BIOGRACE II

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

The BioGrace II tool

General approach and structure

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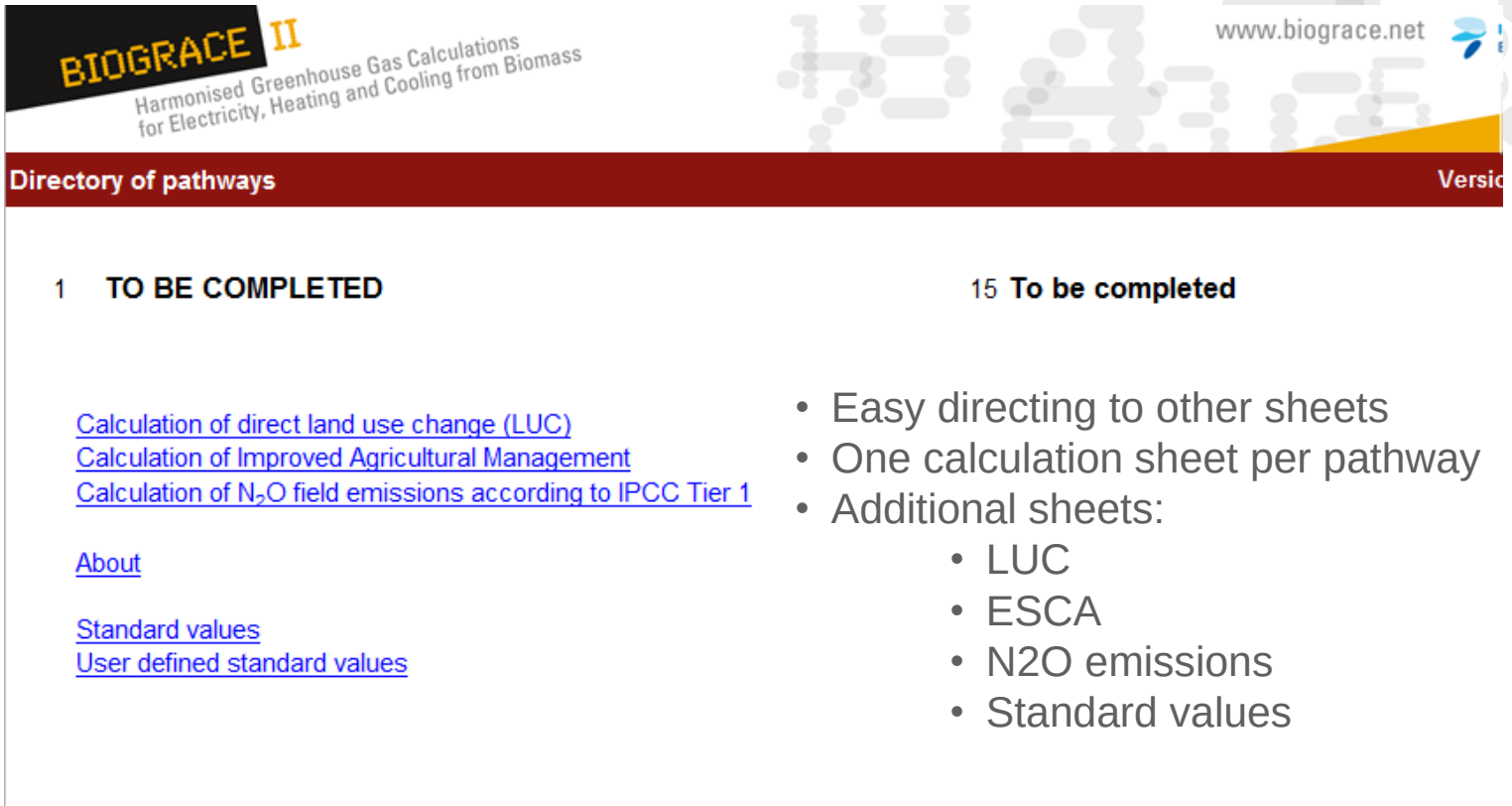
IFEU
Greenhouse gas experts' workshop
23 October 2012, Heidelberg

Directory



- Easy directing to other sheets
- One calculation sheet per pathway
- Additional sheets:
  - LUC
  - ESCA
  - N2O emissions
  - Standard values

➔ **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: relevant for biomass combustion

e_l: following the decision 2010/335/EU

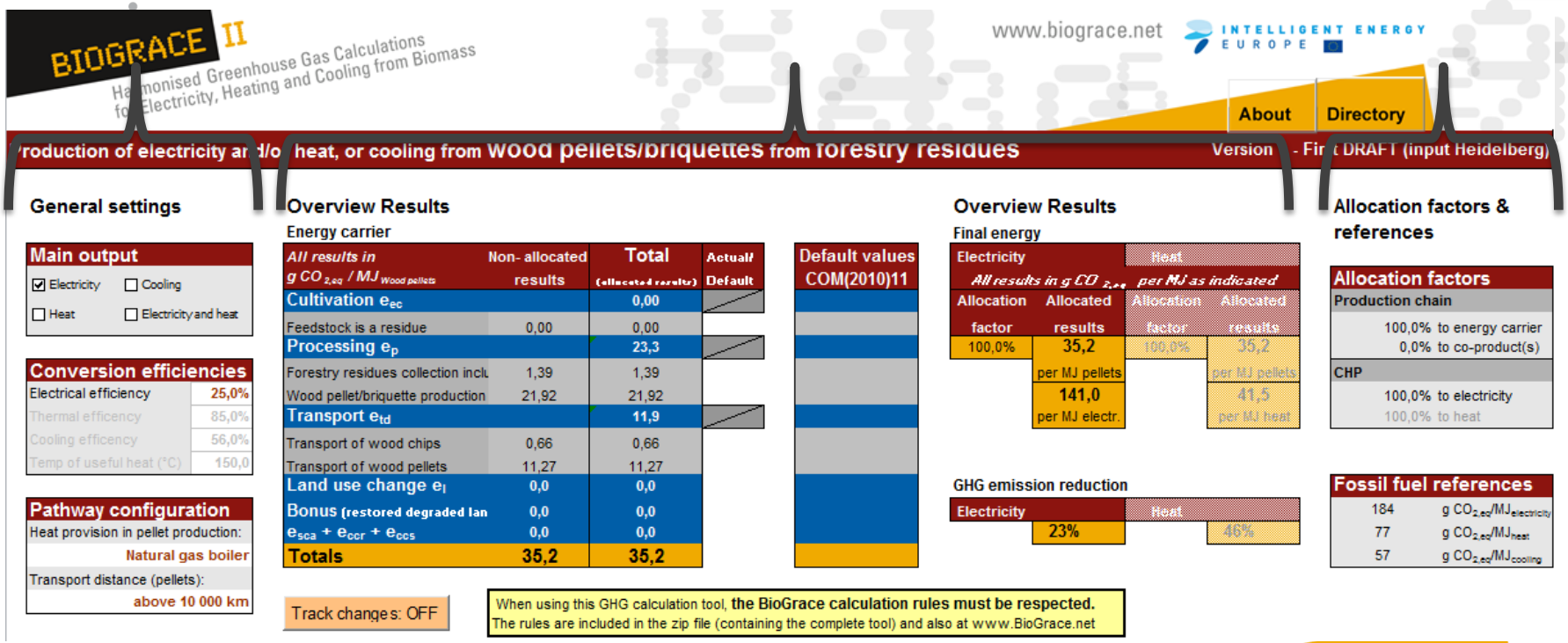
e_{ec}, e_p, e_{td} = basic „disaggregated default values“

The aggregation on top

General settings

Overview results
Energy carrier / Final energy

Allocation factors and references



General settings & allocation factors

General settings

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

Conversion efficiencies	
Electrical efficiency	25,0%
Thermal efficency	85,0%
Cooling efficency	56,0%
Temp of useful heat (°C)	150,0

Pathway configuration
Heat provision in pellet production:
Natural gas boiler
Transport distance (pellets):
above 10 000 km

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 electricity and heat (CHP) according to Carnot efficiency:

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

Overview results

Energy carrier

All results in g $CO_{2,eq}$ / MJ Wood pellets	Non- allocated results	Total (allocated results)	Actual/ Default
Cultivation e_{ec}		0,00	
Feedstock is a residue	0,00	0,00	
Processing e_p		23,3	
Forestry residues collection incl	1,39	1,39	
Wood pellet/briquette production	21,92	21,92	
Transport e_{td}		11,9	
Transport of wood chips	0,66	0,66	
Transport of wood pellets	11,27	11,27	
Land use change e_l	0,0	0,0	
Bonus (restored degraded lan	0,0	0,0	
$e_{sca} + e_{ccr} + e_{ccs}$	0,0	0,0	
Totals	35,2	35,2	

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%	35,2 per MJ pellets	100,0%	35,2 per MJ pellets
	141,0 per MJ electr.		41,5 per MJ heat

GHG emission reduction

Electricity	Heat
23%	46%

Cultivation e_{ec}

Feedstock is a residue			Quantity of product	Calculated emissions			
Yield				Emissions per MJ wood pellets			
Forestry residues	1,0	MJ	1,00 $MJ_{Forestry\ residues}$ / $MJ_{Forestry\ residues}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Moisture content	50%						
				Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		0,00

Forestry residues collection including stump harvesting and chip			Quantity of product	Calculated emissions			
Yield				Emissions per MJ wood pellets			
Wood chips	1,0	$MJ_{Wood\ chips}$ / $MJ_{Wood\ chips}$	1,00 $MJ_{Wood\ chips}$ / $MJ_{Forestry\ residues,\ inpu$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Moisture content	50%		9,50 $MJ_{wood\ chips}$ / $kg_{Wood\ chips,\ wet}$				
			0,106 $kg_{Wood\ chips,\ wet}$/$MJ_{Wood\ pellets}$				
CH_4 and N_2O emissions from wood chipping				0,00	0,00	0,00	0,01
Energy consumption							
Diesel	0,0154	MJ / $MJ_{Wood\ chips}$		1,36	0,00	0,00	1,38
				Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		1,39

fill in actual data

Processing e_p

Wood pellet/briquette production				Quantity of product	Calculated emissions			
Yield					Emissions per MJ wood pellets	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Wood pellets	(bruto)	0,990	$MJ_{Pellets}$ / $MJ_{Wood\ chips}$	0,990 $MJ_{Pellets,\ bruto}$ / $MJ_{Forestry\ residues,\ input}$				
Wood pellets	(nett output)	0,990	$MJ_{Pellets}$ / $MJ_{Wood\ chips}$	0,990 $MJ_{Pellets,\ nett}$ / $MJ_{Forestry\ residues,\ input}$				
Moisture content		10%		0,058 $kg_{Wood\ pellets}$/$MJ_{Wood\ pellets}$				
Energy consumption								
Electricity (excl. input into boiler or CHP)		0,0499	MJ / $MJ_{Pellets}$					
Diesel	(internal transp)	0,0020	MJ / $MJ_{Pellets}$		0,18	0,00	0,00	0,18
Steam		0,1853	MJ / $MJ_{Pellets}$					
Natural gas boiler					Emissions from NG boiler			
CH4 and N2O emissions from NG boiler					0,00	0,00	0,00	0,07
Wood pellet input / MJ steam		0,000	MJ / MJ_{steam}	These two				
Natural gas input / MJ steam		1,111	MJ / MJ_{steam}	be able to				
Wood pellet consumption in boiler		0,000	MJ / $MJ_{Pellets}$	Wood pellet consumption is of course zero for NG boiler				
Natural gas (4000 km, EU Mix quality)		0,206	MJ / $MJ_{Pellets}$	(when using wood pellets, emissions are zero)	12,91	0,04	0,00	13,95
In case of boiler:								
Electricity input / MJ steam		0,020	MJ / MJ_{steam}	Electricity use in boiler (is zero for CHP)				
Electricity use in boiler		0,004	MJ / $MJ_{Pellets}$					
In case of CHP								
Electricity output / MJ steam		0,000	MJ / MJ_{steam}	Electricity production in CHP (is zero for boiler)				
Electricity generation from CHP		0,000	MJ / $MJ_{Pellets}$					
Total electricity use or production in CHP or boiler								
Electricity EU mix LV		0,054	MJ / $MJ_{Pellets}$	Total el. use/generation in pellet production and boiler	7,23	0,02	0,00	7,73
					Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		21,92

conversion factors yield related

fill in actual data

Conversion factors

Quantity of product	
0,990	$MJ_{Pellets,\ bruto}$ / $MJ_{Forestry\ residues,\ Input}$
0,990	$MJ_{Pellets,\ nett}$ / $MJ_{Forestry\ residues,\ Input}$
0,058	$kg_{Wood\ pellets}$/$MJ_{Wood\ pellets}$

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	(bruto)	0,990	$MJ_{Pellets}$ / $MJ_{Wood\ chips}$	0,990 $MJ_{Pellets,\ bruto}$ / $MJ_{Forestry\ residues,\ input}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Wood pellets	(nett output)	0,990	$MJ_{Pellets}$ / $MJ_{Wood\ chips}$	0,990 $MJ_{Pellets,\ nett}$ / $MJ_{Forestry\ residues,\ input}$				
Moisture content		10%		0,058 $kg_{Wood\ pellets}$/$MJ_{Wood\ pellets}$				
Energy consumption								
Electricity (excl. input into boiler or CHP)		0,0499	MJ / $MJ_{Pellets}$					
Diesel	(internal transp	0,0020	MJ / $MJ_{Pellets}$		0,18	0,00	0,00	0,18
Steam		0,1853	MJ / $MJ_{Pellets}$					
Natural gas boiler					Emissions from NG boiler			
CH4 and N2O emissions from NG boiler					0,00	0,00	0,00	0,07
Wood pellet input / MJ steam		0,000	MJ / MJ_{steam}	These two input fields are both listed as to				
Natural gas input / MJ steam		1,111	MJ / MJ_{steam}	be able to use both wood pellets and NG in this calculation				
Wood pellet consumption in boiler		0,000	MJ / $MJ_{Pellets}$	Wood pellet consumption is of course zero for NG boiler				
Natural gas (4000 km, EU Mix quality)		0,206	MJ / $MJ_{Pellets}$	(when using wood pellets, emissions are zero)	12,91	0,04	0,00	13,95
In case of boiler:								
Electricity input / MJ steam								
Electricity use in boiler								
In case of CHP								
Electricity output / MJ steam								
Electricity generation from CHP		0,000	MJ / $MJ_{Pellets}$					
Total electricity use or production in CHP or boiler								
Electricity EU mix LV		0,05	MJ / $MJ_{Pellets}$	Total el. use/generation in pellet production and boiler	7,23	0,02	0,00	7,73
				Result	g $CO_{2,eq}$ / $MJ_{Pellets}$			21,92

STANDARD VALUES

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

Processing e_p

Calculated emissions				Info
Emissions per MJ wood pellets				per kg pellets
g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$	g $CO_{2,eq}$
				0,00
0,18	0,00	0,00	0,18	3,03
Emissions from NG boiler				
0,00	0,00	0,00	0,07	1,27
culation				
oiler				
12,91	0,04	0,00	13,95	238,49
r 7,23	0,02	0,00	7,73	132,11
Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		21,92	374,90

Results related to different units

Transport e_{td}

Transport of wood chips			Quantity of product	Calculated emissions			
Wood chips	1,000	$MJ_{Wood\ chips}$ / $MJ_{Wood\ chips}$		Emissions per MJ wood pellets			
Moisture content	30%		1,000 $MJ_{Wood\ chips}$ / $MJ_{Forestry\ residues,\ input}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Transport per							
Truck for wood chips (Diesel)	100	km	0,0075 ton km / $MJ_{Wood\ chips}$	0,65	0,00	0,00	0,66
Fuel	Diesel						
				Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		0,66

Transport of wood pellets			Quantity of product	Calculated emissions			
Wood pellets	1,000	$MJ_{Pellets}$ / $MJ_{Pellets}$		Emissions per MJ wood pellets			
			0,990 $MJ_{Pellets}$ / $MJ_{Forestry\ residues,\ input}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Transport per							
Truck for wood pellets (Diesel)	0	km	0,0000 ton km / $MJ_{Wood\ pellets}$	0,00	0,00	0,00	0,00
Fuel	Diesel						
Freight train USA (diesel)	750		0,0434 ton km / $MJ_{Wood\ pellets}$	0,96	0,00	0,00	0,99
Fuel	Diesel						
Bulk Carrier class "Handy" - wood pellets	16500		0,9554 ton km / $MJ_{Wood\ pellets}$	10,15	0,01	0,00	10,28
Fuel	Diesel						
				Result	g $CO_{2,eq}$ / $MJ_{Pellets}$		11,27

fill in actual data

Total results

Total results		
Yield (in MJ biomass / hectare cropland / year)	no cropland	
Yield (in MJ biomass / MJ input)	0,9901	$MJ_{Wood\ pellets}$ / $MJ_{Forestry\ residues,\ input}$
Total emission without allocation:	g $CO_{2,eq}$ / $MJ_{Pellets}$	35,24
Total emission with allocation:	g $CO_{2,eq}$ / $MJ_{Pellets}$	35,24

Without and with allocation

Thank you for your attention

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Processing e_p

multiplying input values with "standard values"

Wood pellet/briquette production				Quantity of product	Calculated emissions			
Yield					Emissions per MJ wood pellets			
Wood pellets	(bruto)	0,990	$MJ_{Pellets}$ / $MJ_{Wood\ chips}$	0,990 $MJ_{Pellets,\ bruto}$ / $MJ_{Forestry\ residues,\ input}$	g CO_2	g CH_4	g N_2O	g $CO_{2,eq}$
Wood pellets	(nett output	0,990	$MJ_{Pellets}$ / $MJ_{Wood\ chips}$	0,990 $MJ_{Pellets,\ nett}$ / $MJ_{Forestry\ residues,\ input}$				
Moisture content		10%		0,058 $kg_{Wood\ pellets}/MJ_{Wood\ pellets}$				
Energy consumption								
Electricity (excl. input into boiler or CH		0,0499	MJ / $MJ_{Pellets}$	conversion factors yield related				
Diesel	(internal tra	0,0020	MJ / $MJ_{Pellets}$		0,18	0,00	0,00	0,18
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fill in actual data