Instruction document 1a: Greenhouse Gasses and Energy Balance Calculations

Green Gold Label Program

Introduction

This instruction document has been drawn up for all actors in the biomass supply chain, on behalf of the Green Gold Label Foundation (www.greengoldlabel.com) and is applicable to all GGL participants.

Scope

This instruction document 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. In case of any conflicting or unclear requirements the most recent publication by the European Commission on sustainability criteria for solid biomass apply.
Unless stated otherwise, the calculation is done with data collected over an annual period. Reporting shall include an explanation and source reference. When no specific data is available default values in the appendices may be used. In appendix 1 individual default values are noted and the reference values on which they are based. Alternatively the process default values and disaggregated process default values based on BioGrace-II may be used as noted in appendix 7.

Reference

This instruction document 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*
- *BioGrace-II*

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

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

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

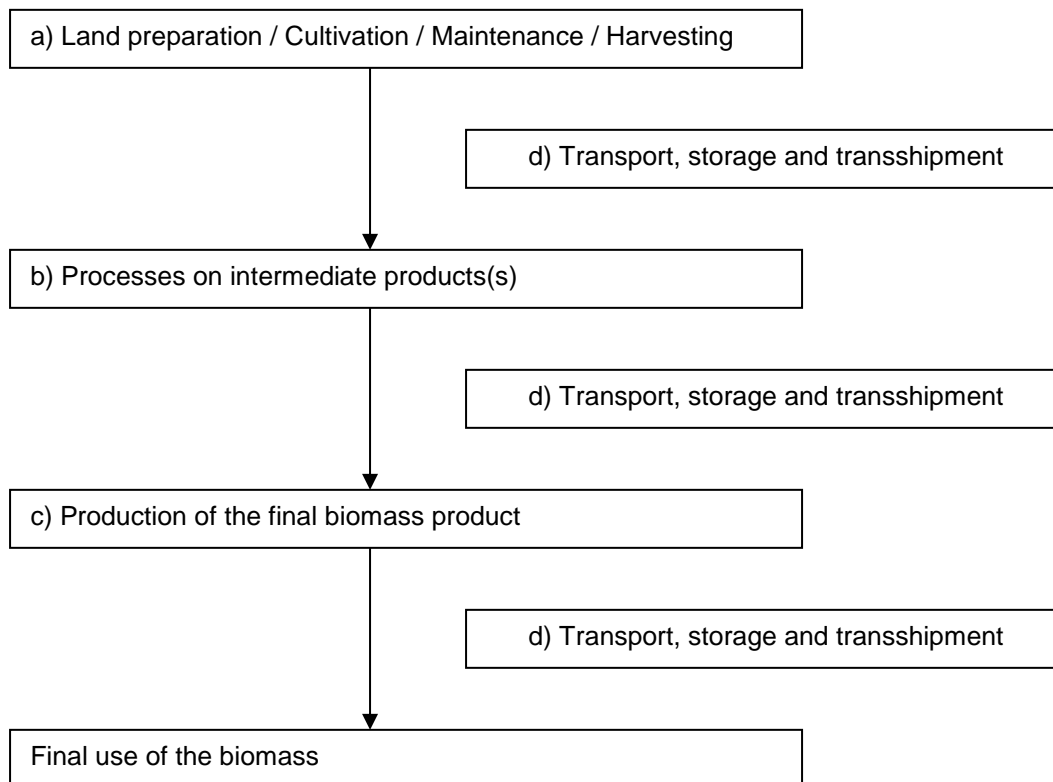## Instruction document 1a: Greenhouse Gasses and Energy Balance Calculations

Default values based on these reference values can be seen as providing an accurate estimates. The uncertainty range, depending on the accuracy of the data collected during the audit, should 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:

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┌────────────────────────────────────────────────────────┐
│ a) Land preparation / Cultivation / Maintenance / Harvesting │
└────────────────────────────────────────────────────────┘
                          │
                          │     ┌──────────────────────────────────────────┐
                          │     │ d) Transport, storage and transshipment  │
                          │     └──────────────────────────────────────────┘
                          ▼
┌────────────────────────────────────────────────────────┐
│ b) Processes on intermediate products(s)               │
└────────────────────────────────────────────────────────┘
                          │
                          │     ┌──────────────────────────────────────────┐
                          │     │ d) Transport, storage and transshipment  │
                          │     └──────────────────────────────────────────┘
                          ▼
┌────────────────────────────────────────────────────────┐
│ c) Production of the final biomass product             │
└────────────────────────────────────────────────────────┘
                          │
                          │     ┌──────────────────────────────────────────┐
                          │     │ d) Transport, storage and transshipment  │
                          │     └──────────────────────────────────────────┘
                          ▼
┌────────────────────────────────────────────────────────┐
│ Final use of the biomass                               │
└────────────────────────────────────────────────────────┘
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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)
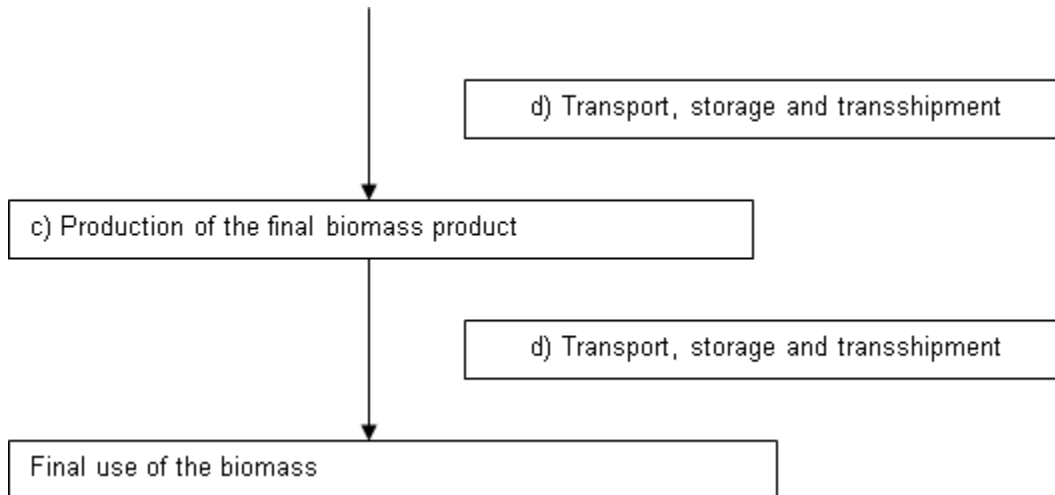
GHG calculation:

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:

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

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 instruction document, 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.

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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:
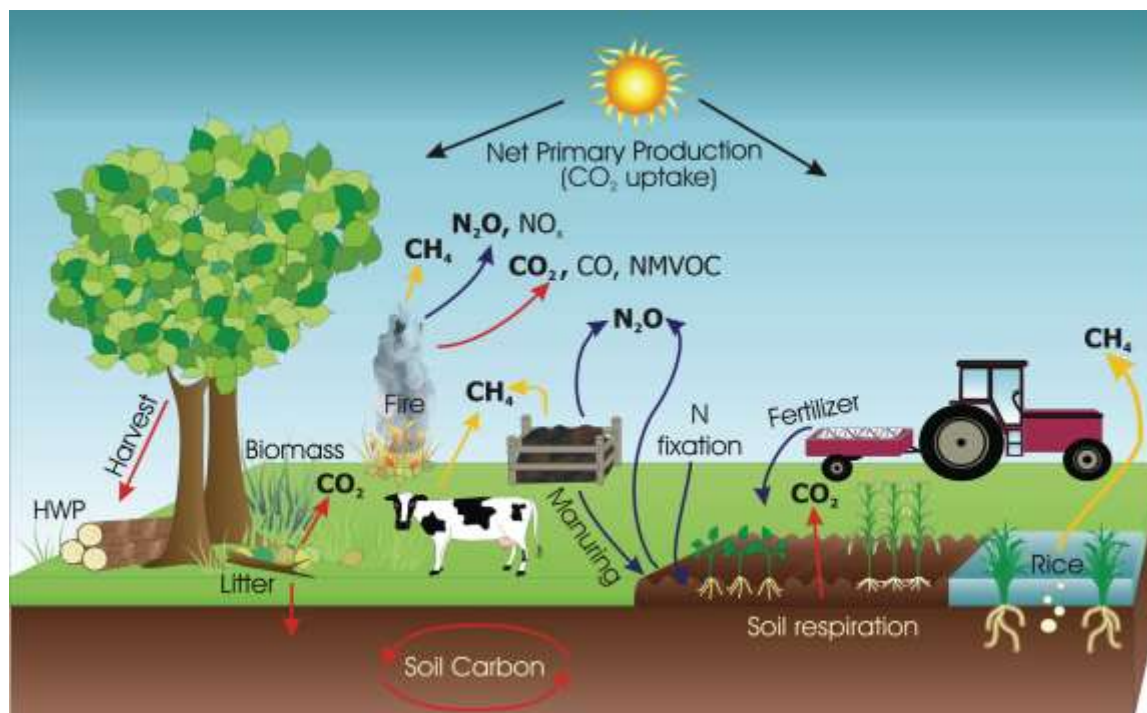
source: IPCC 2006

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This part of the instruction document 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 instruction document. 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] =

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

(([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] =
(([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]$_{step\ 1}$ * [Conversion factor intermediate products of part of the chain]$_{step\ 2}$ * [Conversion factor
           intermediate products of part of the chain]$_{etc}$ * …..

5 D) Transport, Storage and transshipment
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 available 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)

Default values based of 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. If no other figures are available the default value below may be used. The default values are based on the reference value including safety marge of approximately 40%.

Equipment	Fuel type	Default fuel usage	Reference value	
Diesel truck (40 MT)	Gas/diesel oil	0.65 l/km	0.45 l/km	UU 2003 [4]
Diesel truck (25 MT)	Gas/diesel oil	0.50 l/km	0.35 l/km	UU 2003 [4]
Electrical train (40 cards)	electricity	230 kWh/km	163 kWh/km	UU 2003 [4]
Diesel train (Canada)	diesel	8.1 l/1000 RTK	5.76 l/1000 RTK	FAC 2012 [5]
River Barge	Marine diesel oil	9.1 l/km	6.5 l/km	
Panamax size ship (70000 MT)	Residual fuel oil	67.75 kg/km	48.38 kg/km	
Handy size ship (35000 MT)	Residual fuel oil	56.32 kg/km	40.23 kg/km	
Tractor harvesting	Gas/diesel oil	12.8 l/hr	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 70%, calculated against the European fossil fuel mix for the energy grid: the Fossil fuel comparator.

The Fossil fuel comparator are for:
• Electricity = 186 gCO2 eq./ MJ [6]
• Heat = 80 gCO2 eq./ MJ [6]

[6] Reference values from "COMMISSION STAFF WORKING DOCUMENT
State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU SWD(2014) 259" from 28.7.2014.
For electricity the Fossil fuel comparator was based on the following power mix:
50% natural gas fired CCGT plants (with gas sourced from a mixture of sources, from short/long distance as well as LNG), 25% coal fired IGCC plants, and 25% conventional coal. For heat, the FFC was based on natural gas, as this is likely to remain the dominant fossil source of heat in the EU up to 2020.

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

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

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
6) CIPEC 2009. Status of energy use in Canadian wood products sector (including replanting of seedlings)
7) 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

<u>Carbon Stock</u>
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:

Minimum level of greenhouse savings GGL default

	Minimal GHG reduction
Biomass for electricity [a)	70%
Biofuels [b)	35%

Notes for the minimum reduction shares:
a) For energy purposes the emission reduction performance must be 70%, calculated against the European fossil fuel mix for the energy grid, which adds up to 186 gCO2eq/MJ
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"

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

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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 (2013), Russia (2012) and North America (2014)

		Oil %	Natural gas %	Solid fuels (coal) %	Nuclear %	Hydro and other renewables %	Other (*) %
BE	Belgium	0.19	27.75	3.62	51.28	15.53	1.64
BG	Bulgaria	0.53	5.35	44.3	32.37	17.45	0
CZ	Czech Republic	0.06	4.93	47.9	35.32	11.73	0.07
DK	Denmark	1.01	9.78	41.12	0	46.01	2.07
DE	Germany	1.14	12.6	44.76	15.41	25.05	1.04
EE	Estonia	0.98	2.79	86.59	0	9.19	0.45
IE	Ireland	0.77	48.51	27.72	0	22.78	0.23
EL	Greece	9.46	19	46.2	0	25.17	0.16
ES	Spain	4.85	20.63	14.47	20.01	39.83	0.21
FI	Finland	0.32	10.29	19.53	33.28	36.1	0.48
FR	France	0.44	3.51	3.84	74.09	17.78	0.35
IT	Italy	5.36	38.84	15.61	0	39.41	0.79
CY	Cyprus	92.31	0	0	0	7.69	0
LV	Latvia	0	43.06	0	0	56.94	0
LT	Lithuania	4.64	49.01	0	0	45.7	0.66
LU	Luxembourg	0	49.13	0	0	48.79	2.08
HU	Hungary	0.2	18.58	20.83	50.83	9.23	0.33
MT	Malta	98.23	0	0	0	1.77	0
NL	Netherlands	1.24	57.66	24.43	2.87	12.12	1.69
AT	Austria	1.01	12.52	6.15	0	79.25	1.07
PL	Poland	1.08	4.43	83.75	0	10.72	0.02
PT	Portugal	3.29	13.99	22.91	0	59.23	0.58
RO	Romania	0.95	15.74	28.77	19.73	34.81	0
SI	Slovenia	0.06	3.17	30.31	32.92	33.48	0.06
SK	Slovak Republic	1.5	9.91	10.67	54.66	23.19	0.07
SE	Sweden	0.27	0.78	0.64	43.39	54.07	0.84
UK	United Kingdom	0.6	26.95	36.41	19.66	15.75	0.64
HR	Croatia	1.71	15.04	18.02	0	65.23	0
	EU-27 (average)	**1.93.0**	**16.623.4**	**26.725.7**	**26.927.8**	**27.218.3**	0.61,8
RU	Russian Federation	2.6	49.1	15.7	16.6	15.8	0.
CA	Canada	1.3	8.5	9.5	16	64.5	-
US	United States	0.76	28.55	39.65	19.99	11.06	0

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

Sources:

- EU-27 countries:
  https://ec.europa.eu/energy/sites/ener/files/documents/PocketBook_ENERGY_2015%20PDF%20final.pdf

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- Russia: http://www.iea.org/publications/freepublications/publication/Russia_2014.pdf
- Canada: http://www.nrcan.gc.ca/energy/electricity-infrastructure/about-electricity/7359#generation
- US: http://www.eia.gov/electricity/annual/html/epa_01_02.html

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];

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[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".

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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].

Appendix 7: Process default values for greenhouse gas intensity of biomass

For the calculation of the greenhouse gas intensity of fuels every party in the chain must collect sufficient information. This can be done by making own calculations (piossibly using individual default values as described in annex 1) or, by the use of process default values as given by BioGrace-II.

In the first case one will have to make their own calculations in line with the methodology in this instruction document, in the second case one can use the following tables with relevant process default values. In those cases where a party does not make its own calculation, it is sufficient to transmit the values from the table below to the next party in the chain, both for its own part as well as for the previous part of the chain of custody.

In the case of a power plant, the correct default value for the purpose of calculating the greenhouse gas intensity can be applied on the basis of the table below, and the information provided. The information provided must be sufficient to choose the appropriate category; This includes information on:
- Biomass energy
- Raw material
- Transportation Distance
- Configuration pellet mill (if relevant).

If, on the choice of standard values, the actual transport distances and / or the configuration of the pellet mill are unknown, then the most conservative value is to be selected, that is to say, the value for the largest transport distance and / or for the configuration with a natural gas boiler.

Unknown data for part of the chain

As data for own emission calculations are available for part of the chain, and are lacking for another part, a party can use disaggregated process default values in its calculation for that part which is not known. This can be the case, for example, if a company does have its own data for the calculation of the emissions during transport, but not for the emission during cultivation and production. In that case, in BioGrace-II relevant process defaultvalues can be taken for cultivation and production and an own calculation can be made on the basis of the available data for transport.

Calculating GHG intensity of electricity and / or heat

To be able to calculate the final greenhouse gas intensity of the heat and / or electricity produced, a calculation must be carried out in the power plant on the basis of the data from the input fuel of the installation and the output of electricity and / or heat production. This is the conversion made from the units in the tables below, to the required numbers in the unit "amount of greenhouse gas per MJ of electricity" or in the unit "amount of greenhouse gas per MJ of heat." The details of the conversion efficiency of the system are also included in this calculation.

The values in this annex are taken from the JRC Report EUR 27215 EN, updating the JRC Report EUR 26696 EN 2014 and was published as an Annex to the report "SWD (2014) 259 final" on sustainability criteria for solid and gaseous biomass. The full reference of the JRC report is:

Jacopo Giuntoli, Alessandro Agostini, Robert Edwards, Luisa Marelli, "Solid and gaseous bioenergy pathways: input values and GHG emissions", Report EUR 27215 EN, Joint Research Centre – Institute for Energy and Transport, 2015.

Section A – Process default values greenhouse gas emissions

Emission values are expressed on the basis of MJ final biomass delivered at the plant, final conversion efficiency is excluded. No land use emissions are included in these results nor are CO_2 emissions from the combustion of biomass or other indirect effect. Included are CH_4 and N_2O emissions from final combustion. This is in accordance with the methodology of the JRC report.

Biomass energy carrier	Biomass production system	(if relevant) Configuration of pellet mill	Transport distance	Default (g CO_{2-eq} per $MJ_{biomass}$)
Woodchips	Forest residues	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	6 8 14 25
	Stemwood	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	6 8 14 25
	Wood industry residues	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	4 7 13 24
Wood pellets/briquettes	Forest residues	Configuration 1: Natural gas boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	36 36 38 42
		Configuration 2: Wood chips-boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	19 19 21 25
		Configuration 3: Wood chips-CHP	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	7 7 8 13
	Stemwood	Configuration 1: Natural gas boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	36 36 38 42
		Configuration 2: Wood chips-boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	19 18 20 25
		Configuration 3: Wood chips-CHP	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	6 6 8 12
	Wood industry residues	Configuration 1: Natural gas boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	22 21 23 27

Biomass energy carrier	Biomass production system	(if relevant) Configuration of pellet mill	Transport distance	Default (g CO$_{2-eq}$ per MJ$_{biomass}$)
Agricultural systems		Configuration 2: Wood chips-boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	11 11 13 17
		Configuration 3: Wood chips-CHP	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	4 4 6 10
	Agricultural Residues with density <200 kg/m^3 [4]	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	4 9 17 32
	Agricultural Residues – with density >200 kg/m^3 [5]	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	4 6 9 17
	Straw pellets	N.A.	1 to 500 km 500 to 10000 km Above 10000 km	10 12 16
	Bagasse briquettes	N.A.	500 to 10000 km Above 10000 km	6 10
	Palm Kernel Meal	N.A.	Above 10000 km	61
	Palm Kernel Meal (no CH$_4$ emissions from oil mill)	N.A.	Above 10000 km	40

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[4] This group of materials includes agricultural residues with a low bulk density and it comprises materials such as straw bales, oat hulls, rice husks and sugar cane bagasse bales (not exhaustive list).

[5] The group of agricultural residues with higher bulk density includes materials such as corn cobs, nut shells, soybean hulls, palm kernel shells (not exhaustive list).

Section B – Disaggregated process default values

Emissions are expressed per MJ biomass. In case of 'overall' process default values, see Part A

Biomass energy carrier	Biomass production system	(if relevant) Configuration of pellet mill	Transport distance	Default (g CO$_{2-eq}$ per MJ$_{biomass}$)			
				Cultivation	Processing	Transport	Combustion emissions
Woodchips	Forest residues	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	1.9 1.9 1.9 1.9	3.6 5.9 11.7 22.8	0.5 0.5 0.5 0.5
	Stemwood	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	1.1 1.1 1.1 1.1	0.4 0.4 0.4 0.4	3.6 5.9 11.7 22.8	0.5 0.5 0.5 0.5
	Wood industry residues	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	0.4 0.4 0.4 0.4	3.6 5.9 11.7 22.8	0.5 0.5 0.5 0.5
Wood pellets or briquettes	Forest residues	Configuration 1: Natural gas boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	32.5 32.5 32.5 32.5	3.4 3.3 5.1 9.4	0.3 0.3 0.3 0.3
		Configuration 2: Wood chips-boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	15.2 15.2 15.2 15.2	3.6 3.4 5.2 9.7	0.3 0.3 0.3 0.3
		Configuration 3: Wood chips-CHP	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	2.8 2.8 2.8 2.8	3.6 3.5 5.3 9.7	0.3 0.3 0.3 0.3
	Stemwood	Configuration 1: Natural gas boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	1.1 1.1 1.1 1.1	31.1 31.1 31.1 31.1	3.4 3.3 5.1 9.4	0.3 0.3 0.3 0.3

Biomass energy carrier	Biomass production system	(if relevant) Configuration of pellet mill	Transport distance	Default (g CO_{2-eq} per $MJ_{biomass}$)			
				Cultivation	Processing	Transport	Combustion emissions
		Configuration 2: Wood chips-boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	1,3 1,3 1,3 1,3	13.4 13.4 13.4 13.4	3.6 3.4 5.2 9.7	0.3 0.3 0.3 0.3
		Configuration 3: Wood chips-CHP	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	1,4 1,4 1,4 1,4	0.9 0.9 0.9 0.9	3.6 3.5 5.3 9.7	0.3 0.3 0.3 0.3
	Wood industry residues	Configuration 1: Natural gas boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	18.0 18.0 18.0 18.0	3.3 3.2 5.0 9.1	0.3 0.3 0.3 0.3
		Configuration 2: Wood chips-boiler	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	7,3 7,3 7,3 7,3	3.3 3.2 5.0 9.2	0.3 0.3 0.3 0.3
		Configuration 3: Wood chips-CHP	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	0.3 0.3 0.3 0.3	3.4 3.2 5.0 9.2	0.3 0.3 0.3 0.3
Agricultural systems	Agricultural Residues with density <200 kg/m³ [6]	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	1.1 1.1 1.1 1.1	3.1 7.2 15.4 30.7	0.3 0.3 0.3 0.3
	Agricultural Residues – with density >200 kg/m³ [7]	N.A.	1 to 500 km 500 to 2500 km 2500 to 10000 km Above 10000 km	0.0 0.0 0.0 0.0	1.1 1.1 1.1 1.1	3.1 4.2 8.0 15.4	0.3 0.3 0.3 0.3
	Straw pellets	N.A.	1 to 500 km 500 to 10000 km Above 10000 km	0.0 0.0 0.0	6,1 6,1 6,1	3.5 5.4 9.9	0.3 0.3 0.3
	Bagasse briquettes	N.A.	500 to 10000 km Above 10000 km	0.0 0.0	0,4 0,4	5.1 9.4	0.5 0.5
	Palm Kernel Meal	N.A.	Above 10000 km	22.1	25,4	13.3	0.3

[6] This group of materials includes agricultural residues with a low bulk density and it comprises materials such as straw bales, oat hulls, rice husks and sugar cane bagasse bales (not exhaustive list).

[7] The group of agricultural residues with higher bulk density includes materials such as corn cobs, nut shells, soybean hulls, palm kernel shells (not exhaustive list).

Biomass energy carrier	Biomass production system	(if relevant) Configuration of pellet mill	Transport distance	Default (g $CO_{2\text{-}eq}$ per $MJ_{biomass}$)			
				Cultivation	Processing	Transport	Combustion emissions
	Palm Kernel Meal (no CH_4 emissions from oil mill)	N.A.	Above 10000 km	22.1	4.2	13.3	0.3