp}$ / $MJ_{Sugar\ b}$
Energy consumption		
Electricity EU mix MV	0,048	MJ / $MJ_{Ethanol}$
Steam (from NG boiler)	0,393	MJ / $MJ_{Ethanol}$
NG Boiler		
CH_4 and N_2O emissions from NG boiler		
Natural gas input / MJ steam	1,111	MJ / MJ_{Steam}
Natural gas (4000 km, EU Mix quality)	0,436	MJ / $MJ_{Ethanol}$
Electricity input / MJ steam	0,020	MJ / MJ_{Steam}
Electricity EU mix MV	0,008	MJ / $MJ_{Ethanol}$

2. Land use change and N_2O field emissions

Land Use Change – General principles

Types of land cover to be considered in LUC:

- Forest land, grassland, cropland, wetlands, settlements and other lands (IPCC categories), perennial crops *(in [OJ C160, p.8]).*
- LUC can be either:
  - direct: conversion of a land that is cultivated or not to biofuel production land or
  - indirect (ILUC): the land used for biofuel production was previously used for food crops' production. Because of food demand, additional land will be used for food crops. NOT yet taken into account in calculation !

Measure of (direct) land use change:

e.g. Forest land → reference land use (since January 2008)

e.g. Cropland → land use after conversion

$$\frac{(SOC + C_{VEG})_{\text{reference land use}} - (SOC + C_{VEG})_{\text{land use after conversion}}}{\text{nb years during which the C stock changes (20 years taken as a reference)}}$$

= annualised emissions from carbon stock change due to LUC (in kg CO_2 eq / MJ biofuel)

Land Use Change – Issues for biofuels

Issues regarding GHG emissions:

- ILUC for biofuels, combined with an intense food demand, are suspected to lead to a higher demand for crop land, and thus higher GHG emissions.
- Some recent studies suspect that ILUC might have important impacts, for example in the biodiesel industry. *
- Albeit ILUC is mentioned in the RED Directive, it will be accounted for only when appropriate methodology is validated by the European Commission.

LUC is critical to define biofuels as a renewable energy:

- To comply with the European Directive 2009/30/EC:

  a biofuel is considered a renewable energy if its use leads to a 35% GHG emission reduction at least *(Article 7b.2 on the sustainability criteria for biofuels).*
- Depending on the scenario, LUC impacts can vary a lot: LUC from rainforest to palm oil plantation makes it hard to comply with the 35% criterion whereas LUC from grassland to palm oil plantation leads to good GHG emission savings.

* "Assessing the Land Use Change Consequences of European Biofuel Policies" by David Laborde, IFPRI, October 2011.

Land Use Change – Calculation sheet

Method for measuring LUC, in RED, Annex V, C:

$$e_l = (CS_R - CS_A)*3.664*1/20*1/P - e_B$$

$$CS_i = (SOC + C_{VEG})*A$$

Factor scaling to the area concerned

Carbon Stock
i: Reference use or
Actual land use

Soil Organic
Carbon

Above and below
ground vegetation
carbon stock

How to calculate SOC and CVEG of a Carbon Stock:

- **Default with mineral soils**: based on the "Option 1. Default calculation" module.
- **Default with organic soils**: based on the " Option 2. Actual calculation" module, and include the Cveg result from the "Option 1. Default calculation" module.
- **Actual calculation**: based on the " Option 2. Actual calculation" module for both Cveg and SOC.

Then, calculation details reported in the calculation sheet stem from the Commission Decision of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive RED.

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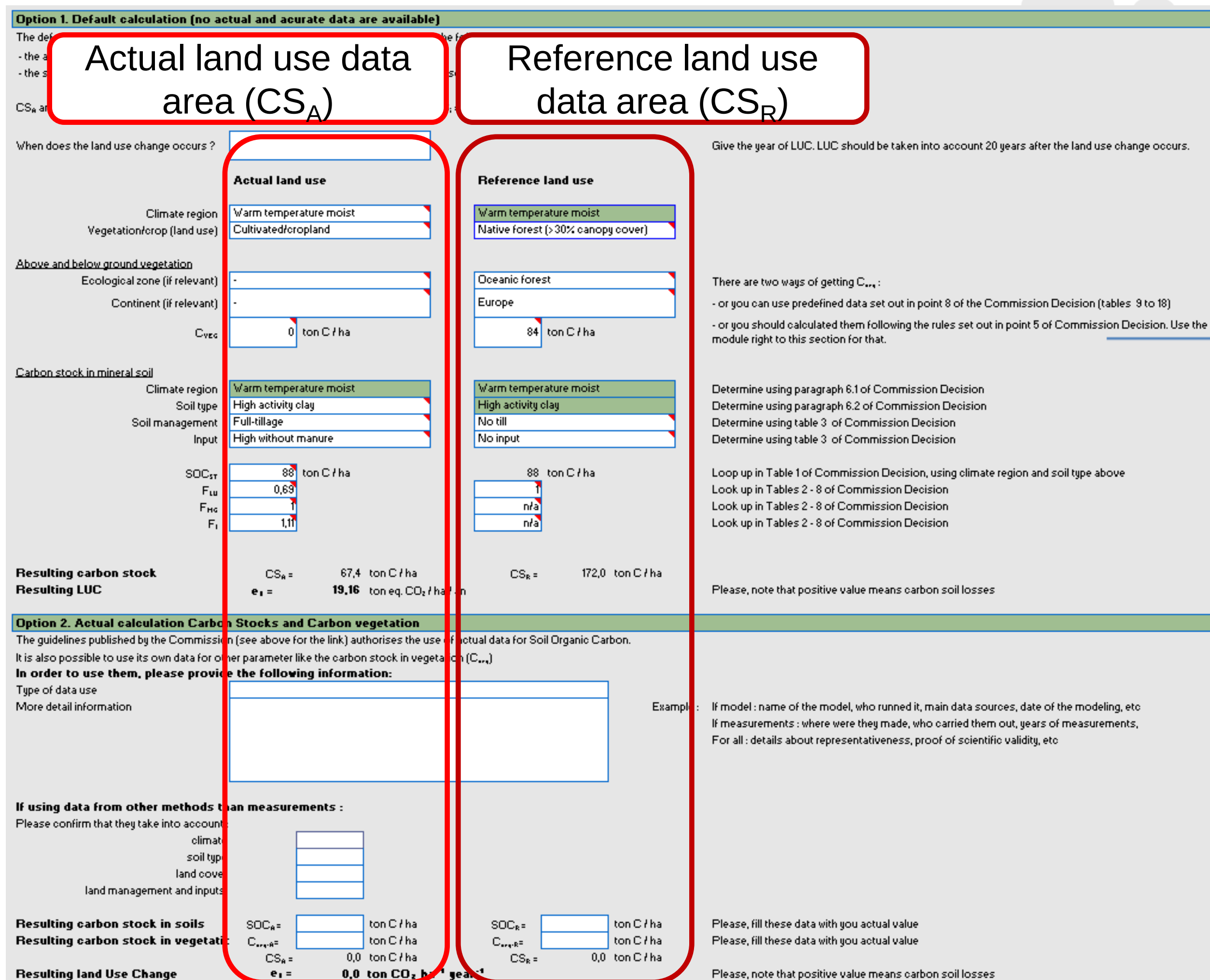
Calculation sheet: Actual and Reference land uses



Calculation sheet: Option 1 – Default calculation

LUC definition

C_{VEG} data area, based on predefined data (point 8, Commission Decision* Tables 9 to 18)

SOC data area

Option 1. Default calculation (no actual and acurate data are available)

The default calculation are based on the calculation of the Commission Decision, with the following assumptions

- the area concerned is 1 hectare. As a result, the factor A (ha / area concerned) equals 1.
- the soils in question are mineral soils. For organic soils, appropriate methods shall be used (see paragraph 4.2 of the Commission Decision).

CS_A and CS_R are calculated with the following equation: $CS_i = C_{VEG} + SOC_{ST} * F_{LU} * F_{MG} * F_I$

When does the land use change occurs ? [ ] — Give the year of LUC. LUC should be taken into account 20 years after the land use change occurs.

	Actual land use	Reference land use	
Climate region	Warm temperature moist	Warm temperature moist	
Vegetation/crop (land use)	Cultivated/cropland	Native forest (>30% canopy cover)	
Above and below ground vegetation			
Ecological zone (if relevant)	-	Oceanic forest	There are two ways of getting C_{veg} :
Continent (if relevant)	-	Europe	- or you can use predefined data set out in point 8 of the Commission Decision (tables 9 to 18)
C_{VEG}	0 ton C / ha	84 ton C / ha	- or you should calculated them following the rules set out in point 5 of Commission Decision. Use the module right to this section for that
Carbon stock in mineral soil			
Climate region	Warm temperature moist	Warm temperature moist	Determine using paragraph 6.1 of Commission Decision
Soil type	High activity clay	High activity clay	Determine using paragraph 6.2 of Commission Decision
Soil management	Full-tillage	No till	Determine using table 3 of Commission Decision
Input	High without manure	No input	Determine using table 3 of Commission Decision
SOC_{ST}	88 ton C / ha	88 ton C / ha	Loop up in Table 1 of Commission Decision, using climate region and soil type above
F_{LU}	0,69	1	Look up in Tables 2 - 8 of Commission Decision
F_{MG}	1	n/a	Look up in Tables 2 - 8 of Commission Decision
F_I	1,11	n/a	Look up in Tables 2 - 8 of Commission Decision

Resulting carbon stock CS_A = 67,4 ton C / ha CS_R = 172,0 ton C / ha

Resulting LUC e_l = **19,16** ton eq. CO_2 / ha / an — Please, note that positive value means carbon soil losses

* 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

Calculation sheet: Option 1 – Default calculation

C_{VEG} data area,
based on calculated data
(point 5, Commission Decision*)

C_{veg} calculation, if carried out under point 5 of the Commission Decision : details of the calculation

For more explaination, please read the Commission Decision of the 10 june 2010, point 5.

Reference land use :

C_{veg}	=	C_{BM}							+	C_{DOM}						
C_{veg}	=	C_{AGB}			+	C_{BGB}			+	C_{DW}			+	C_{LI}		
C_{veg}	=	B_{AGB}	x	CF_B	+	B_{BGB} (or C_{AGB})	x	CF_B (or R)	+	DOM_{DW}	x	CF_{DW}	+	DOM_{LI}	x	CF_{LI}
C_{veg}	=			0,47				0,47				0,5				0,4

data given in purple are suggestion from the Commission Decision

C_{veg} = 0 t carbon / ha — To be reported in C_{VEG} for reference land use

Actual land use :

C_{veg}	=	C_{BM}							+	C_{DOM}						
C_{veg}	=	C_{AGB}			+	C_{BGB}			+	C_{DW}			+	C_{LI}		
C_{veg}	=	B_{AGB}	x	CF_B	+	B_{BGB} (or C_{AGB})	x	CF_B (or R)	+	DOM_{DW}	x	CF_{DW}	+	DOM_{LI}	x	CF_{LI}
C_{veg}	=			0,47				0,47				0,5				0,4

C_{veg} = 0 t carbon / ha — To be reported in C_{VEG} for Actual land use

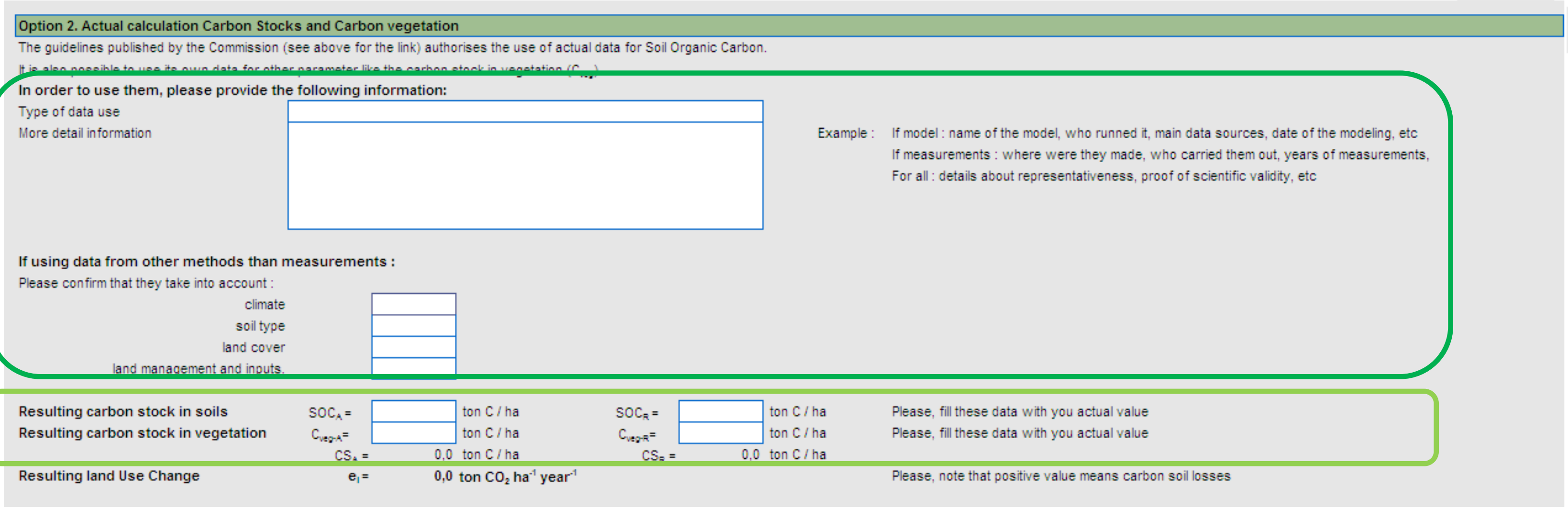
Details about sources :

* 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

Calculation sheet: Option 2 – Actual calculation

Information on dataset area

Actual values area



Option 2. Actual calculation Carbon Stocks and Carbon vegetation

The guidelines published by the Commission (see above for the link) authorises the use of actual data for Soil Organic Carbon.

It is also possible to use its own data for other parameter like the carbon stock in vegetation (C_{veg})

In order to use them, please provide the following information:

Type of data use

More detail information

Example : If model : name of the model, who runned it, main data sources, date of the modeling, etc
If measurements : where were they made, who carried them out, years of measurements,
For all : details about representativeness, proof of scientific validity, etc

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 data with you actual value
Resulting carbon stock in vegetation	$C_{veg\text{-}A}$=		ton C / ha	$C_{veg\text{-}R}$=		ton C / ha	Please, fill these data with you actual value
	CS_A =	0,0	ton C / ha	CS_R =	0,0	ton C / ha	
Resulting land Use Change	e_l =	0,0	ton CO_2 ha^{-1} $year^{-1}$				Please, note that positive value means carbon soil losses

N_2O field emissions – General principles

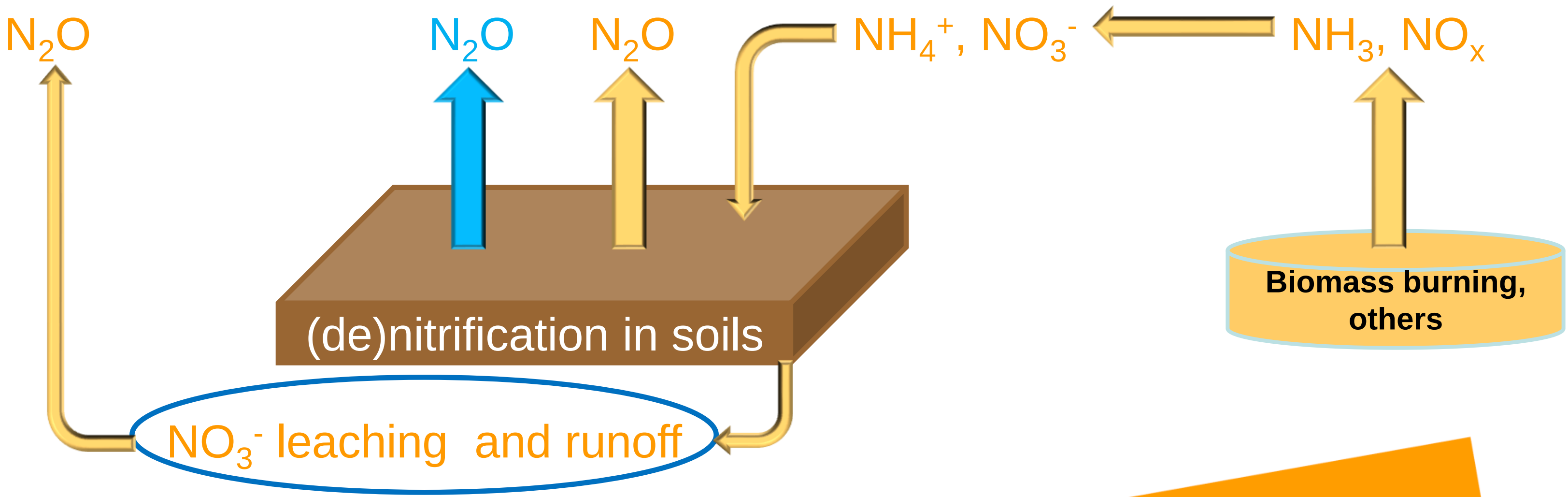
Measure of the direct and indirect N_2O emissions from managed soils (kg N_2O/ha/year):

- N_2O emissions are estimated depending on the quantity of N in soils coming from human activity or from organic matter mineralization.

Measure of N_2O emissions following the IPCC guidelines:

- The methodology used is the Tier 1 of IPCC guidelines 2006 for N_2O emission calculation – Chap.11 "*N_2O emissions from managed soils and CO_2 emissions from lime and urea application*".
- A new methodology using the Stehfest & Bouwman statistical model combined with IPCC Tier1 approach, will be used for the calculations after it is presented by the Commission

- Two types of N2O emissions:
  - **Direct emissions**: due to nitrogen in soils brought by crop residues, fertilizer, urea, lime, trash burning, land use change and agricultural management change
  - **Indirect emissions**:
    - →NH3 and NOx are volatilized (by biomass burning, manure storage, non agricultural activities...) and brought back to soils and shallow waters where they are converted to N2O.
    - →NO3 – runs off and leaches from soil to ground water, riparian zones, ditches, streams, etc. Then, nitrification and denitrification result in N2O emissions.



N_2O field emissions– Issues for biofuels

N_2O field emissions have deep impacts on total GHG emissions:

→ N_2O is a greenhouse gas that is 298 times as much powerful as CO_2. *(RED Directive, Annex V.C.5)*

→ Strong uncertainty remains on N_2O emissions due to general data scarcity.

Connection with LUC and Improved agricultural management:

→ Direct N_2O emissions depend on agricultural practices, thus both LUC and agricultural management impact N_2O emissions.

N_2O field emissions– Calculation sheet

When to use the "N_2O emissions IPCC" calculation sheet ?

When making the actual calculation for the "cultivation" step.

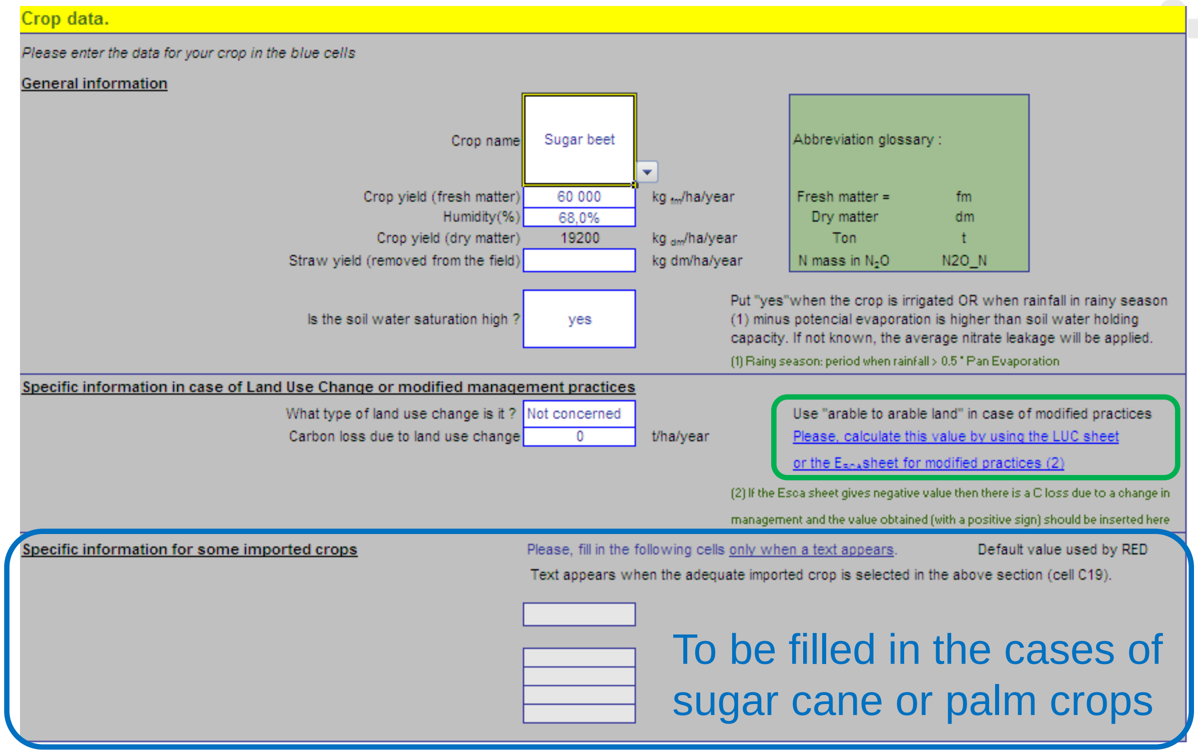
Cultivation of sunflower			Quantity of product	Calculated emissions			
Yield			**Yield**	**Emissions per MJ FAME**			
				g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Sunflowerseed	2 440	kg ha^{-1} year^{-1}	57 974 $MJ_{Sunflowerseed}$ ha^{-1} year^{-1}				
Moisture content	10,0%		1,000 MJ / $MJ_{Sunflowerseed, Input}$				
Co-product Straw	n/a	kg ha^{-1} year^{-1}	0,068 $kg_{Sunflowerseed}/MJ_{FAME}$				
Energy consumption							
Diesel	2 963	MJ ha^{-1} year^{-1}		7,21	0,00	0,00	7,21
Agro chemicals							
N-fertiliser (kg N)	39,0	kg N ha^{-1} year^{-1}		3,06	0,01	0,01	6,41
Manure	0,0	kg N ha^{-1} year^{-1}		0,00	0,00	0,00	0,00
CaO-fertiliser (kg CaO)	0,0	kg CaO ha^{-1} year^{-1}		0,00	0,00	0,00	0,00
K_2O-fertiliser (kg K_2O)	22,0	kg K_2O ha^{-1} year^{-1}		0,33	0,00	0,00	0,35
P_2O_5-fertiliser (kg P_2O_5)	30,0	kg P_2O_5 ha^{-1} year^{-1}		0,80	0,00	0,00	0,84
Pesticides	2,0	kg ha^{-1} year^{-1}		0,55	0,00	0,00	0,61
Seeding material							
Seeds- sunflower	6	kg ha^{-1} year^{-1}		0,07	0,00	0,00	0,12
Field N_2O emissions	1,43	kg ha^{-1} year^{-1}		0,00	0,00	0,04	11,86
Field N_2O emissions can be calculated in the sheet N2O emissions IPCC			Total	**12,02**	**0,01**	**0,05**	**27,41**
			Result	g $CO_{2,eq}$ / MJ_{FAME}			27,41

Structure of the BioGrace Excel sheet:

- Part 1: Crop data
- Part 2: Direct N_2O emissions from managed soils
- Part 3: Indirect N_2O emissions from managed soils
- Part 4: Total N_2O emissions

Part 1: Crop data

- Eight crops are predefined in the “crop name” field.
- For other crops, tables 1 and 4 have to be used. Guidelines appear in IPCC guidelines 2006 - Chap.11, Table 11.2 (*).
- LUC and Esca sheet must be used for Carbon loss calculation if applicable



* IPCC 2006, 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 11 on N2O emissions from managed soils

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Part 2: Direct N_2O emissions from managed soils

- N synthetic fertilizer and N organic fertilizer quantities are required.
- Detailed calculations are displayed on Tables 2, 3, 4 and 5.

Direct N_2O emissions from managed soils (Tier1). See Table 2, Table 3, Table 4 and Table 5 for intermediate calculations (right side of the this sheet)

Please enter the N additions in the form of synthetic or organic fertilizer in the blue cells

N_2O emissions from N inputs:

F_{SN}	119,70	kg N/ha/year	N in synthetic fertilizer
F_{ON}	0,00	kg N/ha/year	N in organic fertilizer
F_{CR}	119	kg N/ha/year	N in crop residues
F_{SOM}	0,00	kg N/ha/year	N mineralized

		average	min	max
Emission factor for direct emission (IPCC Tier 1)	EF_1	1,0%	0,3%	3,0%

		kg N_2O_N/ha/year			kg N_2O/ha/year			
		average	min	max	average	min	max	
Calculated Direct N_2O emissions	$N_2O\_N_{N\ inputs}$	2,38	0,72	7,15	3,75	1,12	11,24	Eq.11.2

Other direct N_2O emissions (trash burning)

data appears only when required

kg N_2O_N/ha/year	kg N_2O/ha/year

TOTAL direct N_2O emissions

	kg N_2O_N/ha/year			kg N_2O/ha/year		
	average	min	max	average	min	max
TOTAL Direct N_2O Emissions :	2,384	0,715	7,153	3,747	1,124	11,240

Part 3: Indirect N_2O emissions from managed soils

- Calculations are automatic.
- Tables 6 and 7 show calculations for N_2O indirect emissions due to :
  - NH_3 and NO_x volatilisation
  - leaching and runoff

Indirect N_2O emissions from managed soils (Tier1) — See Table 6, Table 7, Table 8 for intermediate calculations (right side of the this sheet)

		average	min	max
Quantity of NH_3 volatilized(IPCC Tier 1):	NH_3_N (kg)	12,0	3,6	35,9
Quantity of nitrate leaching (IPCC Tier 1):	NO_3_N (kg)	71,5	23,8	190,7
Emission factor for NH_3 volatilization (IPCC Tier 1):	EF_4 (%)	1,0%	0,2%	5,0%
Emission factor for Nitrate leaching (IPCC Tier 1):	EF_5 (%)	0,75%	0,1%	2,5%

		kg N_2O_N/ha/year			kg N_2O/ha/year		
N_2O from atmospheric deposition of N volatilised:	N_2O(ATD)-N	0,12	0,007	1,80	0,19	0,01	2,82
Emission of N_2O from nitrate leaching effect:	N_2O(L)-N	0,54	0,012	4,77	0,84	0,02	7,49

Part 4: Total N_2O emissions

- The final value in the yellow frame is to be reported in the “Cultivation” step of the pathway.

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

	kg N_2O_N/ha/year			kg N_2O/ha/year		
	average	min	max	average	min	max
per ha	3,04	0,73	13,72	4,78	1,15	21,55
per kg dm	0,16	0,04	0,71	0,25	0,06	1,12
per MJ of crop	0,0097	0,0023	0,0438	0,02	0,00	0,07

Value to report in your pathway : **4,78** kg N_2O/ha/year

Cultivation of sunflower | **Quantity of product** | **C[illegible]culated emissions**

Yield

57 974 $MJ_{Sunflowerseed}$ ha^{-1} $year^{-1}$
1,000 MJ / $MJ_{Sunflowerseed, Input}$
0,068 $kg_{Sunflowerseed}/MJ_{FAME}$

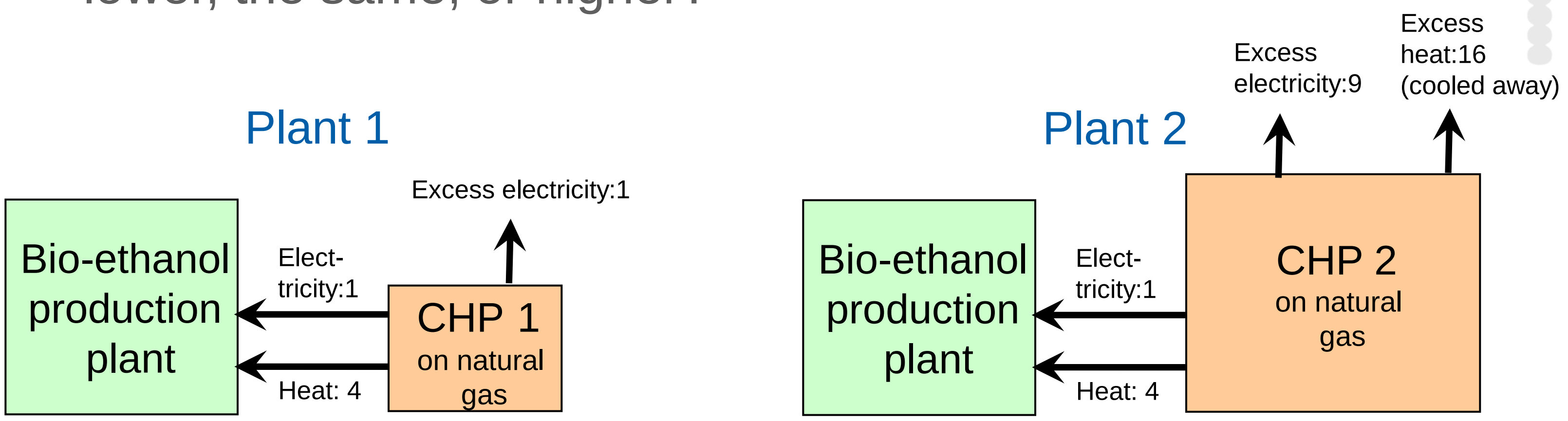
E[illegible]sions per MJ FAME

			[illegible]O_2	g CH_4	g N_2O	g $CO_{2,eq}$
Yield						
Sunflowerseed	2 440	kg ha^{-1} $year^{-1}$				
Moisture content	10,0%					
Co-product Straw	n/a	kg ha^{-1} $year^{-1}$				
Energy consumption						
Diesel	2 963	MJ ha^{-1} $year^{-1}$	7,21	0,00	0,00	7,21
Agro chemicals						
N-fertiliser (kg N)	39,0	kg N ha^{-1} $year^{-1}$	3,06	0,01	0,01	6,41
Manure	0,0	kg N ha^{-1} $year^{-1}$	0,00	0,00	0,00	0,00
CaO-fertiliser (kg CaO)	0,0	kg CaO ha^{-1} $year^{-1}$	0,00	0,00	0,00	0,00
K_2O-fertiliser (kg K_2O)	22,0	kg K_2O ha^{-1} $year^{-1}$	0,33	0,00	0,00	0,35
P_2O_5-fertiliser (kg P_2O_5)	30,0	kg P_2O_5 ha^{-1} $year^{-1}$	0,80	0,00	0,00	0,84
Pesticides	2,0	kg ha^{-1} $year^{-1}$	0,55	0,00	0,00	0,61
Seeding material						
Seeds- sunflower	6	kg ha^{-1} $year^{-1}$	0,07	0,00	0,00	0,12
Field N_2O emissions		kg ha^{-1} $year^{-1}$	0,00	0,00	0,04	11,86
		Total	12,02	0,01	0,05	27,41
		Result	g $CO_{2,eq}$ / MJ_{FAME}			27,41

Field N_2O emissions can be calcu[illegible]et
N2O emissions IPCC

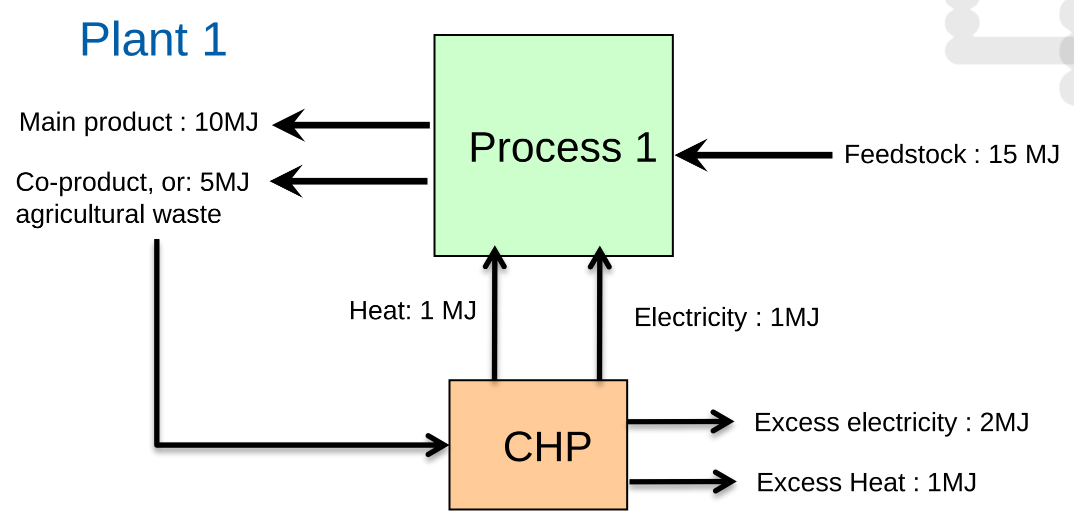
3. Exercise including CHP, land use change and N_2O field emissions

- **Question 1:** Installation sizing - The only difference in the two calculations below is that CHP 2 is five times larger than CHP 1. Will the GHG performance of ethanol from plant 2 - in comparison to the performance of ethanol from plant 1 - be lower, the same, or higher?



Answer: The performance will be the same, as only that part of CHP 2 will be taken into account that is needed to supply the heat for the ethanol plant, which is 1/5 of CHP 2, resulting (again) in an excess electricity of 1. See rule 6.1

- **<u>Question 2:</u>** Calculate the credit due to excess of electricity



Answer: *It depends if it is a co-product or an agricultural waste (RED, Annex V.C.16) :*

- For an agricultural crop residue : it is a simple case of sizing the CHP according to the excess of heat produced (so the credit is calculated using 0.5MJ for the excess electricity)

- For a co-product : There is no credit strictly speaking; the system should be extended to the process and the CHP so that the input is the feed stock and the outputs are the main product, the excess of electricity and the excess of heat. Then there is an allocation between the 3 outputs where, :

- 0MJ is used for the excess of heat (as the LHV for heat is null)

- the allocation between electricity and the main product is related to their energy which means 1/6 of emissions allocated to excess of electricity and 5/6 to the main product

- **Question 3:** If I buy a green certificate for using green energy to fuel my CHP, how can I take it into account to calculate the credit related to this green certificate ?

Answer: Green certificates are not taken into account in calculation, so no credit can be used.

- **Question 4:** If a land use change occuring in 2010 led to an increase in the C storage, how do I take it into account in my calculation? How do I take it into account if the LUC occured in 2000?

Answer: For 2010, the formula given in the RED should be used to find the result which also depends on the productivity of the biofuel. For 2000, the LUC is not taken into account as is happened before the 1st January 2008.

- **Question 5:** Can I use the default values for the cultivation step listed in the Annex V of the RED, if a land use change occurred in 2010 ?

Answer: *It depends. If a land use change occurred after January 2008, you are allowed to use the default values provided in Annex V of the RED, only if this land use change lead to an increase in the carbon stock.*

- **Question 6:** If actual data are available for the calculation of SOC and Cveg, I am allowed to make default calculation using the data liste in the "Guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC" ?

Answer: Yes, it is always possible to use both possibilities

- **Question 7:** I can use the same LUC value for several plots but only if they are in the same NUTS 2 area ?

Answer: The use of an identical value for LUC is not related to the closeness of the plots but to their identical management history, biophysical conditions, and input history (cf "Guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC")

- **Question 8:** For a CHP using waste, shall we account the wastes' transport in the calculation?

Answer: Yes, according to BioGrace methodology .But there are inconstitencies: JRC sometimes took it into account, France does not take these transports into account, England take these transports into account, EC take them into account if waste have changed their destination by being used in the CHP. The RED states that wastes (…) shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials.

- **Question 9:** The excess electricity from the ethanol plant is -0,113 MJ/MJEthanol with the following data: right or wrong?

Ethanol plant		
Yield		
Ethanol	0,361	$MJ_{Ethanol}$ / $MJ_{Sugarcane}$
Co-products	0,000	MJ / $MJ_{Sugar\ cane}$
Energy consumption		
Electricity (taken from CHP)	0,076	MJ / $MJ_{Ethanol}$
Steam (from CHP)	0,509	MJ / $MJ_{Ethanol}$
CHP		
Size of CHP		
Steam prod. considered	0,509	MJ / $MJ_{Ethanol}$
Input to CHP		
Fuel input / MJ steam	1,405	MJ / MJ_{Steam}
Fuel input per MJ ethanol	0,715	MJ / $MJ_{Ethanol}$
Emissions from CHP		
CH_4 and N_2O emissions from CHP (to be further specified - give G		
CHP fuel - specify	0,715	MJ / $MJ_{Ethanol}$
CH_4 and N_2O emissions from CHP (to be further specified - give G		
CHP fuel - specify	0,715	MJ / $MJ_{Ethanol}$
Electricity generation in CHP plant		
CHP net output / MJ steam	0,222	MJ / MJ_{Steam}
CHP net output / MJ Ethanol	0,113	MJ / $MJ_{Ethanol}$
Net production or consumption in ethanol plant	-0,037	MJ / $MJ_{Ethanol}$
Electricity - specify	0,037	MJ / $MJ_{Ethanol}$
Pure CaO for processes	0,000670	kg / $MJ_{Ethanol}$
Cycle-hexane	0,000040	kg / $MJ_{Ethanol}$
Sulphuric acid (H_2SO_4)	0,000598	kg / $MJ_{Ethanol}$
Lubricants	0,000010	kg / $MJ_{Ethanol}$

Answer: Wrong, the excess electricity is -0,037MJ/MJEthanol
= Electricity Lignite ST = Electricity taken from CHP - Electricity generation
= 0,076 MJ/MJ Ethanol – 0,113 MJ/MJ Ethanol

- **Question 10:** Make the 3 exercices included in the excel sheet given in annexe
  - Exercice on CHP calculation
  - Exercice on LUC
  - Exercice on N2O emissions

4. CO_2 storage or replacement:

→Improved agricultural management (soil organic carbon accumulation)
→CO2 capture and geological storage
→CO2 capture and replacement

Improved agricultural management – General principles

What is measured:

e.g. Full-tillage

e.g. No tillage, increased residue incorporation

SOC reference agricultural management (January 2008 or for 20 years) – SOC actual agricultural management

nb years during which the C stock changes (20 years taken as a reference)

= annualised emissions from carbon stock change due to agricultural management change (in kg CO_2 eq / MJ biofuel)

Land Use Change and e_{sca} (soil carbon accumulation):

	Esca	LUC
Nature of change	Agricultural management change	Land use change
Carbon stock change accounted for	**Soil**	**Soil and vegetation**
Meaning	e_{sca} positive <=> CS increase in soil <=> GHG emissions depletion	e_l positive <=> CS losses <=> GHG emissions increase

Improved agricultural management – Issues for biofuels

Agricultural management & LUC:

The impacts of Improved agricultural management are included in the Land use change impacts.

Issues that are similar to the Land Use Change's:

As for LUC, the value of improved agricultural management is critical for a biofuel classification as a renewable energy or not.

CO_2 storage and replacement – general principles

What do CO_2 storage and replacement account for?

- CO_2 capture and geological storage (CCS):

  Emission saving from carbon capture and geological storage e_{ccs}, that have not already been accounted for in e_p, shall be limited to **emissions avoided through the capture and sequestration of emitted CO_2 directly related to the extraction, transport, processing and distribution of fuel**. *(in the RED Directive, Annex V.C.14)*

- CO_2 capture and replacement (CCR):

  Emission saving from carbon capture and replacement, e_{ccr}, shall be limited to **emissions avoided through the capture of CO_2 of which the carbon originates from biomass and which is used to replace fossil-derived CO_2 used in commercial products and services**. *(in the RED Directive, Annex V.C.15)*

  Example of CO_2 replacement: use of captured CO2 to replace CO2 to greenhouses, that originally was produced by burning natural gas.

CO_2 storage and replacement – issues for biofuels

- The RED Directive mentions a credit for CO_2 avoided by CCS and CCR, in Annex V.C.14 and Annex V.C.15.
- However, no supporting methodology is proposed in the Directive.
- CO_2 capture involves additional energy and possibly CO_2 emissions. Thus the amount of CO_2 avoided is not the same as the CO_2 captured.

CO_2 storage and replacement – calculation sheet

- CO_2 capture and replacement (e_{ccr}) and CO_2 capture and geological storage (e_{ccs}) are the last modules of each pathway.
- Both modules are directly filled by users without intermediary calculation.

CO_2 capture and replacement				
e_{ccr}		Emissions per MJ FAME		
0	$g\ CO_{2,eq}$ / MJ_{FAME}			0,00
		Result	$g\ CO_{2,eq}$ / MJ_{FAME}	0,00

CO_2 capture and geological storage				
e_{ccs}		Emissions per MJ FAME		
0	$g\ CO_{2,eq}$ / MJ_{FAME}			0,00
		Result	$g\ CO_{2,eq}$ / MJ_{FAME}	0,00

CO_2 storage and replacement – calculation sheet

- The white cells have to be filled with a positive value.
- The credit from the CO_2 storage or replacement is automatically deducted in the upper part of the sheet.

	A	B	C	D	E
2	**Production of Ethanol from Sugarcane**				
3	**Overview Results**				
4	*All results in*	Non- allocated	Allocation	Allocated	**Total**
5	*g $CO_{2,eq}$ / $MJ_{Ethanol}$*	results	factor	results	
6	**Cultivation e_{ec}**				14,5
7	Cultivation of sugarcane	14,33	100%	14,33	
8	Transport of vinasse and filt	0,14	100%	0,14	
9	**Processing e_p**				0,9
10	Ethanol plant	0,85	100%	0,85	
11	**Transport e_{td}**				9,0
12	Transport of sugarcane	0,85	100%	0,85	
13	Transport of ethanol	7,73	100%	7,73	
14	Filling station	0,44	100%	0,44	
15	**Land use change e_l**	143,5	100%	143,5	143,5
16	**Bonus** (restored degrade	0,0	100,0%	0,0	0,0
17	$e_{sca} + e_{ccr} + e_{ccs}$	100,0	100%	100,0	100,0
18	**Totals**	=SOMME(B7:B16)-B17			67,8
19			Track changes: OFF		When using this
20	**Calculation per phase**				The rules are inc
174					

175	**CO_2 capture and replacement**			
176	e_{ccr}	Emissions per MJ ethanol		
177	50 g $CO_{2,eq}$ / $MJ_{Ethanol}$			50,00
178		Result	g $CO_{2,eq}$ / $MJ_{Ethanol}$	50,00
179				
180				
181	**CO_2 capture and geological storage**			
182	e_{ccs}	Emissions per MJ ethanol		
183	50 g $CO_{2,eq}$ / $MJ_{Ethanol}$			50,00
184		Result	g $CO_{2,eq}$ / $MJ_{Ethanol}$	50,00

5. Exercice and examples on CO_2 storage or replacement

Exercice on CO_2 storage and replacement – the consumption of CO_2 by greenhouses

- **Question 1:** **If CO_2 captured from an ethanol plant is used as fertiliser in a greenhouse, does it lead to a CCR credit?**

Answer : It depends on the origin of the CO2 previously used in the reference scenario:

•The CO2 came from the atmosphere → no CCR credit

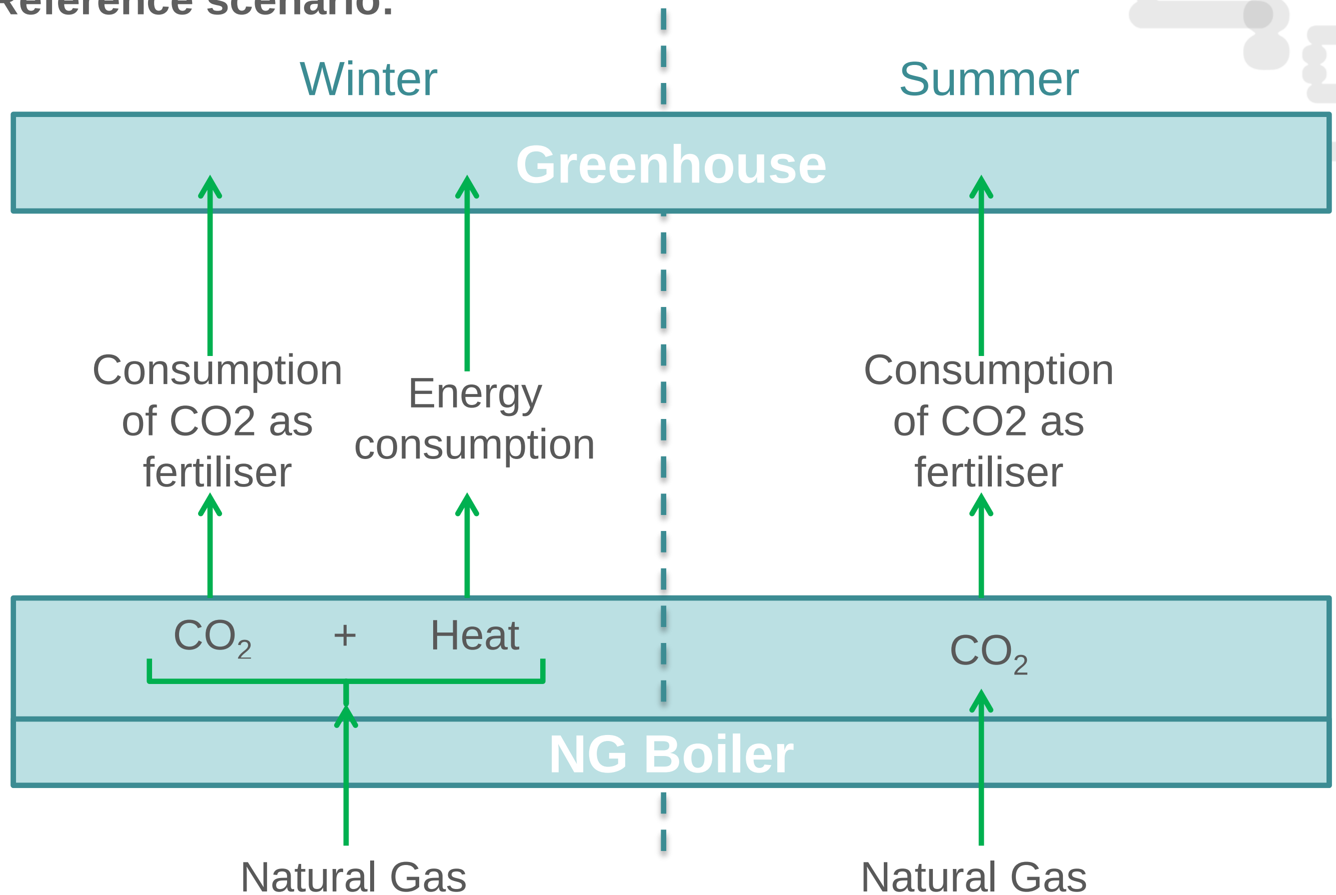
•The CO2 came from a fossil fuel combustion:

- *And the use of captured CO2 from the Ethanol plant leads to stop fossil fuel burning → CCR credit is possible*
- *But fossil fuel still needs to be burnt → no CCR credit*

(see the following example)

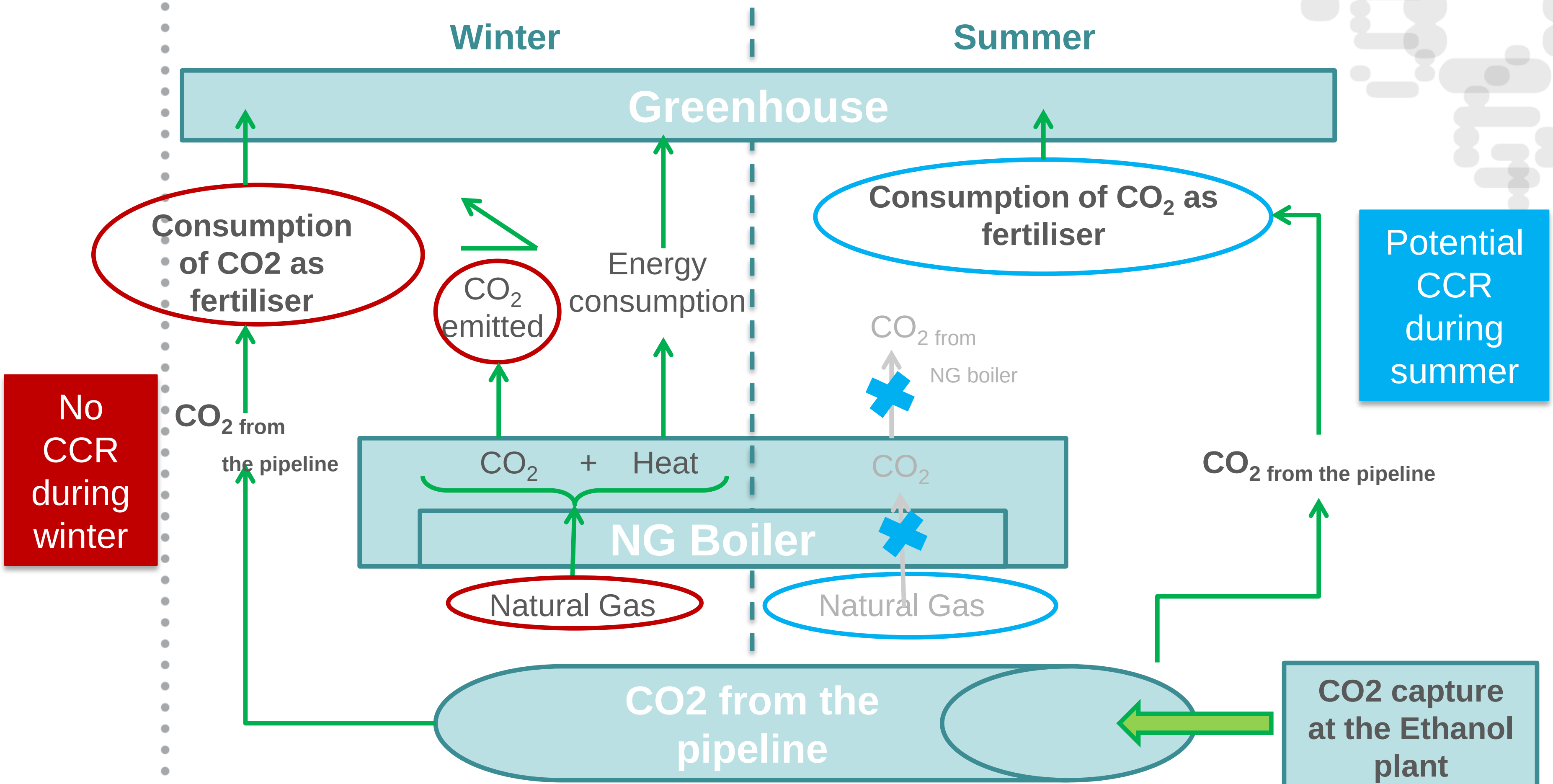
CO_2 storage and replacement – example of the consumption of CO_2 by greenhouses

→ **Reference scenario:**



CO_2 storage and replacement – example of the consumption of CO_2 by greenhouses

→ **Scenario with CO2 captured at Ethanol plant and provided by pipeline:**



CO_2 storage and replacement – example of the consumption of CO_2 by greenhouses

- **Question 2: How to calculate the CCR credit for the situation in summer?**

Considering only the amount of CO2 replaced does not lead to a comprehensive result.

Calculations have to account for all the environmental costs generated by the capture of CO_2 at the ethanol plant, transportation and use of CO_2.

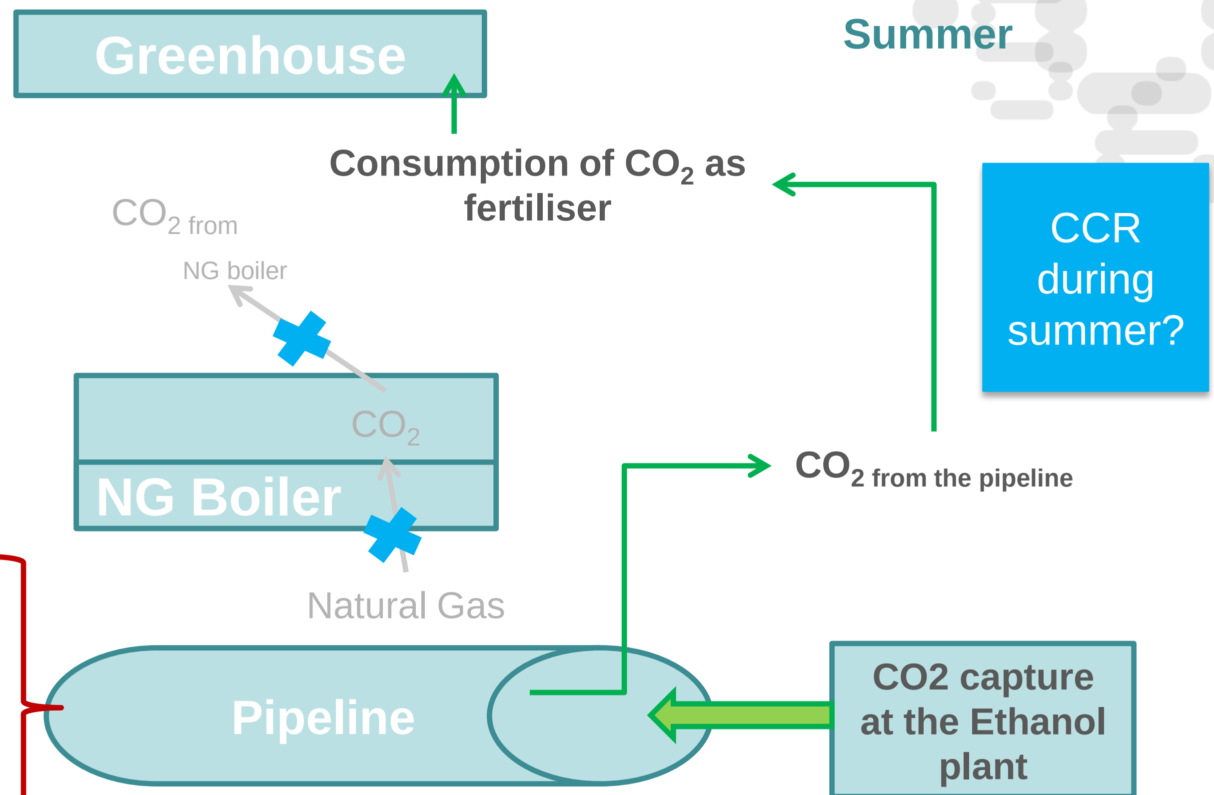
If the environmental costs are higher than GHG emissions savings, then there is no CCR credit.

Example of additional environmental cost:

GHG emissions due to the building of pipelines for CO_2 transportation.

CO_2 storage and replacement – example of the consumption of CO_2 by greenhouses

→ **Environmental cost:**



- **Transport pipeline (steel): 97 km pipeline**
- **Distribution pipeline (HDPE): 200 km**
- **Total supply: 400,000 tons of CO2 per year**

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

INTELLIGENT ENERGY EUROPE

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