BIOGRACE II

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

Some specific functions of the BIOGRACE II-tool

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Public Workshop
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Summary

1. Land use change
2. N_2O field emissions
3. Final conversion sheet

GHG emissions from the production and use of electricity, heating and cooling from biomass

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. Land use change

Land Use Change – General principles

- **Direct LUC :** conversion of a land that is cultivated or not to ‘biomass for energy production’ land
- **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]).*

Measure of direct land use change:

e.g. Forest land → $CS_{\text{reference land use}}$ (since January 2008)

e.g. Cropland → $CS_{\text{land use after conversion}}$

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

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

Land Use Change – Calculation sheet

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

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

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

Carbon Stock
i: Reference use or
Actual land use

Soil Organic
Carbon

Above and below
ground vegetation
carbon stock

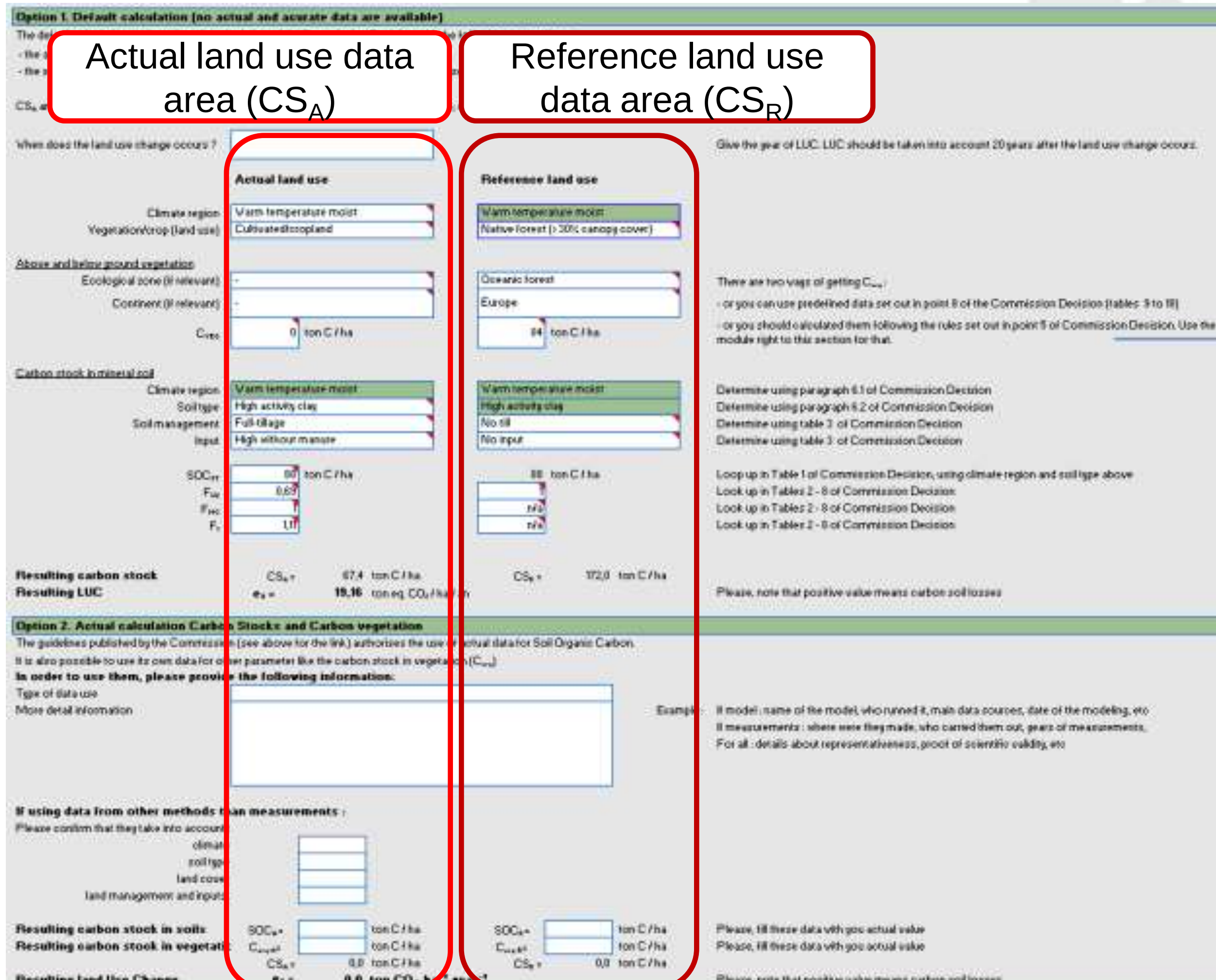
Factor scaling to the area
concerned

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.

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: $CS_i = C_{VEG} + SOC_{ST} * F_{LU} * F_{MG} * F_I$

	Actual land use		Reference land use		
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.
Climate region	Warm temperature moist		Warm temperature moist		
Vegetation/crop (land use)	Cultivated/cropland		Native forest (>30% canopy cover)		

Above and below ground vegetation

	Actual land use		Reference land use		
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

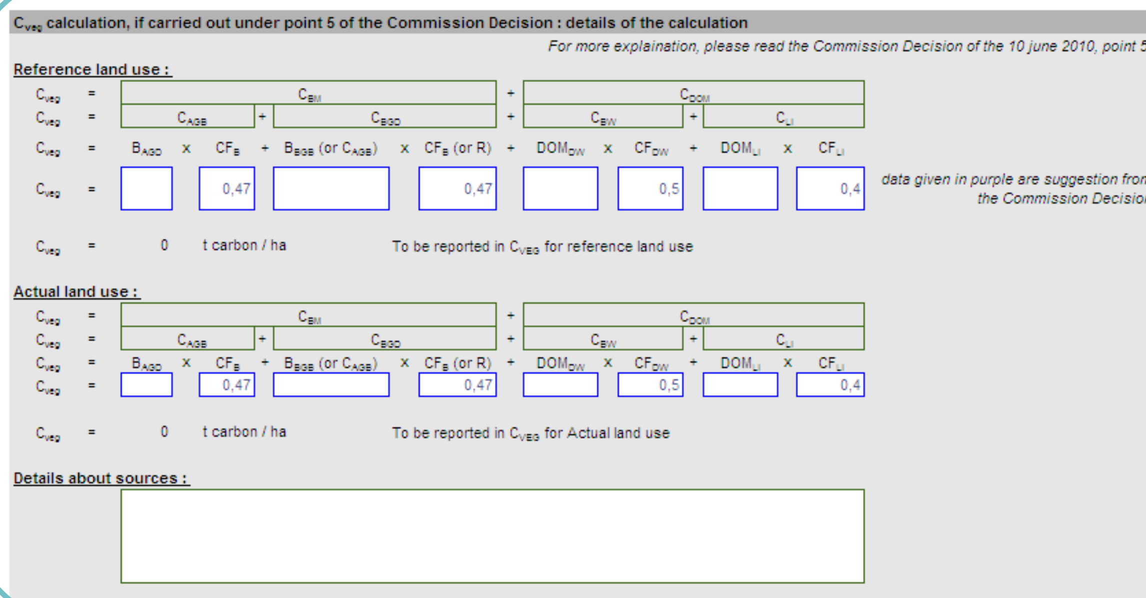
	Actual land use		Reference land use		
Climate region	Warm temperature moist		Warm temperature moist		Determine using paragraph 6.1 of Commission Decision
Soil type	High activity clay		High activity clay		Determine using paragraph 6.2 of Commission Decision
Soil management	Full-tillage		No till		Determine 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 :

$C_{veg} = C_{BM} + C_{DOM}$

$C_{veg} = C_{AGB} + C_{BGD} + C_{BW} + C_{LI}$

$C_{veg} = B_{AGD} \times CF_B + B_{BGB}$ (or C_{AGB}) $\times CF_B$ (or R) $+ DOM_{DW} \times CF_{DW} + DOM_{LI} \times CF_{LI}$

$C_{veg} =$ [ ] x 0,47 + [ ] x 0,47 + [ ] x 0,5 + [ ] x 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 :

$C_{veg} = C_{BM} + C_{DOM}$

$C_{veg} = C_{AGB} + C_{BGD} + C_{BW} + C_{LI}$

$C_{veg} = B_{AGD} \times CF_B + B_{BGB}$ (or C_{AGB}) $\times CF_B$ (or R) $+ DOM_{DW} \times CF_{DW} + DOM_{LI} \times CF_{LI}$

$C_{veg} =$ [ ] x 0,47 + [ ] x 0,47 + [ ] x 0,5 + [ ] x 0,4

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

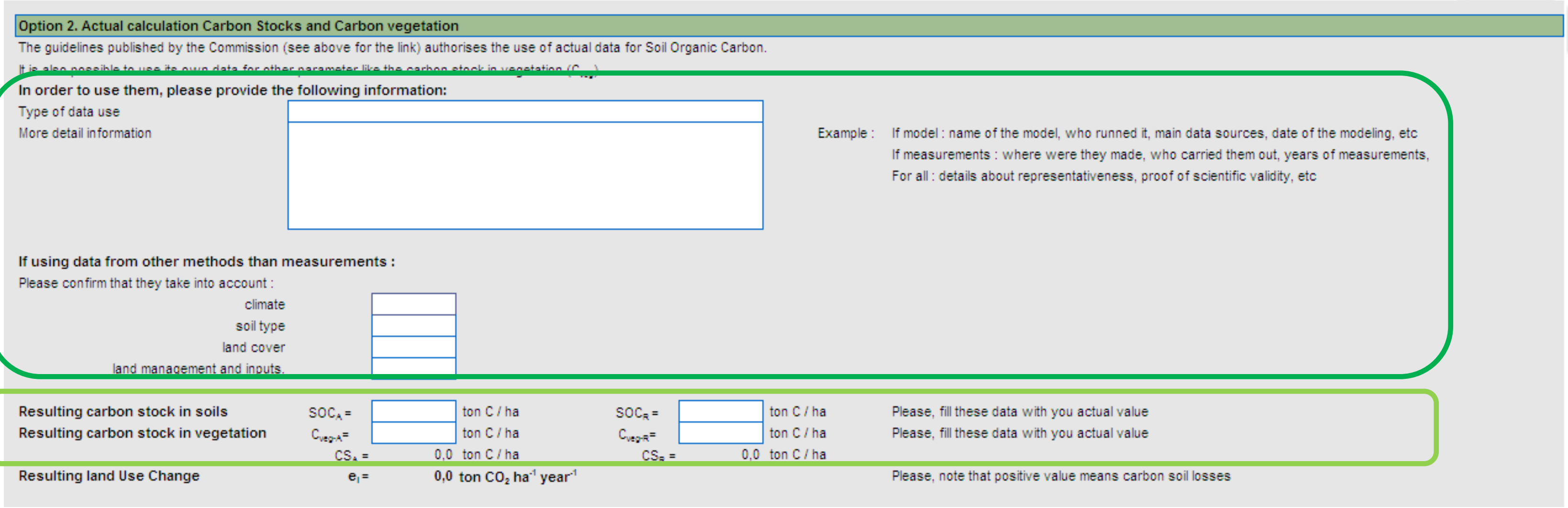
Details about sources :

* 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.

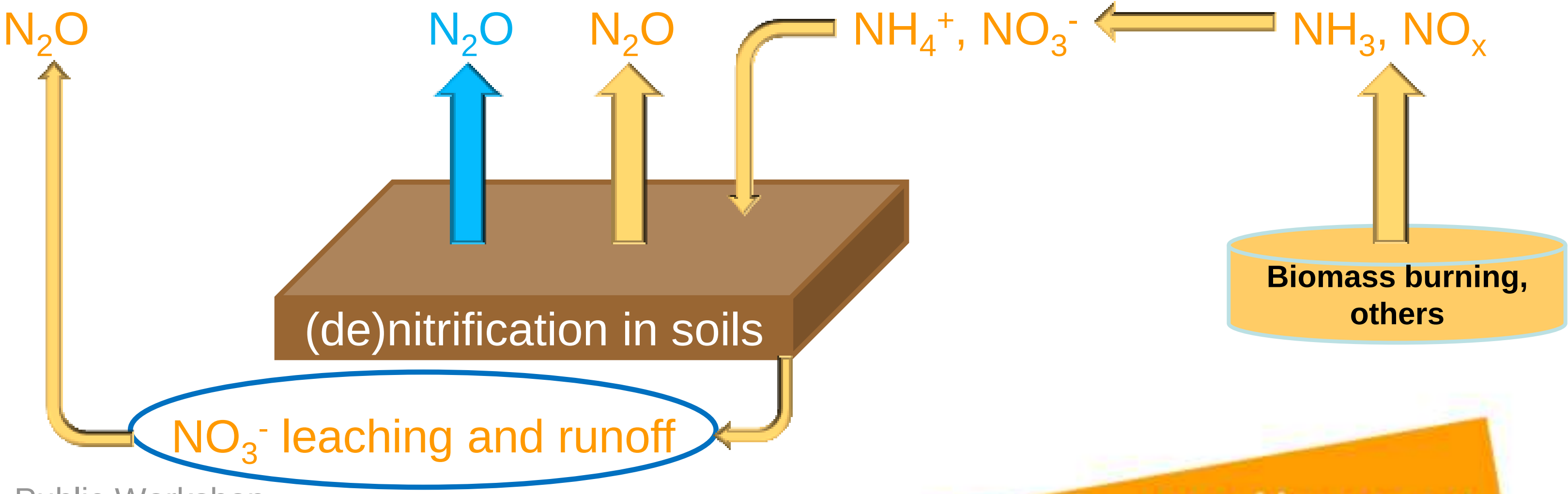
Resulting carbon stock in soils	SOC_A =		ton C / ha	SOC_R =		ton C / ha	Please, fill these data with you actual value
Resulting carbon stock in vegetation	$C_{veg\text{-}A}$=		ton C / ha	$C_{veg\text{-}R}$=		ton C / ha	Please, fill these data with you actual value
	CS_A =	0,0	ton C / ha	CS_R =	0,0	ton 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

2. N_2O field emissions

N_2O field emissions – General principles

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

- **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.



Issues on N_2O field emissions

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.

The Global Nitrous Oxide Calculator (GNOC)

Developed by the JRC

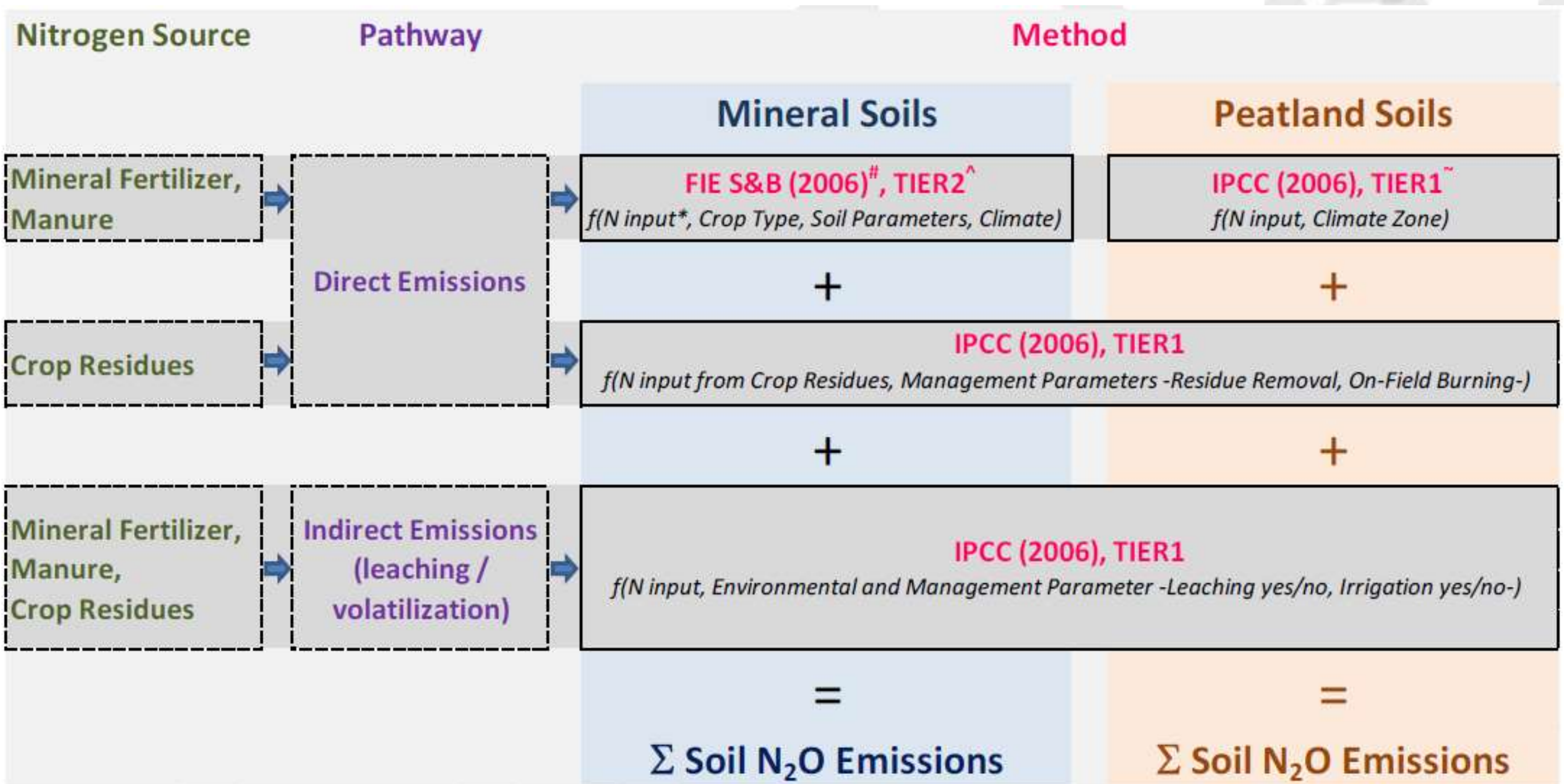
- Geographic variability and different environmental and agricultural management conditions

Available at:

http://gnoc.jrc.ec.europa.eu/

GNOC model

- **Measure of N_2O emissions following the IPCC guidelines + Stehfest & Bouwman statistical model :**



Fertilizer Induced Emissions (FIE) based on the model of Stehfest and Bouwman (2006)

~ TIER 1 = global emission factor

^ TIER 2 = crop and site specific emission factor

* from mineral fertilizer and manure

GNOC model

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GNOC - Global Nitrous Oxide Calculator

European Commission > JRC > IET > Sustainable Transport Unit > GNOC

Place [ ] Search

x [ ] y [ ]

Reset Form

Select/Insert Parameters

Crop	Barley
Soil Type	mineral
Irrigation	no
Fresh Yield [kg ha^{-1}]	
Mineral Fertilizer F_{SN} [kg N ha^{-1}]	
Manure F_{ON} [kg N ha^{-1}]	

Calculate

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Information Section (download User Manual V1.2.1, 12.09.2013) Last update of the GNOC website 12.09.2013

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Place [ ] Search

x -0.7251 y 48.1954

Reset Form

Select/Insert Parameters

Crop	Barley
Soil Type	mineral
Irrigation	no
Fresh Yield [kg ha^{-1}]	
Mineral Fertilizer F_{SN} [kg N ha^{-1}]	
Manure F_{ON} [kg N ha^{-1}]	

Calculate

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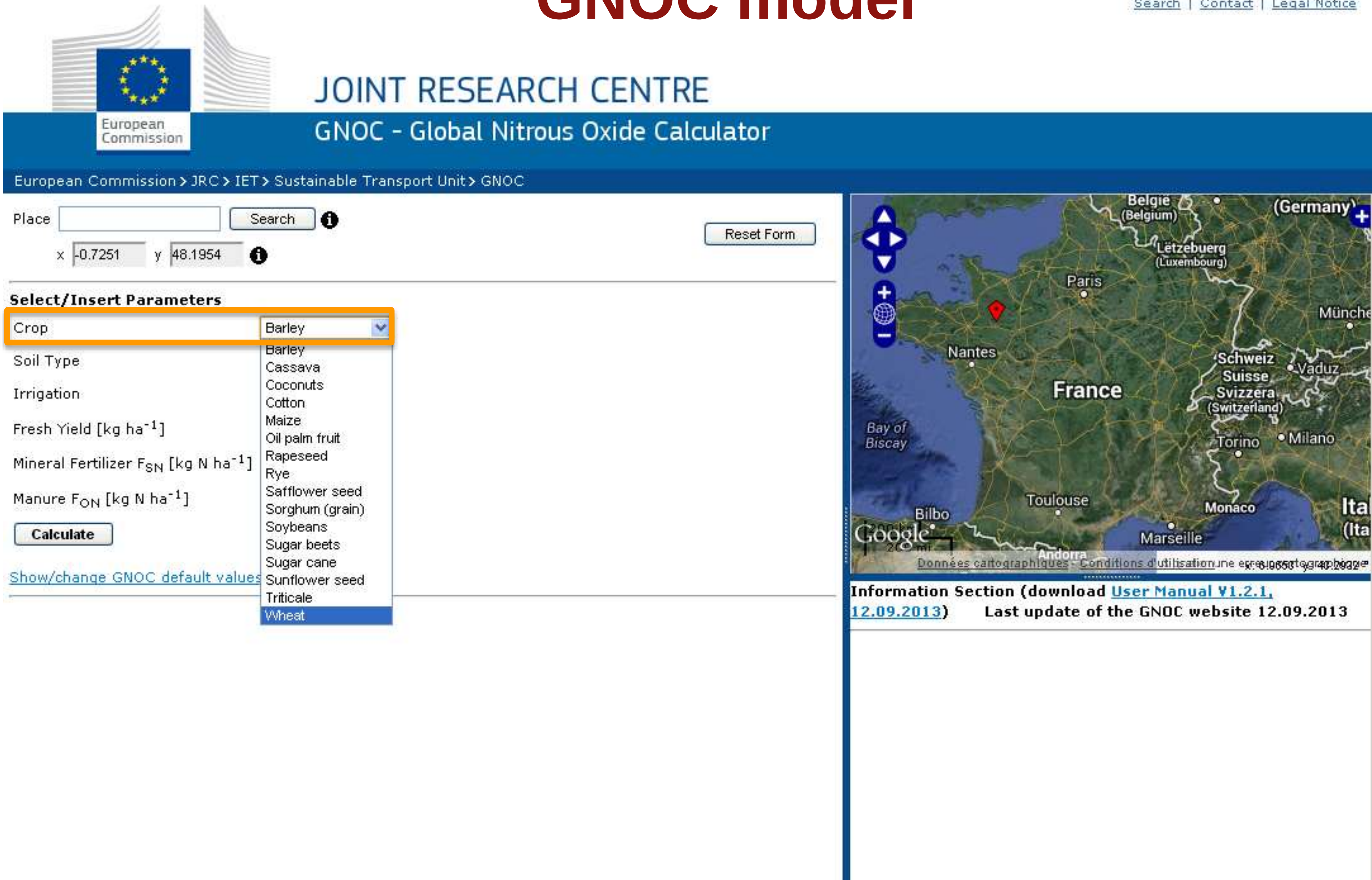

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Reset Form

Select/Insert Parameters

Crop: Barley

Soil Type: mineral (mineral / organic)

Irrigation

Fresh Yield [kg ha^{-1}]

Mineral Fertilizer F_{SN} [kg N ha^{-1}]

Manure F_{ON} [kg N ha^{-1}]

Calculate

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Definition "Organic Soil"

According FAO 1998 (cited in IPCC 2006; Vol. 4, Ch. 11 p. 11.6) soils are organic if they satisfy the requirements 1 and 2, or 1 and 3 below:

1. Thickness of 10 cm or more. A horizon less than 20 cm thick must have 12 percent or more organic carbon when mixed to a depth of 20 cm;

2. If the soil is never saturated with water for more than a few days, and contains more than 20 percent (by weight) organic carbon (about 35 percent organic matter);

3. If the soil is subject to water saturation episodes and has either:

(i) at least 12 percent (by weight) organic carbon (about 20 percent organic matter) if it has no clay; or

(ii) at least 18 percent (by weight) organic carbon (about 30 percent organic matter) if it has 60 percent or more clay; or

(iii) an intermediate, proportional amount of organic carbon for intermediate amounts of clay.

Sources:

IPCC (2006): 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Prepared by the National Greenhouse Gas Inventories Programme, Eggleston H.S., Buendia L., Miwa K., Ngara T. and Tanabe K. (eds). Published: IGES, Japan.

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Select/Insert Parameters

Crop	Wheat
Soil Type	mineral
Irrigation	no
Fresh Yield [kg ha^{-1}]	7000
Mineral Fertilizer F_{SN} [kg N ha^{-1}]	100
Manure F_{ON} [kg N ha^{-1}]	20

[Calculate]

Show/change GNOC default values

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Mineral Fertilizer F_{SN} [kg N ha^{-1}] = Annual amount of synthetic N fertilizer applied to the field

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[Calculate]

Show/change GNOC default values

Information Section (download User Manual V1.2.1, 12.09.2013) Last update of the GNOC website 12.09.2013

Mineral Fertilizer F_{SN} [kg N ha^{-1}] = Annual amount of synthetic N fertilizer applied to the field

Result: Total N_2O Emissions

Location ID	2145 - 517
Country name	FRANCE
Total soil N_2O emmissions [kg N_2O-N ha^{-1}]	2.0816
Total soil N_2O emmissions [g CO_2eq $MJ^{-1}{}_{crop}$]	9.7519

Result details - values are given in [kg N_2O-N ha^{-1}] unless specified differently

Direct N_2O emissions from fertilizer application $N_2O_{(dir,F)}$	0.7721
Direct N_2O emissions from drained/managed organic soils N_2O_{OS}	0.0000
Indirect N_2O emissions produced from leaching and runoff from fertilizer application $N_2O_{(L,F)}$	0.2475
Indirect N_2O emissions produced from atmospheric deposition of N volatilised $N_2O_{(ATD)}$	0.1200
Above-ground residue dry matter AG_{DM} [kg d.m. ha^{-1}]	9398.8000
Annual amount of N in crop residues F_{CR} [kg N ha^{-1}]	76.8984
N input from sugarcane vignasse and filtercake F_{VF} [kg N ha^{-1}]	0.0000
Direct N_2O emissions from N in crop residues $N_2O_{(dir,CR)}$	0.7690
Indirect N_2O emissions produced from leaching and runoff from N in crop residues $N_2O_{(L,CR)}$	0.1730

GNOC model

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[Calculate]

Show/change GNOC default values

Environmental Parameters

Eco-Climatic Zone	Temperate Moist
Climate Class	Temperate Oceanic
Vegetation Class	Cereals
Soil pH	< 5.5
Soil Organic C (%)	1 - 3
Soil Texture	Medium
Leaching	yes

Optional Query Parameters

- [x] Environmental Parameters
- [ ] Crop Residue Parameters
- [ ] Conversion Factors

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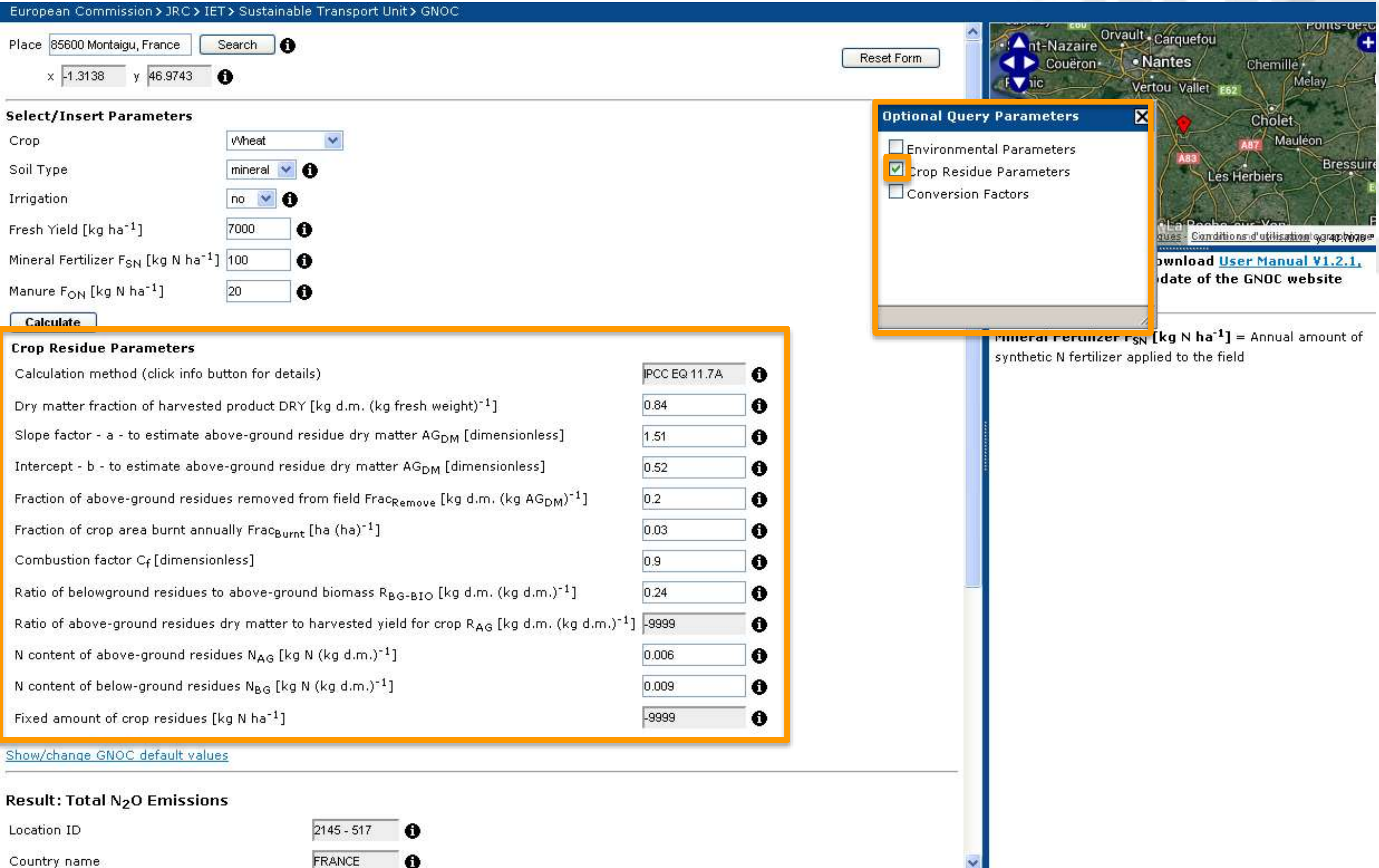

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[Calculate]

Show/change GNOC default values

Conversion Factors

Lower Heating Value LHV of feedstock[MJ (kg d.m.)$^{-1}$]	17.0
Global Warming Potential GWP of N_2O	298
Conversion factor N_2O-N to N_2O	1.5714

Optional Query Parameters

- [ ] Environmental Parameters
- [ ] Crop Residue Parameters
- [x] Conversion Factors

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Perspectives

- Some types of biomass are still not covered by the GNOC model:
  - Jatropha
  - Perennial crops (miscanthus, giant reed, etc.)
  - Short rotation forestry (eucalyptus, willow, poplar)
- Biograce is discussing how to deal with this
  - Apply IPCC's global emission factor – f(N input)

  or
  - Users determine coefficients for their own crops and use the current N2O calculation sheet provided in BioGrace I tool

3. BioGrace II tool : Final conversion sheet

Calculation on final conversion

GHG emissions of biomass

Explanation

(to be completed, along the following lines:

- Company/person making the calculation has bought biomass ("energy carrier")
- The GHG calculation of this biomass has been calculated using BioGrace-II or has been taken from default values
- In case of actual GHG calculations: a verifier has verified the GHG calculations
- The above claims can be substantiated by documentation such as delivery notes and verification statements
- ....

GHG emission of biomass feedstock ("energy carrier")

Type of energy carrier:	give description	
GHG emission of energy carrier	44,00	g $CO_{2,eq}/MJ_{energy\ carrier}$

Results

Final energy

Electricity		Heat	
All results in g $CO_{2,eq}$ per MJ as indicated			
Allocation factor	Allocated results	Allocation factor	Allocated results
100,0%	44,0 per MJ chips	100,0%	44,0 per MJ chips
	176,0 per MJ electr.		0,0 per MJ heat

GHG emission reduction

Electricity	Heat
4%	100%

General settings

Main output

- [x] Electricity
- [ ] Heat
- [ ] Cooling
- [ ] Electricity and heat

Conversion efficiencies

Electrical efficiency	25,0%
	85,0%
	56,0%
	150,0

! When using this GHG calcul
rules must be respected
(containing the complete tool)

Requirements for use

Explanation

(to be completed, along the following lines:

- Company/person making the calculation has bought biomass ("energy carrier")
- The GHG calculation of this biomass has been calculated using BioGrace-II or has been taken from default values
- In case of actual GHG calculations: a verifier has verified the GHG calculations
- The above claims can be substantiated by documentation such as delivery notes and verification statements
- ....

WHO can use this sheet?

- Company who has bought biomass / energy carrier and wants to use it for heat / electricity / cooling

WHAT conditions must be met?

- GHG calculation based on default values or calculated with BioGrace II tool
- Verification of actual calculation (incl. all obligations to provide proof)

General settings

GHG emission of biomass feedstock ("energy carrier")

Type of energy carrier:	give description	
GHG emission of energy carrier	44,00	g $CO_{2,eq}/MJ_{energy\ carrier}$

GHG emissions from production of energy carrier

General settings

Main output

- [x] Electricity
- [ ] Heat
- [ ] Cooling
- [ ] Electricity and heat

Conversion efficiencies

Electrical efficiency	25,0%
	85,0%
	56,0%
	150,0

Choice of main output and conversion efficiencies for final results

Results

GHG emission of biomass feedstock ("energy carrier")

Type of energy carrier:	give description	
GHG emission of energy carrier	44,00	g CO

Results

Final energy

Electricity		Heat	
All results in g CO2,eq per MJ as indicated			
Allocation factor	Allocated results	Allocation factor	Allocated results
100,0%	44,0 per MJ chips	100,0%	44,0 per MJ chips
	176,0 per MJ electr.		0,0 per MJ heat

GHG emission reduction

Electricity	Heat
4%	100%

General settings

Main output

- ☑ Electricity
- ☐ Heat
- ☐ Cooling
- ☐ Electricity and heat

Conversion efficiencies

Electrical efficiency	25,0%
	85,0%
	56,0%
	150,0

Choice of main output and conversion efficiencies for final results

Allocation factors & references

Allocation factors & references

Allocation factors	
CHP	
100,0%	to electricity
100,0%	to heat

Fossil fuel references	
184	g $CO_{2,eq}/MJ_{electricity}$
77	g $CO_{2,eq}/MJ_{heat}$
57	g $CO_{2,eq}/MJ_{cooling}$

⇒ **Allocation of electricity and heat (CHP) according to Carnot efficiency:**

$$EC_{el} = \frac{E}{\eta_{el}} \left(\frac{C_{el} \cdot \eta_{el}}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right)$$

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Thank you for your attention

BioGrace – partners and contact

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  John Neeft

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- Project website: www.BioGrace.net