BIOGRACE II

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

The BioGrace II tool

General approach and structure

Susanne Köppen
IFEU
Public workshop
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Directory

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

Directory of pathways Version 1.0.4

1 Wood chips from forest residues
2 Wood chips from short rotation forests
3 Wood chips from round wood
4 Wood chips from industry residues
5 Wood briquettes or pellets from forest residues
6 Wood briquettes or pellets from short rotation forestry
7 Wood briquettes or pellets from roundwood
8 Wood briquettes or pellets from wood industry residues
9 Agricultural residues
10 Pellets from straw

Calculation of direct land use change (LUC)
Calculation of Improved Agricultural Management
Calculation of N_2O field emissions according to IPCC Tier 1

About

Standard valu
User defined standard values

- Easy direction to other sheets
- One calculation sheet per pathway
- Additional sheets:
  - LUC
  - e_{sca}
  - N_2O field emissions
  - Standard values
  - Final conversion only

➔ **Example: Wood pellets from forestry residues**

Steps from cultivation to final energy

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

$ee_{ccs/ccr}$: technology not in place

e_{sca}: methodology still under discussion

e_u: maybe relevant for biogas pathways

e_l: following the decision 2010/335/EU

e_{ec}, e_p, e_{td} = basic „disaggregated default values“

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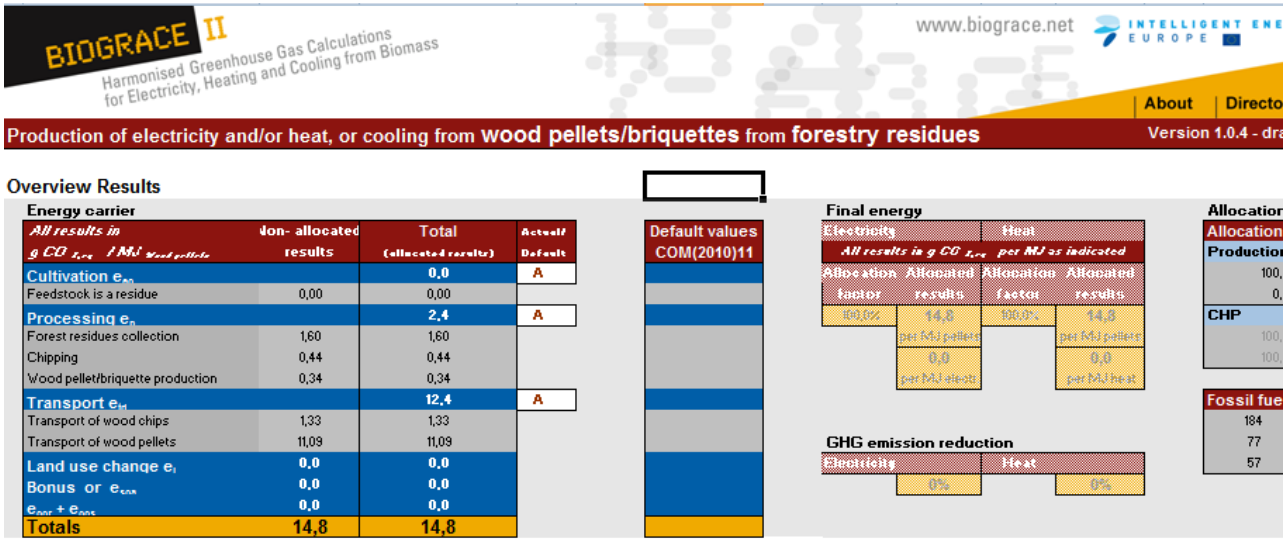

I. Overview results

II. General settings

III. Calculation per phase

www.biograce.net

30 October 2013, Brussels

I. Overview results

Energy carrier

Final energy

Energy carrier

All results in $g\ CO_{2,eq}\ /\ MJ_{Wood\ pellets}$	Non- allocated results	Total (allocated results)	Actual/ Default	Default values COM(2010)11
Cultivation e_{ec}		0,0	D	
Feedstock is a residue	0,00	0,00		
Processing e_p		2,4	A	
Forest residues collection	1,60	1,60		
Chipping	0,44	0,44		
Wood pellet/briquette production	0,34	0,34		
Transport e_{td}		12,4	A	
Transport of wood chips	1,33	1,33		
Transport of wood pellets	11,09	11,09		
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	**14,8**	**14,8**		

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%	14,8 per MJ pellets	100,0%	14,8 per MJ pellets
	0,0 per MJ electr		0,0 per MJ heat

GHG emission reduction

Electricity	Heat
0%	0%

Indication of actual and default values

I. Overview results

Energy carrier

Final energy

Energy carrier

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Bonus or e_{sca}	0,0	0,0	
e_{ccr} + e_{ccs}	0,0	0,0	
Totals	**14,8**	**14,8**	

Default values COM(2010)11

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%	14,8 per MJ pellets	100,0%	14,8 per MJ pellets
	0,0 per MJ electr		0,0 per MJ heat

GHG emission reduction

Electricity	Heat
0%	0%

Final conversion based on actual efficiency

I. Overview results

Allocation factors and references

Allocation factors & references

Allocation factors	
Production chain	
100,0%	to energy carrier
0,0%	to co-product(s)
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 by-products and main products in production chain: lower heating value

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

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

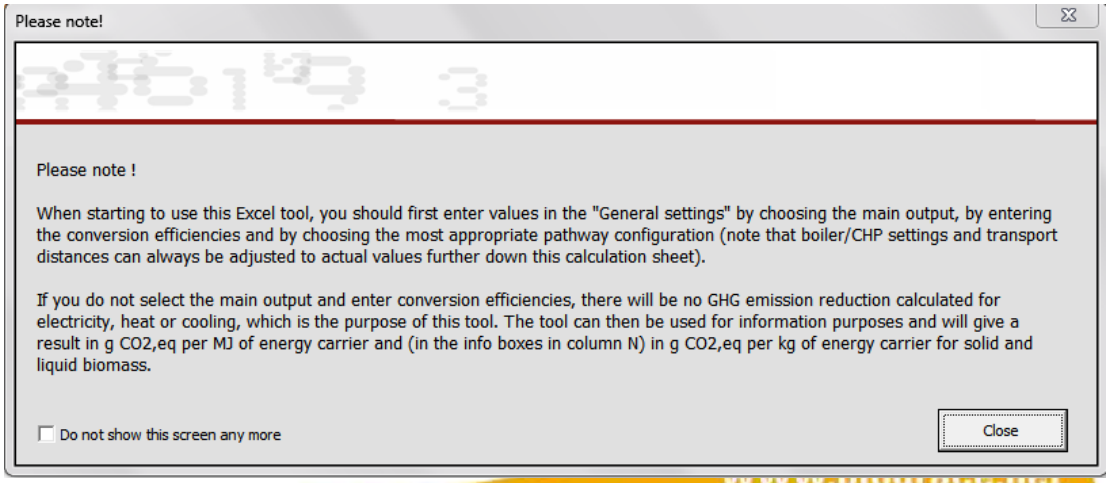
II. General settings

Main output	
☐ Electricity	
☐ Heat	
☐ Cooling	
☑ Electricity and heat	

Conversion efficiencies	
Electrical efficiency	25,0%
Thermal efficiency	85,0%
Temp of useful heat (°C)	150,0

Pathway configuration	
Heat provision in pellet production:	
	Wood pellet CHP (ORC)
Transport distance (pellets):	
	above 10 000 km

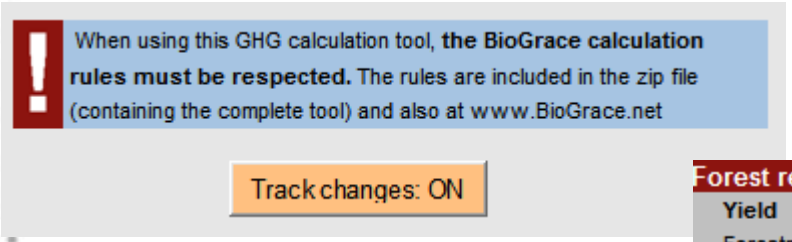
Without filling this in, NO GHG emissions reductions will be calculated !

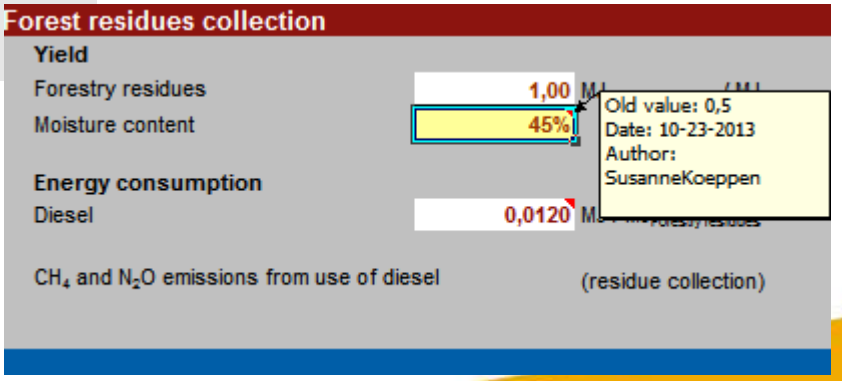


II. General settings

When actual calculations are done:

- The Biograce rules must be followed
- Track changes must be switched on:
  - Highlights all changes
  - Shows editor's name and old values in the comment field





III. Calculation per phase – Cultivation e_{ec}

multiplying input values with "standard values"

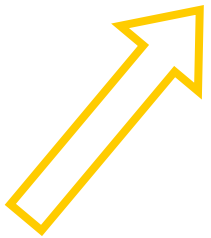
Forest residues collection			Quantity of product	Calculated emissions			
Yield				Emissions per MJ wood pellets			
Forestry residues	1,00	$MJ_{Forestry\ residues}$ / $MJ_{Forestry\ res}$	1,00 $MJ_{Forestry\ residues}$ / $MJ_{Forestry\ residues}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Moisture content	50%		0,157 $kg_{Forestry\ residues,\ wet}$/$MJ_{Wood\ pellets}$				
Energy consumption							
Diesel	0,0120	MJ / $MJ_{Forestry\ residues}$		1,57	0,00	0,00	1,59
CH_4 and N_2O emissions from use of diesel		(residue collection)		0,00	0,00	0,00	0,01
			Total	**1,57**	**0,00**	**0,00**	**1,60**
				Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		1,60

Yield related conversion factors

fill in actual data

III. Calculation per phase – Cultivation e_{ec}

Calculated emissions				Info	
Emissions per MJ wood pellets				per kg residues	per ha, year
g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$	kg $CO_{2,eq}$
1,57	0,00	0,00	1,59	10,13	-
0,00	0,00	0,00	0,01	0,06	
1,57	**0,00**	**0,00**	**1,60**	**10,19**	
Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		1,60		



Results related to different units

III. Calculation per phase – Processing e_p

Wood pellet/briquette production			Quantity of product		Calculated emissions			
Yield					Emissions per MJ wood pellets			
Wood pellets	0,990	$MJ_{Pellets, bruto}$ / $MJ_{Wood\ chips}$	0,966	$MJ_{Pellets, bruto}$ / $MJ_{Forestry\ residues, in}$	g CO_2	g CH_4	g N_2O	g $CO_{2, eq}$
Wood pellets	0,687	$MJ_{Pellets, nett\ output}$ / $MJ_{Wood\ ch}$	0,670	$MJ_{Pellets, nett\ output}$ / $MJ_{Forestry\ residues, in\ out}$				
Moisture content	10%		0,058	$kg_{Wood\ pellets, nett\ output}$/$MJ_{Wood\ pellets}$				
Energy consumption								
Electricity (excl. input into boiler)	0,0499	MJ / $MJ_{Pellets, bruto}$	(emissions are calculated below the light grey boiler/CHP box)					
Diesel	0,0020	MJ / $MJ_{Pellets, bruto}$	(internal transport)		0,25	0,00	0,00	0,26
CH_4 and N_2O emissions from use of diesel					0,00	0,00	0,00	0,00
Heat	0,1853	MJ / $MJ_{Pellets, bruto}$						
Wood pellet CHP based on ORC	1	Emissions wood pellet CHP inc			s from wood pellet CHP			
Wood pellet input / MJ electricity	6,1350	MJ / $MJ_{Electricity}$	Plea		city demand			
Wood pellet consumption in CHP	0,3062	MJ / $MJ_{Pellets, bruto}$	Amount of wood pellets used for generation of heat and electricity					
Heat output / MJ electricity	4,2699	MJ / $MJ_{Electricity}$						
Electricity generation from CHP	0,0499	MJ / $MJ_{Pellets, bruto}$						
Heat generation from CHP	0,2131	MJ / $MJ_{Pellets, bruto}$	Heat generation is larger than heat demand, surplus heat is cooled away					
CH_4 and N_2O emissions from Wood chip/pellet CHP (per MJ_electricity)					0,00	0,00	0,00	0,09
Total electricity use in wood pellet production plus CHP								
Electricity EU mix LV	0,0000	MJ / $MJ_{Pellets, bruto}$	Should be zero as the CHP is dimension		0,00	0,00	0,00	0,00
				Total	**0,25**	**0,00**	**0,00**	**0,34**
				Result	**g $CO_{2,eq}$ / $MJ_{Pellets}$**			**0,34**

conversion factors yield related

fill in actual data

Conversion factors

0,966	$MJ_{Pellets,\ bruto}$ / $MJ_{Forestry\ residues,\ In}$
0,670	$MJ_{Pellets,\ nett\ output}$ / $MJ_{Forestry\ residues,\ Input}$
0,058	$kg_{Wood\ pellets,\ nett\ output}$/$MJ_{Wood\ pellets}$

yield related conversion factors:
➔ raw material per final biofuel

values as a function of input values and/or of the chain

Principle of calculation

- o Input data
- o Standard values ("conversion factors")

Wood pellet/briquette production			Quantity of product		Calculated emissions			
Yield					Emissions per MJ wood pellets			
Wood pellets	0,990	$MJ_{Pellets, bruto}$ / $MJ_{Wood\ chips}$	0,966	$MJ_{Pellets, bruto}$ / $MJ_{Forestry\ residues, in}$	g CO_2	g CH_4	g N_2O	g $CO_{2, eq}$
Wood pellets	0,687	$MJ_{Pellets, nett\ output}$ / $MJ_{Wood\ ch}$	0,670	$MJ_{Pellets, nett\ output}$ / $MJ_{Forestry\ residues, input}$				
Moisture content	10%		0,058	$kg_{Wood\ pellets, nett\ output}$/$MJ_{Wood\ pellets}$				
Energy consumption								
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Diesel	0,0020	MJ / $MJ_{Pellets, bruto}$	(internal transport)		0,25	0,00	0,00	0,26
CH_4 and N_2O emissions from use of diesel					0,00	0,00	0,00	0,00
Heat	0,1853	MJ / $MJ_{Pellets, bruto}$						
Wood pellet CHP based on ORC	1	Emissions wood pellet CHP included in final results			Emissions from wood pellet CHP			
Wood pellet input / MJ electricity	6,1350	MJ / $MJ_{Electricity}$	Please note: The CHP is dimensioned to the electricity demand					
Wood pellet consumption in CHP	0,3062	MJ / $MJ_{Pellets, bruto}$	Amount of wood pellets used for generation of heat and electricity					
Heat output / MJ electricity	4,2699	MJ / $MJ_{Electricity}$						
Electricity generation from CHP	0,0499	MJ / $MJ_{Pellets, bruto}$						
Heat generation from CHP	0,2131	MJ / $MJ_{Pellets, bruto}$	Heat generation is larger than heat demand, surplus heat is cooled away					
CH_4 and N_2O emissio								0,09
Total electricity use in								
Electricity EU mix LV	0,0000	MJ / $MJ_{Pellets, bruto}$	Should be zero as the CHP is dimension		0,00	0,00	0,00	0,00
				Total	0,25	0,00	0,00	0,34
				Result	g $CO_{2,eq}$ / $MJ_{Pellets}$			0,34

STANDARD VALUES

parameter:	GWP				GHG emissio
unit:	$gCO_{2,eq}$/ g	gCO_2/kg	gCH_4/kg	gN_2O/kg	gCO_{2-eq}/kg

List of standard values

STANDARD VALUES	parameter:	GWP				GHG emissio
	unit:	$gCO_{2,eq}$/ g	gCO_2/kg	gCH_4/kg	gN_2O/kg	gCO_{2-eq}/kg
Global Warming Potentials (GWP's)						
	CO_2	1				
	CH_4	25				
	N_2O	298				
Agro inputs						
	N-fertiliser (kg N)		3794,0	7,93	7,3150	6172,1
	P_2O_5-fertiliser (kg P_2O_5)		991,2	1,40	0,0532	1042,1
	K_2O-fertiliser (kg K_2O)		547,9	1,60	0,0129	591,8
	CaO-fertiliser (calculated as kg CaO)		65,2	0,12	0,0029	69,0
	CaO-fertiliser (calculated as kg $CaCO_3$)		36,5	0,07	0,0016	38,7
	Pesticides		10371,8	28,44	1,7145	11593,8
	Seeds- barley		176,8	0,39	0,4005	305,9
	Seeds- corn		176,8	0,39	0,4005	305,9
	Seeds- corn (whole plant)		176,8	0,39	0,4005	305,9
	Seeds- cottonseed					0,0
	Seeds- jatropha					0,0

User defined standard values

User Defined Standard Values parameter: unit:	Comments	GHG emissio gCO_2/kg	gCH_4/kg	gN_2O/kg	gCO_{2-eq}/kg
User defined standard values					
Example 1 (diesel from standard values)					0
Example 2 (methanol from standard values)					0
Example 3 (N-fertiliser from standard values)		2827,0	8,68	9,6418	5917,2313
					0
Ammonium nitrate		2900,0	0,00	0,0000	2900
Urea		1707,0	0,00	0,0000	1707
Compound		5376,0	0,00	0,0000	5376
					0

fill in actual data

III. Calculation per phase – Transport e_{td}

Transport of wood chips			Quantity of product		Calculated emissions			
Wood chips	1,00	$MJ_{Wood\ chips}$ / $MJ_{Wood\ chips}$			Emissions per MJ wood pellets			
Moisture content	50%		0,976	$MJ_{Wood\ chips}$ / $MJ_{Forestry\ residues,\ input}$	$g\ CO_2$	$g\ CH_4$	$g\ N_2O$	$g\ CO_{2,\ eq}$
			0,153	$kg_{Wood\ chips,\ wet}$/$MJ_{Wood\ pellets}$				
Transport per								
Truck (40 ton) for chips (and simila siz	50	km	0,0051	ton km / $MJ_{Forestry\ residues,\ input}$	0,65	0,00	0,00	0,67
Fuel	Diesel			Total	0,65	0,00	0,00	0,67
				Result	$g\ CO_{2,eq}$ / $MJ_{Pellets}$			0,67

Transport of wood pellets			Quantity of product		Calculated emissions			
Wood pellets	1,000	$MJ_{Pellets}$ / $MJ_{Pellets}$			Emissions per MJ wood pellets			
			0,670	$MJ_{Pellets}$ / $MJ_{Forestry\ residues,\ input}$	$g\ CO_2$	$g\ CH_4$	$g\ N_2O$	$g\ CO_{2,\ eq}$
Transport per								
Truck (40 ton) for pellets (Diesel)	0	km	0,0000	ton km / $MJ_{Forestry\ residues,\ input}$	0,00	0,00	0,00	0,00
Fuel	Diesel							
Freight train USA (diesel)	750		0,0294	ton km / $MJ_{Forestry\ residues,\ input}$	0,96	0,00	0,00	0,99
Fuel	Diesel							
Bulk Carrier class "Handy" - pellets	16500		0,6467	ton km / $MJ_{Forestry\ residues,\ input}$	10,10	0,00	0,00	10,10
Fuel	HFO for maritime transport							
				Total	11,06	0,00	0,00	11,09
				Result	$g\ CO_{2,eq}$ / $MJ_{Pellets}$			11,09

fill in actual data

III. Calculation per phase – Total results

Total results			
Yield (in MJ biomass / hectare cropland / year)	no cropland		
Yield (in MJ biomass / MJ input)	0,6702 $MJ_{Wood\ pellets}$ / $MJ_{Forestry\ residues,\ input}$		
Total emission without allocation:		g $CO_{2,eq}$ / $MJ_{Pellets}$	14,81
Total emission with allocation:		g $CO_{2,eq}$ / $MJ_{Pellets}$	14,81

GHG emissions per MJ energy carrier

➔ final conversion takes place in the overview result section

➔ without and with allocation

Co-funded by the Intelligent Energy Europe Programme of the European Union

Thank you for your attention