Green Gold Label Program

Version 2012.2 (August 2012)

Introduction

This standard has been drawn up for all actors in the biomass supply chain, on behalf of the Green Gold Label Foundation (www.greengoldcertified.org).

Scope

This standard contains the rules and reference values for the greenhouse gas (GHG) and energy balance calculation for biomass. With the GHG calculation the fossil greenhouse gasses coming from fossil fuels used for producing the biomass are calculated. Comparing it against a reference value for the European fossil fuel mix for the energy grid that the biomass is to replace, in order to decrease the amount of fossil GHG, the balance needs to be positive and above a given value. With the energy balance the total fossil energy used for production and transport of the biomass is subtracted from the final green power produced by the biomass. The result has to be positive, and in some countries only credits are given on this result of the green power minus the fossil fuel used for production and transport.

The aim of this document is to provide lean, simple, accurate and open (with clear reference to all the values used and the origin) GHG and Energy calculations.
Unless stated otherwise, the calculation is done with data collected over an annual period. This standard and reference values are based on net calorific value (lower heating value) at constant pressure. When the calculation uses typical factors on constant volume, net calorific value at constant volume may be used. The report should in that case include an explanation and source reference.

Reference

This standard complies with the GHG calculation as prescribed by the

- *Directive 2009/28/EC of the European Parliament and the Council of 23 April 2009 on the promotion of the use of energy from renewable sources*
- *NTA 8080: Sustainability criteria for biomass for energy purposes (2008).*

The calculation is done in compliance with the EU described formula for (liquid) biofuels:

[F.1] $$\mathbf{E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr} - e_{ee}}$$

where:
- E = total emissions from the use of the fuel;
- e_{ec} = emissions from the extraction or cultivation of raw materials;
- e_l = annualized emissions from carbon stock changes caused by land use change;
- e_p = emissions from processing;
- e_{td} = emissions from transport and distribution;
- e_u = emissions from the fuel in use;
- e_{sca} = emission savings from soil carbon accumulation via improved agricultural management;
- e_{ccs} = emission savings from carbon capture and sequestration;
- e_{ccr} = emission savings from carbon capture and replacement; and
- e_{ee} = emission savings from excess electricity from cogeneration

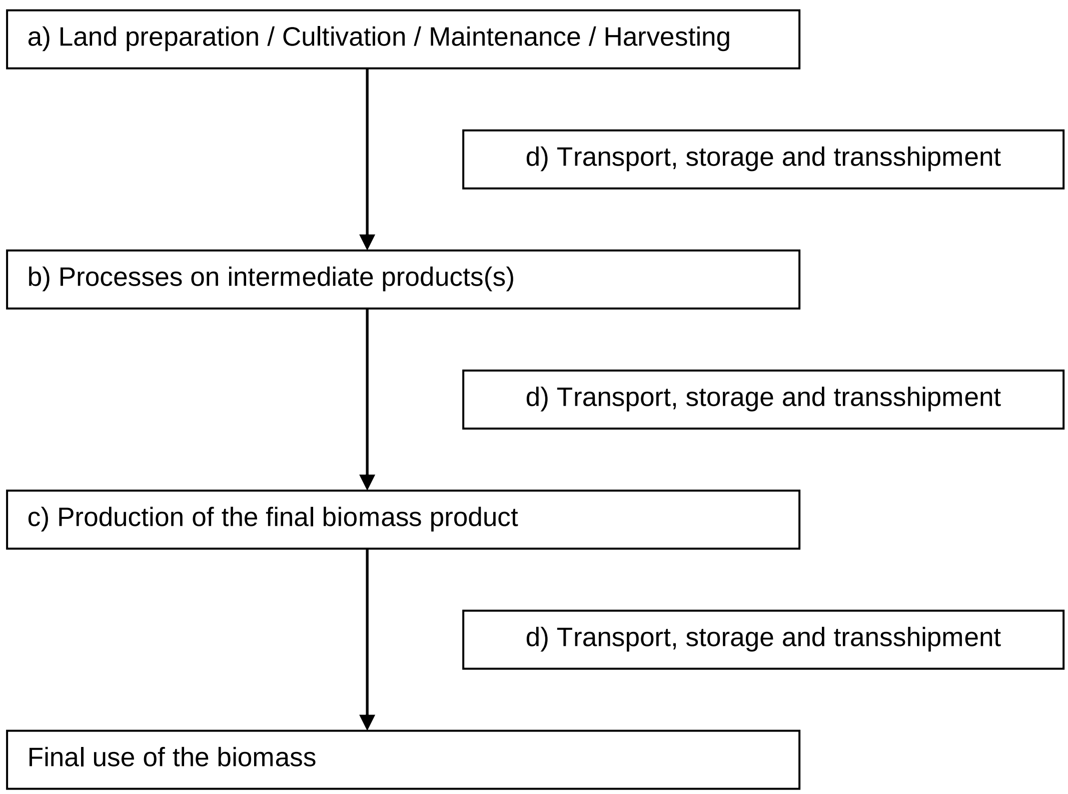
The reference values described in this document are noted including to the source found. Most of these values are average values derived from national and international energy balances and energy statistics. Such data are usually seen as providing quite accurate estimates. The default uncertainty range, depending on the accuracy of the data collected during the audit, should as default be assumed to be plus or minus 5 % (2006 IPCC Guidelines for National Greenhouse Gas Inventories)

System description and rules

Systematical overview

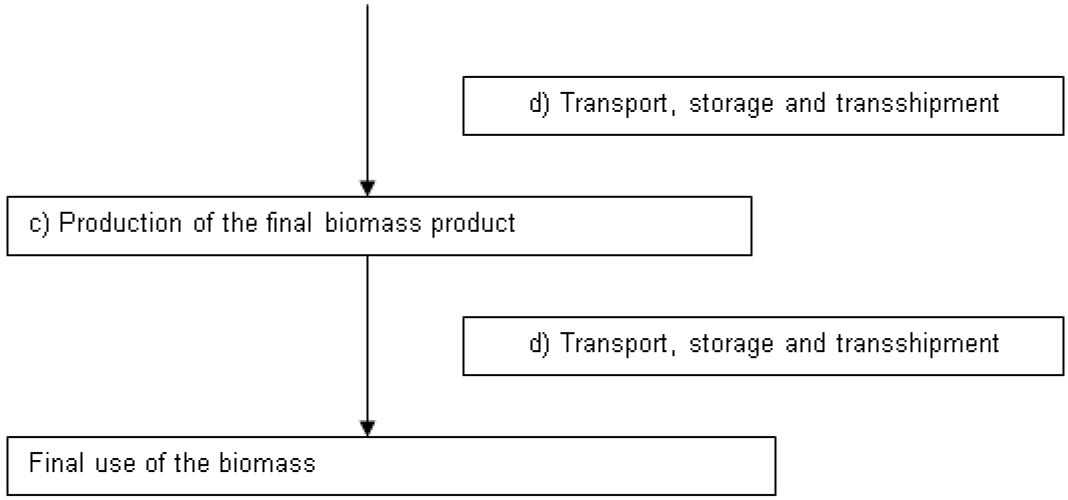
The system is roughly divided into 4 grouped processes or process blocks. Each block will split up into sub processes in the relevant chapter.

Figure 1: The systematical overview for biomass (calculation) chain of which the biomass is one of the main products produced:



NTA 8080 describes that the number of criteria residual products (with only 10% value of the main product, and having no other useful applications or which is included on the exceptions list of the NTA 8080) have to comply with is limited. For this reason the systematical overview is also shorter for those products that are named on the NTA 8080 list of exceptions (Appendix 6).

Figure 2: The systematical overview for biomass (calculation) chain of which the biomass is the residual product of a process or the material is listed on the exception list of NTA 8080 (Appendix 6)



GHG calculation:

Greenhouse gas emissions coming from fossil fuels that are calculated at each process block shall be expressed in terms of grams of CO_2 equivalent per metric ton of fuel (gCO_2eq/ton) and added up to a total emission for the biomass.

With the use of the measured Net Caloric Value (NCV) of the biomass, the GHG emissions per MJ of heat (in g CO_2eq/MJt_h) shall be calculated using the formula [F.21]. If the fuel reference is in MJ_e or kWh, the total GHG emissions per MJ_{th} (heat) shall be converted to MJ_e (electricity) before it is used in formula [F.2]. To calculate the GHG from gCO_2eq/MJ_{th} to gCO2eq/MJ_e, the formula [F.22] shall be used.

The total fossil fuel GHG saving against the GHG from fossil fuel reference value will be calculated as:

[F.2] $$[\text{GHG saving}] = \frac{([\text{GHG fossil fuel reference}] - [\text{GHG biomass calculation}])}{[\text{GHG fossil fuel reference}]}$$

The GHG fossil fuel reference can be found in Appendix 1.

The minimum GHG savings per sector, in order to certify the product in accordance with this standard, are given in NTA 8080.

The processes may be broken down is subsections and a separate calculation can be made on each subsection adding the results at the end, as long as all subsections are included.

In the calculation, negative GHG figures are GHG advantages which shall be subtracted from the GHG emissions.

Energy balance:

The energy balance is done almost in the same way as the GHG calculation. All relevant rules which apply for the GHG calculation also apply for the energy balance.

The energy balance shall be calculated in accordance with:

[F.3] [Energy advantage] =
([Energy from biomass] – [Fossil Energy used]) / [Energy from biomass].

Energy/Emission allocation:

For the processes where more products are made from the raw material only the relative amount of the emissions of the biomass raw material to all the raw material for all products on caloric value basis shall be allocated to the biomass:

[F.4] [Emission allocated to biomass] =
([Emission] * [Energy raw material used biomass product]) / [Energy raw material of the total products]

The energy is calculated by multiplying the NCV (GJ/MT) with the total mass (MT).

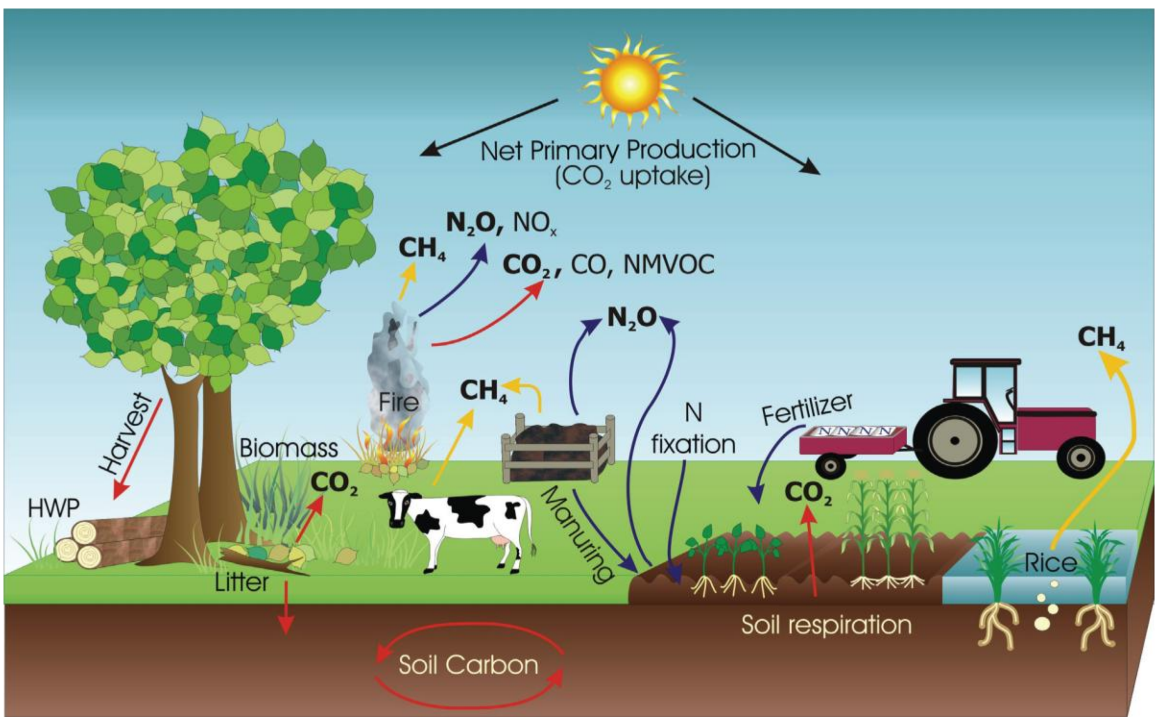
Note: for convenience in this calculation the NCV of bark equals white wood.

The same Energy/Emission allocation rules apply for one or more products being manufactured from a half-made product(s).

Sub processes per system block

In this chapter the rules for calculating the GHG and energy balance of each of the 4 process blocks are given. Each process block is broken down into sub processes.

A) Land preparation /Maintenance/Harvesting/ Cultivation:



source: IPCC 2006

This part of the standard does not need to be included in the calculation when the biomass product is on the NTA 8080 list of residual products and it is not the main product of the process (Appendix 6).

The emissions for land maintenance, harvesting and cultivation of raw materials shall include the fossil GHG emissions of the processes themselves, as well as the emissions from fertilizing, waste and leakages.

For these sub processes the Energy/Emission allocation rule applies.

The organic (sub) products of the plants or trees left on the field after harvesting in a system cycle that is in a steady state (GGL endorsed sustainable managed system) shall not be taken into account in the GHG, energy and allocation calculations.

5.1.1 Land preparation:

The change in carbon stock as a result of land use should be taken into account when the land use change happened less than 20 years ago. The change in carbon stock shall be calculated as emission and divided over 20 years.

The carbon stock should include the carbon storage in vegetation and in the soil.

The change in carbon stock in vegetation and/or soil can be positive as a result of for instance inundation of peatland or reforestation. This positive change should be taken into account.

The calculation shall be made on a steady state, the expected average of 20 years.

[F.5] [GHG emission per MT of biomass] =
3.664 * ([Average 20 year carbon storage per hectare after the change] - [Average 20 year carbon storage per hectare before the change]) * [number of hectares] / (20 [total annual mass of biomass grown in MT] - bonus)

The 20 in the formula is 20 year period. The 3.664 is to calculate the CO_2 out of the C.

Reference figures can be found in appendix 1.

The total annual mass of the biomass produced can be calculated from the conversion factor between the raw material and the biomass produced.

In the RED, a bonus reduction of 29 gCO_2eq/MJ is given under certain conditions.

[F.6] [total annual mass of biomass grown in MT] =
[biomass - raw material conversion factor] * [total annual mass of raw material grown in MT]

The calculation of the biomass-raw material conversion factor is described in chapter 4 c) Production of the final biomass product below.

In both the EU directive and the NTA 8080 the GHG emissions for equipment used for the land change are not included in the calculations and should also not be taken into account in the GGL GHG and energy balance calculations described in this standard. The calculation should only include the carbon stock change as described above for land preparations.

Energy used in land change and land preparation shall not be taken into account in the energy balanced.

5.1.2 Cultivation and maintenance of the land:

For fertilizers and waste the CO_2 equivalency of N_2O and CH_4 has to be calculated.

Only direct process related waste is taken into account, meaning: waste of materials used for land preparation, maintenance, harvesting and cultivation. Appendix 4 shows as a guideline the waste types that should not be included, although it is not an exhaustive list.

Because fertilization and waste management can deviate between enterprises from the best practices applied, there are no reference figures given for the calculation. Only actual figures from the process should be used, and since the system should encourage improvements, the most recent figures of the previous year shall be used[1].

[F.7] [GHG emission from waste and fertilizing per MT of biomass] =
[total GHG emissions from waste and fertilizing used in the cultivation and maintenance process] / [total annual mass of biomass grown in MT])

To calculate the amount of biomass grown out of the raw material, please refer to § 5.1.1. "Land preparation."

The GHG calculation for Cultivation and maintenance of the land shall include the fossil fuel and fossil energy use of equipment used in the process. Only the energy coming from fossil fuel is counted in the equation. Renewable fuel or renewable energy is assumed to produce zero GHG. When the fuel or energy used is a mix of renewable and fossil only the fossil portion is used.
In case of electricity use, the reference values of the electricity supply mix in Appendix 5 shall be used if acceptable official specific information is not available.

[F.8] [GHG emission from electricity for cultivation and maintenance per MT of biomass] =
([Total energy use for cultivation and maintenance] * [fossil fuel emission factor of the energy mix]) / [total annual mass of biomass grown in MT])

[F.9] [GHG emission from fossil fuel use for cultivation and maintenance per MT of biomass] =
([Total fossil fuel use for cultivation and maintenance] * [emission factor of the fossil fuel]) / [total annual mass of biomass grown in MT])

The energy used from fossil fuels shall be calculated with the use of the above stated formula's, after replacing [fossil fuel emission factor] with [fossil fuel NCV]

5.1.3 Harvesting

The GHG calculation for harvesting shall include the fossil fuel use and fossil energy use of equipment used in the process. Only the energy coming from fossil fuel is used in the equation. Renewable fuel or renewable energy is assumed to produce zero GHG. When the fuel or energy used is a mix of renewable and fossil only the fossil portion is used. Appendix 1 shows GHG emission data (indicative references only) per m^3 harvested wood, including maintenance, planting and, or regeneration.

In case of electricity use, the reference values of the electricity supply mix in Appendix 5 shall be used if acceptable official specific information is not available.

[F.10] [GHG emission from electricity for harvesting per MT of biomass] =

(([Total energy use for harvesting] * [fossil fuel emission factor of the energy mix]) / [total annual mass of biomass harvested in MT])

[F.11] [GHG emission from fossil fuel use for harvesting per MT of biomass] =

[1] for all calculations: actual data shall be used (past 12 months, prior to the audit)

(([Total fossil fuel use for harvesting] * [emission factor of the fossil fuel]) / [total annual mass of biomass harvested in MT])

To calculate the amount of biomass grown out of the raw material, please refer to “5.1.1. Land preparation.”

The energy used from fossil fuels shall be calculated with the use of the above stated formula’s, after replacing [fossil fuel emission factor] with [fossil fuel NCV]

B) Processes on intermediate products(s)

This part does not need to be included when the biomass product is on the list of residual products of NTA 8080 and it is not the main product of the process (see Appendix 6).

For these processes the Energy/Emission allocation rule applies.

In order to calculate the amount of biomass produced from raw material a conversion factor is needed. When intermediate products are used in the production chain, a factor for part of the chain may be used. To get the final conversion factor the different part chain factors are multiplied with each other. To calculate the production conversion factor for intermediate products the following equation is to be used:

[F.12] [Conversion factor intermediate products of part of the chain] =
[annual amount of product produced in this part of the chain in MT] / [annual amount of incoming raw material or intermediate products in this part of the chain in MT]

This calculation is done for each type of organic ingredient of the final biomass separately.

Use all other relevant calculations as described under “5.3 C) Production of the final biomass product”, also for the processes on the intermediate products.

C) Production of the final biomass product

For these processes the Energy/Emission allocation rule applies.

The GHG calculation for the production shall include the fossil fuel use and fossil energy use of equipment used in the process. Only the energy coming from fossil fuel is counted in the equation. Renewable fuel or renewable energy used is assumed to produce zero GHG. When the fuel or energy used is a mix of renewable and fossil only the fossil portion is used.
In case of electricity use, the reference values of the electricity supply mix in Appendix 5 shall be used if acceptable official specific information is not available.

[F.13] [GHG emission from electricity for production per MT of biomass] =
(([Total annual electricity use for production] * [fossil fuel emission factor of the energy mix]) / [total annual mass of biomass produced in MT])

The annual electricity produced from co-generation (included electricity excess delivered to the grid) from biofuels shall be subtracted from the [Total annual electricity use for production] prior to performing the calculation for [GHG emission from electricity for production per MT of biomass] above.

[F.14] [GHG emission from fossil fuel use for production per MT of biomass] =
(([Total annual fossil fuel used for production] * [emission factor of the fossil fuel]) / [total annual mass of biomass produced in MT])

The annual excessive heat delivered to third parties for industrial or household heating produced by burning part of the raw materials included in the equation shall be subtracted from the [Total annual fossil

fuel used for production] prior to performing the calculation for [GHG emission from fossil fuel use for production per MT of biomass].
The energy used from fossil fuels shall be calculated with the use of the above stated formula's, after replacing [fossil fuel emission factor] with [fossil fuel NCV]

When the biomass product is on the NTA 8080 list of residual product and it is not the main product of the process (Appendix 6), a production factor per type of raw material may be needed to calculate the GHG and energy back from raw material back to the biomass produced. See chapter "4.1.1. Land preparation" for the use of this [biomass-raw material conversion factor]. This can be done using the following formula's:

[F.15] [Production factor of the final process] =
[annual amount of product produced in the final process] / [annual amount of incoming raw material or intermediate products in the final process in MT]

If only 1 process step is involved in producing the biomass, the [Production factor of the final process] for each raw material is the same as the [biomass-raw material conversion factor]. If more steps are involved the [biomass-raw material conversion factor] should be calculated by multiplying for each raw material each factor from each process step with each other:

[F.16] [biomass-raw material conversion factor] =
[Production factor of the final process] * [Conversion factor intermediate products of part of the chain]$_{\text{step 1}}$ * [Conversion factor intermediate products of part of the chain]$_{\text{step 2}}$ * [Conversion factor intermediate products of part of the chain]$_{\text{etc}}$ * …..

5 D) Transport, Storage and transsphipment

For each type of transport the total emission factor is calculated with the most actual values and the calculation factors as described in appendix 1. If the specific information is not know the reference values of Appendix 1 can be used for the fuel usage. The report should include why the actual value could not be obtained.

[F.17] [GHG Emission of the transport] =
([average distance traveled in km] * [fossil fuel use per km] * [GHG Emission factor of the fossil fuel used]) / [average amount of MT of biomass transported]

Appendix 4 also shows specific rules for transport.

For these processes the Energy/Emissions allocation rule applies. The slightly different allocation rule also applies when the means of transport is hauling more than 1 cargo. The fuel use may be allocated between the different cargos on relative amount of holds used by the biomass cargo and the cargo holds used for other products. If a hold contains more than 1 product the part of the hold is allocated relative to the volume of the different products in the hold.

[F.18] [Transport GHG emission allocated to biomass] =
([GHG Emission of the transport] * [number of holds or haulage spaces with biomass]) / [total number of holds containing cargo]

[F.19] [Hold of haulage space allocation] =
[Volume of hold or haulage the biomass takes up] / [Volume the total cargo in this hold or haulage takes up]

[F.20] [Emission allocated to biomass transported] =
[Emission transport unit] * [mass of biomass transported]/[total mass transported]

The energy used from fossil fuels shall be calculated with the use of the above stated formula's, after replacing [fossil fuel emission factor] with [fossil fuel NCV] and replacing [GHG Emission] with [energy used].

Final calculation and conclusion

The total GHG emissions per MT of biomass are added up, negative numbers (emissions savings) are subtracted.

The GHG emissions per MJ_{th} (heat) shall be calculated using the formula in [F.21].

[F.21] [GHG in gCO_2eq/MJ_{th} = [GHG in gCO_2eq/tonne/1000] * [NCV in GJ/tonne]; where NCV = net caloric value

With the use of the formula in 3.2 the final [GHG saving] is calculated.

If the fuel reference is in MJe (or kWh electricity), the total GHG emission per MJ_{th} (heat) shall be converted to MJ_e (electricity), before it is used in formula [F.2]. To calculate the GHG from gCO_2eq/MJ_{th} to gCO_2eq/MJ_e, formula [F.22] below shall be used

[F.22] [GHG in gCO2eq/MJe] = [boiler efficiency in GJ_e/GJ_{th}] * [GHG in gCO_2eq/MJ_{th}], where the boiler efficiency reference values can be found in Appendix 1.

The total [Fossil Energy used] per MT of biomass are added up, negative numbers (emissions savings) are subtracted. With the use of the formula in 3.2 and the average [Energy from biomass] from analyses results performed for the relevant biofuel or biomass standard by an ISO/IEC 17025 accredited or proven compliance laboratory the final [Energy advantage] is calculated.

The numbers have to be compared with the performance values per sector as given in Appendix 2. If the [Energy advantage] is below the number given and/or when the maximum [GHG saving] is below the given value the biomass or biofuel cannot be certified as GGL material.

In case of pellets for electricity, the maximum GHG emissions in kg CO_2eq per ton pellet are illustrated [example boxes] for facilitating the certification process.

Appendix 1: Reference values and calculation factors

The reference values below are noted for the most common used types of fossil fuels. Most of these values are average values derived from national and international energy balances and energy statistics. Such data are usually seen as providing quite accurate estimates. The default uncertainty range, depending on the accuracy data collected during the audit, should as default be assumed to be plus or minus 5 %.

1a. Transport emissions

If no more accurate of process specific values are known the relevant figures below should be used.

CO_2 emissions and energy per fuel type

Fuel type	Default CO_2 emission factor (kg/GJ)	Default NCV (GJ/MT)	Density kg/m^3
	Sources: EU 2004 [1)] or IPCC 2006 [2)]	Source: IPCC 2006 [2)]	Source: AGO 2003 [3)]
Gas/diesel oil	74.1	43.0	822
Marine diesel oil			846
Residual fuel oil	77.4	40.4	995
Liquid petroleum gas	63.1	47.3	534
Gasoline	69.3	44.3	746
Natural gas	56.1	48.0	
Other Bituminous Coal	94,6	25.8	
Brown Coal Briquettes	97.5	20.7	
Peat	106.0	9.76	

CO_2-equivalent transmissions per transport type

Transport type	Fuel type	Default CO_2 -equivalent emission factor (kg/GJ)	Default NCV (GJ/MT)	Density kg/m^3
		Source: EU 2004 [1)]	Source: IPCC 2006[2)]	Source: AGO 2003 [3)]
Gasoline truck	Gasoline	72.2	44.3	740
Gasoline truck with catalyst	Gasoline	71.0	44.3	740
Heavy diesel truck	Gas/diesel oil	75.3	43.0	822
Diesel train	Gas/diesel oil	82.7	43.0	822
Sea Going vessels	Residual fuel oil	78.2 [2)]	40.4	995

References:

[1)] Commission of the European Communities Commission Decision of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the (2004/156/EC)

[2)] IPCC 2006 Guidelines for National Greenhouse Gas Inventories.

[3)] Australian Green House Office, Factors and Methods Workbook, 03-2003

Additional notes for the means of transport:

Road:
Because the amount of CH_4 and N_2O produced from combustion depends on the technology use, it is decided for road transport that based on:
- ✓ EU diesel. Average diesel combustion for a European heavy duty diesel truck (0.0039 kg/GJ CH_4 and 0.0039 kg/GJ N_2O) the CO_2 emission factor shall be adjusted by 1.68 % to have an estimation for the GHG for diesel road vehicles.
- ✓ USA catalyst vehicles. Average gasoline combustion for a American light duty truck with catalyst (0.025 kg/GJ CH_4 and 0.008 kg/GJ N_2O) the CO_2 emission factor shall be adjusted by 4.25 % to have an estimation for the GHG for gasoline road vehicles with catalyst and
- ✓ USU non catalyst vehicles. Average gasoline combustion for a American light duty truck with catalyst (0.033 kg/GJ CH_4 and 0.0032 kg/GJ N_2O) the CO_2 emission factor shall be adjusted by 2.46 % to have an estimation for the GHG for gasoline road vehicles without catalyst (or unknown). (IPCC 2006).

Trains:
For diesel train locomotives the CO_2-equivalent is 11.6 % higher than the CO_2 content (0.00415 kg/GJ CH_4 and 0.0286 kg/GJ N_2O) and for coal fired locomotives the CO_2-equivalent is 0.51% higher (0.002 kg/GJ CH_4 and 0.0015 kg/GJ N_2O). (IPCC 2006)

Vessels:
For seagoing vessels the CO_2-equivalent is 0.97% higher than the CO_2 content (0.007 kg/GJ CH_4 and 0.02 kg/GJ N_2O). (IPCC 2006)

Reference values for fuel use

The references below are indicative and may be used to support more detailed references for fossil fuel consumption of transport.

Equipment	Fuel type	Default fuel usage	
Diesel truck (40 MT)	Gas/diesel oil	0.45 l/km	UU 2003 [4)]
Diesel truck (25 MT)	Gas/diesel oil	0.35 l/km	UU 2003 [4)]
Electrical train (40 cards)	electricity	163 kWh/km	UU 2003 [4)]
Diesel train (Canada)	diesel	5.76 l/1000 RTK	FAC 2012 [5)]
River Barge	Marine diesel oil	6.5 l/km	
Panamax size ship (70000 MT)	Residual fuel oil	48.38 kg/km	
Handy size ship (35000 MT)	Residual fuel oil	40.23 kg/km	
Tractor harvesting	Gas/diesel oil	9.1 l/hr	UU 2003 [4)]

[4)] University of Utrecht, Hamelinck,Suurs, Faaij, International bio energy transport cost and energy balance, august 2003.

[5)] Locomotive Emissions Monitoring Program, Railway Association of Canada (RAC) for Freight Class I. Figures are based on a 4-year average of rail fuel consumption in the period 2006-2009: 5.76 liter per 1,000 Revenue Ton Kilometer (RTK) equals to 17.32 gram CO_2/ton km (and an emission factor of 3,007 kgCO_2eq per liter diesel). Retrieved on 21 June 2012. The following internet sources are combined:
- http://www.cn.ca/en/greenhouse-gas-calculator-emission-factors.htm.
- http://www.tc.gc.ca/eng/programs/environment-ecofreight-rail-report2009-2730.htm

1 B. Emissions from heat and power production

Reference figures for power production or heating from fossil fuels

For energy purposes the emission reduction performance must be 60%, calculated against the European fossil fuel mix for the energy grid, which adds up to 712.8 kg CO_2/MWH

The fossil comparators are:
- 198 g CO_2eq / MJ electricity (from [2], solid and gaseous biomass)
- 87 g CO_2eq / MJ heat (from [2], solid and gaseous biomass)
- 91 g CO_2eq / MJ fuel in electricity production (from [1], bioliquids)
- 77 g CO_2eq / MJ fuel in heat production (from [1], bioliquids)
- 85 g CO_2eq / MJ fuel in cogeneration systems (from [1], bioliquids)

References:
6) NL Agency, version 1, May 2011.
Details: Dutch CO_2-tool for electricity, gas and heat from biomass. Table 3-3: conversion step in pathway wood pellet co-firing (basis is Y 850 MW_e power plant @ 8760 h/year and 10% co-firing). The NCV for wood pellets is set on 17.2 GJ/ton in case of wood pellets with 6% moisture content.

CO_2 equivalence for other Greenhouse gasses

Greenhouse gas	CO_2 equivalence
CO_2	1
N_2O	296
CH_4	23

The above mentioned figures are to be used as stated in "Commission of the European Communities Commission Decision of 29 January 2004 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the (2004/156/EC)"

Reference values boiler efficiencies

type	Electricity ($GWh_{electricity}$ / year)	Input (in kilo ton of pellets per year)	Efficiency based on GWh production
100% coal firing			35%
Combustion in coal plant (co-firing)	750	400	39.24%

Sources: RED; NL Agency 2011 [6)]

1C. Emissions from land use change and forest operations

Indicative values for harvesting emissions in Canada and Europe (including regeneration, replanting and maintenance)

The references below are indicative and may be used to support more detailed references for fossil fuel consumption of harvesting.

	Default value	Source:	Conversion factor *)	GHG emissions for pellet production
	In kg CO_2eq / m^3			kg CO_2 per ton pellet
Canada		CIPEC 2009 [7)]		
- Country average	19			
- Eastern Canada	21			
- Western Canada	16			
Europe		Eco-invent 2010 [8)]		
- Hardwood (logs)	13.7			
- Softwood (logs)	13.8			
- *Eucalyptus sp.* (plantations)	15.9			

*) Note that conversion factors from solid m^3 round wood (logs) to 1 ton of pellet are depending on the local conditions of a pellet plant

References

7) CIPEC 2009. Status of energy use in Canadian wood products sector (including replanting of seedlings)
8) Eco-invent 2010. Database on http://www.ecoinvent.ch (Accessed 1st of June 2012). Energy use and Global Warming Potential (GWP100) for "extraction of round wood", including forest maintenance and road construction

Carbon Stock

To calculate the total amount of biomass above and below ground from the total amount of merchantable wood the follow factors may be used:

	Above-Ground ration	Below-ground ratio
Softwood species	2.159	0.170
Hardwood species	2.240	0.155

Reference:

3) USDA, Carbon Storage and accumulation in Unites States Forest Ecosystems.

The above average figures can be used to calculate the carbon stock if figures of the volume of merchantable timber are known.

To calculate the root biomass from the biomass above ground with root to shoot ratio:

	Root to shoot ratio
Softwood species	0.2
Hardwood species	0.25

Source: AGO 2003 [3)]

Reference values for the carbon fraction of aboveground forest biomass

Domain	Part of tree	Carbon fraction, (CF) [tonne C (tonne/tonne dry matter)	Range
Default value	All	0.47	
Tropical and subtropical	All	0.47	0.44-0.49
	wood	0.49	
	wood, tree d < 10 cm	0.46	
	wood, tree d ≥ 10 cm	0.49	
	foliage	0.47	
	foliage, tree d < 10 cm	0.43	
	foliage, tree d < 10 cm	0.46	
Temperate and boreal	All	0.47	0.47-0.49
	broad-leaved	0.48	0.46-0.50
	conifers	0.51	0.47-0.55

Source: IPCC 2006 [2)]

Reference values for emission factors for drained organic soils in managed forests (not being included in the calculation)

Climate	Average emission factor	Range
Tropical	1.36	0.82-3.82
Temperate	0.68	0.41-1.91
Boreal	0.16	0.08-1.09

Source: IPCC 2006 [2)]

Reference value of carbon stock (including both soil and vegetation)

land use	Carbon stock in tonne C (carbon) per hectare
Oil palm plantation	189
Permanent grassland (older than 5 years)	181
Lightly forested area (not continuously forested)	181
Arable and non-permanent grassland)	82
Desert and semi-desert	44

Source: EU 2004 [1)]

Appendix 2: Minimal values for certification:

We have two options: (1) either direct GGL certificates or (2) GGL-NTA8080 certificates, according to Principle 2 of GGL Standard 1.

Option 1. **Minimum level of greenhouse savings GGL default**

	Minimal GHG reduction
Biomass for electricity [a)]	60%
Biofuels [b)]	35%

Notes for the minimum reduction shares:

a) For energy purposes the emission reduction performance must be 60%, calculated against the European fossil fuel mix for the energy grid, which adds up to 712.8 kg CO_2/MWh

b) Decree of Flemish Government regarding the use of renewables (5 March 2004): "the organic-biological share of residual waste, provided that the concerned processing installation by means of energy recuperation can realize a primary energy saving of at least 35% of the energy content of the residual product processed by the installation")
"Besluit van de Vlaamse Regering inzake de bevordering van elektriciteitsopwekking uit hernieuwbare energiebronnen" (5 maart 2004): "het organisch-biologisch deel van restafval, op voorwaarde dat de betrokken verwerkingsinstallatie door energierecuperatie een primaire energiebesparing realiseert van minstens 35 % van de energie-inhoud van de afvalstoffen verwerkt in de installatie"

Calculation example 1. What does it mean for pellets for electricity (60% GHG savings)?
The following parameters are valid

- ✓ *0.277 MWh per GJ primair*
- ✓ *Efficiency co-firing pellets: 39.24%*
- ✓ *Primary energy content (LHV)of wood pellets: 17.6 GJ per tonne*
- ✓ *Resulting power production after co-firing of pellets: 1.92 MWe per ton pellets*

Following a European fossil fuel mix with a GHG emissions of 712.8 kg CO_2 per MWh, the maximum GHG contribution of wood pellets is <u>547 kg CO2 per ton pellet</u>.
Disclaimer:

- ✓ *Fossil fuel mix does vary per year, thus also a the GHG emissions*
- ✓ *The efficiency of co-firing pellets may increase in long term, also that of coal firing.*

Option 2: Minimum level of greenhouse savings in case of NTA 8080 certificates:

	Minimal GHG reduction	reference
Biomass for electricity and heating	50% when referring to natural gas	NTA8080
Biomass for electricity and heating	70% when referring to the Dutch electricity mix	NTA8080
Biogas	60%	NTA8080
Biofuels	50%	NTA8080

Calculation example 2. What does it mean for pellets for electricity (70% GHG savings)?
The following parameters are valid

- ✓ *0.277 MWh per GJ primair*
- ✓ *Efficiency co-firing pellets: 39.24%*
- ✓ *Primary energy content (LHV)of wood pellets: 17.6 GJ per tonne*
- ✓ *Resulting power production after co-firing of pellets: 1.92 MWe per ton pellets*

Following a Dutch fossil fuel mix (excl. renewables) with a GHG emission of 715 CO_2 per MWh, the maximum GHG contribution of wood pellets is <u>412 kg CO2 per ton pellet</u>.
Disclaimer:

- ✓ *Fossil fuel mix does vary per year, thus also a the GHG emissions*
- ✓ *The efficiency of co-firing pellets may increase in long term, also that of coal firing.*

Appendix 3: Factors and multipliers

1 metric ton (MT)	1000 kilogram (kg)
1 hectare	10,000 square meter (m^2)
1 hectare	2.47 acres
1 acre	0.4047 hectares
1 joule (J)	0.239 calories (cal)
1 calorie	4.1868 J
1.0 British thermal unit (Btu)	1055.056 joule (1.055 kJ)
1 pound (lb)	0.4535924 kg
1000 Btu/lb	2.33 gigajoule per tonne (GJ/t)
1 Watt (W)	1 Joule/second (J/s)
1 Kilowatt Hour (kWh)	3.6 megajoule (MJ)
1 Btu/hr	0.2930711 W
1 liter	0,001 m^3
1 (us) mile	1.609347 kilometer (km)
1 inch (in)	2.54 cm
1 foot	0.3048 meter (m)
1 square foot (sq ft)	0.09290304 m^2
1 horsepower (hp)	745.6999 W
1 sea mile (or nautical mile)	1852 m
1 knot	1.852 km/hr
1 RTK	1 Revenue Ton Kilometer (train transport)

Multiplication Factor		Symbol	Prefix
10^{12}	1,000,000,000,000	T	tera
10^{9}	1,000,000,000	G	giga
10^{6}	1,000,000	M	mega
10^{3}	1,000	k	kilo
10^{2}	100	h	hecto
10^{1}	10	da	deca
1	1		
10^{-1}	0.1	d	deci
10^{-2}	0.01	c	centi
10^{-3}	0.001	m	milli
10^{-6}	0.000001	μ	micro
10^{-9}	0.000000001	n	nano
10^{-12}	0.000000000001	p	pico

To get from	to	Multiply by
Carbon	CO_2	3.664
CO_2	Carbon	0.2729
kg	MT	0.001
MT	kg	1000

Appendix 4: Emissions to be included and excluded in the calculations

Emissions of waste materials
To be excluded from the calculations:
- Emissions of broken equipment
- Emissions of packaging material

Emissions of indirect processes:

To be excluded from the calculations:
- Emissions and energy used for home-work travels of employers
- Emissions and energy used for de production of equipment and tools used in the process
- Emissions and energy used by the means of transport before and after transporting the material.
- Emissions and energy used for de production of packaging materials
- Auxiliary materials (like manure) and (product) additives that are residual products of another process, and which commercial value is less than 10% of the main product or other products (Appendix 6).
- Emissions for constructing infrastructure
- Emissions for building factories, processing units and offices.
- Emissions from drained organic soil.

To be included in the calculations:
- Emissions and energy used for producing production of auxiliary materials (like fertilizers) and (product) additives.
- Carbon changes in the soil if the process has direct influence on it (taking material containing carbon from the ground or leaving material that was include in the emission allocation calculation on the ground). Beware that extracting soil material containing carbon cannot be part of a sustainable managed system: see GGL approved systems.

Appendix 5: Electricity generation mix per region

Only information shall be used from official government documents or websites. The below table shall be used as reference as of the date of publication of this version GGLS8. The most recent data of the electricity generation mix shall be used for the calculations.

Table Gross electricity generation mix for European countries (2009) and North America (2010)

		Oil %	Natural gas %	Solid fuels (coal) %	Nuclear %	Hydro and other renewables %	Other (*) %
BE	Belgium	0.3	33.2	5.7	51.8	6.0	3,0
BG	Bulgaria	0.8	4.6	49.1	35.5	8.6	1,4
CZ	Czech Republic	0.2	4.5	55.9	33.1	6.3	0.0
DK	Denmark	3.2	18.5	48.6	0	27.6	2,1
DE	Germany	1.6	14.3	42.4	22.8	15.9	3,0
EE	Estonia	0.5	5.8	87.6	0	6.1	0.1
IE	Ireland	3.2	57.7	23.5	0	14.3	1,3
EL	Greece	12.5	18.0	55.7	0	13.1	0,7
ES	Spain	6.5	36.9	12.3	18.0	25.0	1,3
FI	Finland	0.7	14.1	21.5	32.6	30.1	1,0
FR	France	1.1	4.4	4.8	75.5	12.9	1,3
IT	Italy	8.9	51.6	13.6	0	23.7	2,2
CY	Cyprus	99.2	0	0	0	0.1	0,7
LV	Latvia	0.1	36.0	0.0	0.0	63.9	0,0
LT	Lithuania	4.8	13.7	0	70.7	4.5	6,3
LU	Luxembourg	0	73.3	0	0	6.9	19,8
HU	Hungary	1.8	29.2	17.7	43	8.1	0,2
MT	Malta	98.7	0	0	0	0	1,3
NL	Netherlands	1.3	62.6	21.4	3.7	9.5	1,5
AT	Austria	1.6	19.7	5.4	0	67.5	5,8
PL	Poland	1.8	4.0	87.9	0	5.7	0,6
PT	Portugal	6.5	29.3	25.7	0	36.4	2,1
RO	Romania	1.8	13.2	37.5	20.3	26.8	0,4
SI	Slovenia	0.2	3.6	31.3	35.0	29.9	0,0
SK	Slovak Republic	2.4	9.1	14.7	53.8	18.8	1,2
SE	Sweden	0.5	1.4	0.9	38.2	58.3	1,6
UK	United Kingdom	1.2	44.4	27.8	18.4	6.7	1,5
	EU-27 (average)	**3.0**	**23.4**	**25.7**	**27.8**	**18.3**	1,8
RU	Russian Federation	1.6	47.3	16.5	16.5	17.9	0.2
CA	Canada	1	9	14	14	62	-
US	United States	0.9	24.2	44.8	19.6	10.3	0.2

(*) in case of less than 100%: the remaining part is allocated to other.

Sources:

- EU-27 countries: http://ec.europa.eu/energy/observatory/countries/doc/2011-2009-country-factsheets.pdf
- Russia: http://www.iea.org/stats/electricitydata.asp?COUNTRY_CODE=RU
- Canada: http://www.neb-one.gc.ca/clf-nsi/rnrgynfmtn/nrgyrprt/nrgyftr/2011/fctsht1134mrgngfl-eng.html
- US: http://www.eia.gov/electricity/annual/html/tablees1.cfm (based on Net Generation in GWh)

The figures below are derived from the reference values for fossil fuels:

	GHG Emission factor kg CO_2-eq / kWh (electricity)	Source
Fossil fuel shares		
Electricity from (petroleum) oil	0.893	US
Electricity from gas fired power plant	0.551	CML
Electricity from coal fired power plant	1.200	CML
Non fossil fuel shares		
Nuclear	0	
Renewable fuels	0	
Other	0	

CML= CML Institute of Environmental Sciences Leiden University in Greenhouse Gas Calculator for Electricity and Heat from Biomass and used as reference by Senter Novem for the GHG calculator

US = Carbon Dioxide Emissions from the Generation of Electric Power in the United States July 2000: (1.969 [pounds CO_2 per kWh] * 0.4535924 [kg/lb])

Appendix 6: List of residual products from NTA 8080

The list with exceptions includes residual flows being biomass flows which are released during the production of other (main) products and which represent an economic value of less than 10 % of the value of the main product. Only the sustainability requirements specified in 5.2.1 and 5.5.1.2 are applicable to these biomass flows.

The list with exceptions has been classified according to NTA 8003:2008 Classification of biomass for energy application. The group number such as included in NTA 8003:2008 is mentioned between square brackets.

When a residual flow is not included in this list, sufficient evidence shall be submitted that this biomass is nevertheless accepted as an exception. Reliable information about prices of residual flows and main products shall be submitted as sufficient evidence among other things.

- bark [112];
- prunings (park and public garden) [113];
- sawdust [115][2];
- remaining fresh wood [119][3] as far it concerns the branch and top wood and/or low worthy spillage wood originating from forestry and nature grounds managed for a long term preservation of their function;

  NOTE Examples of low worthy spillage wood are wood with limited value by limited diameter, wood with big curvatures, wood with many and heavy knots, wood with rottenness/mildew/discolouring, wood broken by a storm.

- processed wood [150]:
  - untreated (A-wood) [160];

  NOTE It concerns here a mixture of untreated wood [161], cork [162] and other untreated wood [169].

  - wood from processing [190];

  NOTE It concerns here a mixture of wood from processing [191], wood from composting [192], wood from fermentation [193], wood that has been in water for a long time [194] and other wood from processing [199].

- grass from roadside [213];
- straw [220];

NOTE It concerns here a mixture of straw [221], barley straw [222], wheat straw [223], rice stalk [224], hemp [225] and other straw [229].

- residual products (shucks) [230];

NOTE It concerns here a mixture of shucks [231], cacao shucks [232], peanut shucks [233], (wal)nuts [234], almond shucks [235], rice skins [236] and other shucks [239].

- other residual products [250];

[2] Following the NTA 8080 list, GGL Foundation has included shavings under the same category [115] as “sawdust”.
[3] Following the NTA 8080 list, GGL Foundation has included slash (branches & tops), coarse woody debris after thinning and harvesting, snags and stumps under the same category [119], i.e. “remaining fresh wood”.

NOTE It concerns here auction waste [251], horticulture waste [252], fruit culture [253], bulb peeling [254] and agriculture waste [255].

- manure [300];

NOTE It concerns here a mixture of manure [301], other types of manure [309], poultry manure [310], cow manure [320], pig manure [330], horse manure [340], processed manure from manure fermentation (digestate) [351], processed manure from co-fermentation with manure (digestate) [352] and processed manure from other processing [359].

- sludge [400];

NOTE It concerns here a mixture of sludge [401], other sludge (including industrial sludge) [409], sludge from sewage/ waste water treatment plants [410], sludge from sewers, cesspits and pumping stations [420], sludge from preparation of drinking-water [430] and paper sludge [440].

- potato peelings shucks [522] as far it concerns no concentrated potato juice and/or potato protein;
- rice skins [523] as far it concerns rice chaff;
- pulp from manufacturing of sugar [532] as far it concerns the press pulp of beets;
- beet pulp [533] as far it concerns beet heads, beet tails and/or leaves;
- moist fibre/ brewing dregs and waste [535] as far it concerns brewer’s grain;
- coffee pulp [536];
- palm oil [554] as far it concerns palm shells;
- used frying fats and oils [572];
- soft drink and light alcoholic spirits unsuitable for human consumption [581];
- dairy products unsuitable for human consumption [582];
- foodstuffs unsuitable for human consumption [583];
- offal [586];
- black liquor [594];

NOTE Black liquor is chemical treated wood that comes from the production of paper. This is a mixture of chemicals and dissolved wood material that remains after boiling in sulphate.

- organic waste form households and companies [600];

NOTE It concerns here organic waste from households [610] and organic waste from companies (trading, services, other) [620].

- solid recovered fuels (SRF) [900].

NOTE Solid recovered fuels (SRF) are solid fuels which are prepared from non-dangerous waste products which are used for the recovery of energy in (co-)burning installations. It concerns here mixture [901], SRF from separation afterwards of garbage [902], SRF from separation afterwards of oversized trash [903], SRF from separation afterwards of industrial waste [904] and other SRF [909].