

**BIOGRACE**

Harmonised Calculations  
of Bioenergy Greenhouse Gas Emissions in Europe



February 2021

# **BioGrace I and II**

## **Methodological Background Document**

Version 4a



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## 1 Introduction

The Renewable Energy Directive (RED) as published in 2008<sup>1</sup> includes biofuel and bioliquid sustainability criteria but does not contain sustainability requirements for solid biomass. Instead, guidance on sustainability criteria for solid and gaseous biomass for electricity, heating and cooling was included in a February 2010 report on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling<sup>2</sup> and in the July 2014 Staff Working Document on biomass sustainability<sup>3</sup>.

As a result, in the period 2008 – 2020 the methodology for bio-energy GHG calculations was included in the RED for biofuels and bioliquids, whereas it was described in the two reports mentioned above for solid and gaseous biomass used for heating/cooling and electricity production.

Sustainability criteria for solid and gaseous biomass have more recently been included in the recast of the European Renewable Energy Directive (RED-II)<sup>4</sup>. As a result the RED-II now contains methodologies for GHG emission calculations for biofuels and bioliquids (in RED-II Annex V.C) as well as for solid and gaseous biomass fuels (in RED-II Annex VI.B). In 2020 a “Corrigendum to the RED-II”<sup>5</sup> was published.

This methodological background document provides additional information on methodological choices for calculating GHG emissions from biofuels, bioliquids and biomass fuels as included in these RED-II annexes. This document applies for both BioGrace-I (biofuels) as well as for BioGrace-II (electricity, heat and cooling from biomass). It is an update of an earlier 2015 version which only applied to BioGrace-II.

This document includes an explanation on allocation methods applied (chapter 2), on the RED-II fossil fuel comparators (chapter 3) and on the approach applied to the biogas production chain (chapters 4 and 5). Finally, this document offers further explanation on the methodology for calculating nitrous oxide emissions (chapter 6) and the choice of lower heating value as a measure of energy content (chapter 7).

The Annex to this document includes the GHG accounting methodology from the RED-II. The RED-II gives two separate (but very similar) methodological annexes for biofuels and bioliquids (Annex V.C) and biomass fuels (Annex VI.B). This document combines these two annexes into one methodological description, pointing to the limited amount of differences between RED-II Annex V.C and Annex VI.B. This is the methodology to be applied when making actual GHG calculations using the BioGrace-I and/or the BioGrace-II GHG calculation tools.

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<sup>1</sup>: [Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC.](#)

<sup>2</sup>: COM/2010/11, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2010:0011:FIN:EN:PDF>

<sup>3</sup>: SWD(2014) 259, [http://ec.europa.eu/energy/sites/ener/files/2014\\_biomass\\_state\\_of\\_play\\_.pdf](http://ec.europa.eu/energy/sites/ener/files/2014_biomass_state_of_play_.pdf)

<sup>4</sup>: [Directive \(EU\) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources.](#)

<sup>5</sup>: [Corrigendum to Directive \(EU\) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources \(Official Journal of the European Union L 328 of 21 December 2018\)](#)

## 2 Allocation methods

How emissions are being divided between different co-products has a large impact on the final result of a life cycle analysis of a fuel or as final energy. When making GHG calculations, the allocation method is therefore crucial to the result.

### 2.1 Clarifications to the use of exergy for allocation between electricity and heat

For most co-products the methodology for GHG calculations in the RED-II uses energy allocation based on the lower heating value of the co-products. Since energy allocation does not reflect the different values of heat and electricity, the method was not used for allocation between heat and electricity. When heat is co-produced with other energy commodities, exergy has been chosen as the basis for the allocation, instead of energy. Exergy is only used as allocation method when heat at different temperatures is produced and when heat is co-produced with electricity. Allocation between other types of products is described in section 2.3.

Different allocation methods for dividing emissions between heat, electricity and cooling were evaluated by the Commission when drawing up the new methodology for solid biomass applications. The alternatives studied were allocation based on

- energy,
- economic value, and
- exergy.

Energy allocation does not take into account the different value of different energy carriers. Energy allocation would not differentiate between 1 MJ of heat and 1 MJ of electricity even if the economic value and the capacity of performing work of the two energy carriers are not the same. Nor would energy allocation differentiate between 1 MJ of heat at 10 °C, which is unable to produce any work in any thermal cycle, and 1 MJ of heat at 1000 °C, which can be used for many purposes. This makes it difficult to distinguish between useful and useless energy when dividing emissions between electricity and heat at different temperatures. Energy allocation was therefore discarded as an allocation method when dividing emissions between electricity, heat and cooling.

The allocation method based on economic value was also discarded, mainly because of difficulties in finding relevant data. Economic allocation factors would also have had to handle both fluctuating energy prices and the various taxing and subsidising schemes of different countries in the EU.

Exergy is a thermodynamic concept that describes the maximum useful work that can be done by the available energy. Thus, it considers the different value of heat and electricity. This is the main reason why the proposal from the EC ended up with exergy as the basis for allocations between energy carriers. However, the term is not commonly used due to its moderately higher complexity compared to the concept of energy with which a larger audience is accustomed. The condition for choosing exergy as the basis for allocation was that the calculation could be kept simple.

For heat the exergy value can easily be calculated using a physical formula called the Carnot efficiency (the thermodynamic quality of heat).

$$C_h = \frac{T_h - T_0}{T_h}$$

Where

- T is measured in absolute temperature (K = kelvin),
- $T_h$  is the temperature of the heat (K),
- $T_0$  is the temperature of the environment, or surroundings, set at 273.15 K in EU legislation (equal to 0 °C).

The formula means that the exergy of heat is dependent of the temperature of the heat; high temperatures give high values of exergy. Electricity is always given an exergy value of 1. In principle this means that heat is weighted lower than electricity, because of its lower exergy value.

The allocation factors for electricity and heat are calculated by the following formulas:

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

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

where

- $EC_{el}$  is total greenhouse gas emissions from the electricity (per MJ).
- $EC_h$  is total greenhouse gas emissions from the heat (per MJ).
- E is the total greenhouse gas emission of the biomass fuel before end-conversion (per MJ)
- $\eta_{el}$  is the electrical efficiency, defined as the annual electricity produced divided by the annual fuel input, based on its energy content.
- $\eta_h$  is the heat efficiency, defined as the annual useful heat output divided by the annual fuel input, based on its energy content.

For heat temperatures below 150 °C (423.15 kelvin), and when exporting excess heat for heating of buildings, a constant Carnot efficiency of 0.3546 is set (the Carnot efficiency of heat at 150 °C). The reason is to avoid very low allocation factors for the district heating. Very low allocation factors for the district heating would give disproportionate high emissions allocated to the electricity.

Using the exergy-based allocation between heat and electricity forms an effective incentive to recover waste heat, as the more heat is usefully used, the more emissions are allocated to heat resulting in a better GHG emission saving for electricity.

### Example of the allocation method:

A CHP is fed with biomass fuel with upstream emissions of 100g CO<sub>2,eq</sub>/MJ. The electric efficiency is 25 per cent and the thermal efficiency (= useful heat output divided by the total fuel input) is 50 per cent. The temperature of the heat delivered for heating of buildings is 120 °C. Since the heat temperature is below 150 °C the Carnot factor is set at 0.3546 (see *Figure 1*).

$$EC_{el} = \frac{E}{\eta_{el}} \left( \frac{C_{el} \cdot \eta_{el}}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right) = \frac{100}{0.25} \left( \frac{1 \cdot 0.25}{1 \cdot 0.25 + 0.3546 \cdot 0.5} \right) = 234 \left[ \frac{g}{MJ_{el}} \right]$$

$$EC_h = \frac{E}{\eta_h} \left( \frac{C_h \cdot \eta_h}{C_{el} \cdot \eta_{el} + C_h \cdot \eta_h} \right) = \frac{100}{0.5} \left( \frac{0.5 \cdot 0.3546}{1 \cdot 0.25 + 0.3546 \cdot 0.5} \right) = 83.0 \left[ \frac{g}{MJ_{heat}} \right]$$

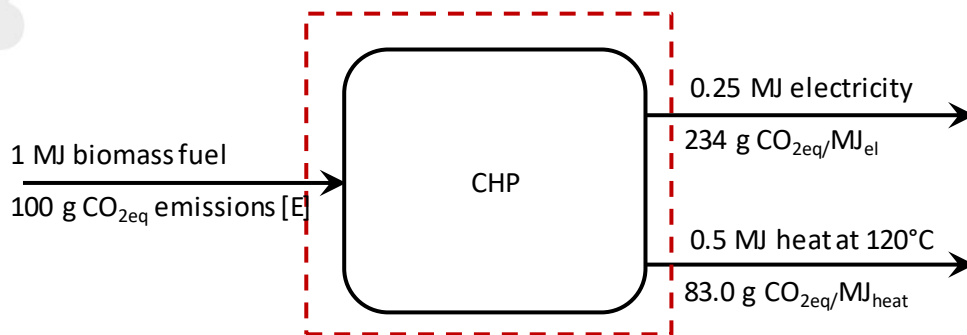


Figure 1. Allocation between electricity and heat at 120 °C in a CHP.



### 2.2 Allocation in the case of cooling being produced

The BioGrace-II Excel tool allows calculating the emission savings from the use of waste heat to provide cooling via an absorption chiller. Even calculating a tri-generative process is possible, where electricity, heat and cooling are produced. As cooling is made from waste heat, heat production is always the first step. Depending on whether additional electricity is produced, the above described allocation step between electricity and heat may be necessary. Only in a second step, heat is further transformed into cooling based on a cooling efficiency (see *Figure 2*).

The efficiency is expressed as the seasonal coefficient of performance (SCOP). It is defined as the refrigeration effect, divided by the net heat input. The value should reflect an annual average efficiency rather than a theoretical value.

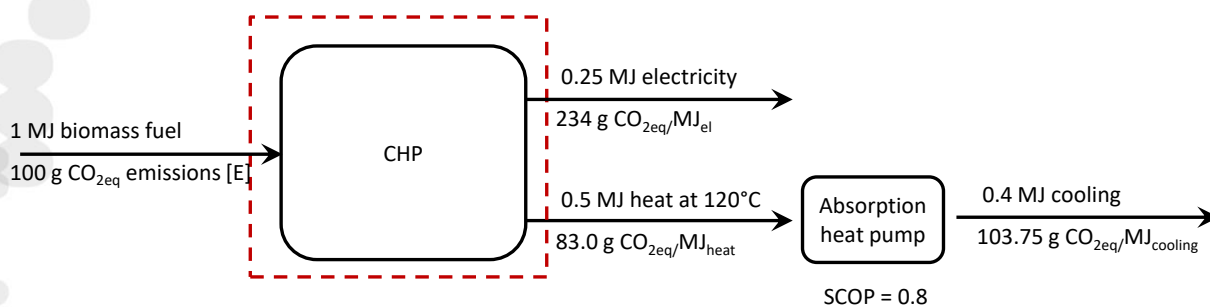


Figure 2. Allocation between electricity and heat and production of cooling from heat.

### 2.3 Energy allocation between other products than heat, cooling and electricity

Exergy allocation is only used between electricity and heat, also in case the heat is used for the production of cooling via an absorption chiller. For all other allocation issues, energy allocation shall be used. The RED-II contains in paragraph 17 in Annex V.C as well as in Annex VI.B the following requirement: “Where a fuel production process produces, in combination, the fuel for which emissions are being calculated and one or more other products (co-products), greenhouse gas emissions shall be divided between the fuel or its intermediate product and the co-products in proportion to their energy content (determined by lower heating value in the case of co-products other than electricity and heat)”.

### 3 Fossil fuel comparators

In order to define the fossil fuel comparators (FFC), different alternatives for the geographical scope, the end-use technology and the replaced technologies were considered. For biofuels one average FFC was chosen. For production of heat and/or electricity, which includes end-use technology, the following three alternatives were considered:

- One single comparator irrespective of end-use (weighted average)
- One comparator for each main technology cluster; heat plants, electricity plants and CHP
- One comparator for heat and electricity respectively

One single comparator irrespective of end-use was excluded since it does not pay attention to the different utilities of different forms of final energy, for example heat and electricity.

Also the alternative of one FFC for each main technology cluster i.e. one for heat plants, one for electricity plants and one for CHPs, was discarded. This alternative would imply that a fixed ratio between electricity and heat in CHPs was set. Thus, a CHP with low electricity efficiency would obtain the same FFC as a plant with higher electricity efficiency. Since electricity has higher GHG emissions, this alternative would not give the right incentives. As a result, in 2008 the alternative of one FFC for heat and electricity respectively, was chosen. In addition, in the document ‘State of play on the sustainability of solid and gaseous biomass used for electricity, heating and cooling in the EU’ (SWD(2014) 259 final) FFCs for cooling and for natural gas (to be used when producing biomethane<sup>6</sup>) were added.

In the recast of the RED (2018), the FFCs for electricity, for heat and for biofuels were updated. FFCs for cooling and for natural gas are not included in the RED-II. Two additional FFCs were added: one for electricity for the outermost regions and one for the production of useful heat in which a direct physical substitution of coal can be demonstrated. The RED-II values for the FFC’s are:

- Electricity: 183 g CO<sub>2,eq</sub>/MJ
- Electricity (for the outermost regions): 212 g CO<sub>2,eq</sub>/MJ
- Heat: 80 g CO<sub>2,eq</sub>/MJ
- Heat, in which a direct physical substitution of coal can be demonstrated: 124 g CO<sub>2,eq</sub>/MJ
- Biomass fuels used as transport fuels: 94 g CO<sub>2,eq</sub>/MJ

In the case of co-production, the emissions are allocated to the different energy commodities before the comparison with the FFC.

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<sup>6</sup>: Gas of biogenic origin upgraded to comply with the characteristics of fossil natural gas injected in the distribution grid.



## 4 GHG intensity of electricity used from the grid

This topic relates to the fossil fuel comparators (FFC). The European Commission decided, when updating the FFC's in the RED-II, to calculate the FFC for electricity to be the GHG intensity of electricity produced from the average fossil fuel mix throughout Europe. This means that electricity production from renewables was not taken into account in the calculation of the FFC for electricity of 183 g CO<sub>2,eq</sub>/MJ. The reason for doing so is the following. Suppose that in the future a large share of the electricity in Europe is produced from renewable sources, in particular from wind turbines and from photovoltaic solar panels. The challenge for ensuring security of supply in such a situation, is to provide sufficient electricity during periods in which the electricity production from wind and sun is low. In the coming decades, electricity production from fossil fuels and from biomass will be needed (together with increasing interconnection, energy storage and electricity from nuclear power plants) to provide security of supply. As a result, electricity from biomass is expected to increasingly replace fossil fuel electricity rather than electricity from the total yearly average “fuel” mix (including wind and sun).

Whereas the use of bioliquids and biomass fuels for electricity production is in the future likely to peak at moments of low production of renewable electricity (as described above), the production of bioliquids and solid and gaseous biomass fuels will have another time-profile. This production will either be independent of the share of renewable energy in the grid or – when high electricity prices during periods of the year cause the production to be lowered or stopped – will peak at moments of high shares of renewable energy in the grid. As a result, the BioGrace calculation rules allow to use the GHG intensity of the average national electricity mix for making actual calculations. The average does here refer to the average over fossil and renewable generation of electricity. See paragraph 4.3 of the BioGrace calculation rules for more details.

## 5 Credits in biogas pathways

### 5.1 Avoided methane emissions from improved manure management

Paragraph 1(c) in RED-II Annex VI.B stipulates that “for  $e_{sca}$  a bonus of 45 g CO<sub>2,eq</sub>/MJ manure shall be attributed for improved agricultural and manure management in the case animal manure is used as a substrate for the production of biogas and biomethane”. This “animal manure bonus” earlier was included in the “solid biomass GHG methodology” in SWD (2014) 259, but did not apply under the RED in case biomethane was used as a biofuel. Once the RED-II is implemented in national legislation, the animal manure bonus also applies to biomethane used as a biofuel.

When raw manure is stored or spread on the fields, greenhouse gases are released due to bacterial activity. It is mainly methane (CH<sub>4</sub>) that is released, but also nitrous oxide (N<sub>2</sub>O). These GHG emissions are avoided when manure is treated in an anaerobic digester. There are no incentives to cover manure storage tanks to avoid GHG emissions. Thus, it can be assumed that CH<sub>4</sub> and N<sub>2</sub>O are emitted in all reference scenarios of manure digestion. As a result, the European Commission has included this animal manure bonus of 45 g CO<sub>2,eq</sub>/MJ manure, which has been calculated as the sum of 37g of CO<sub>2,eq</sub>/MJ manure due to avoided CH<sub>4</sub> emissions plus 8 g CO<sub>2,eq</sub>/MJ manure due to avoided N<sub>2</sub>O emissions. A detailed explanation of these numbers (37 g CO<sub>2,eq</sub>/MJ and 8 g CO<sub>2,eq</sub>/MJ) is given by the JRC<sup>7</sup>.

### 5.2 Digestate as fertiliser replaces synthetic fertiliser

Similar to the credits for manure management also credits for the use of digestate as fertiliser were demanded by stakeholders. It is argued that applying digestate lowers the demand for synthetic N-fertiliser and its emissions. Such a credit has been included indirectly in the JRC calculations. In the maize biogas/biomethane pathways it is assumed that the digestate from the biogas plant is put back to the field. The input of mineral N-fertiliser to maize crop is thus lower compared to systems where no organic fertilisation is applied. The plant-available N content in the digestate is calculated taking into account N losses during digestion and the storage period.

Although this approach has been chosen by JRC to calculate the default emission factors, it has to be noted that in actual calculation no general credit can be attributed to biogas digestate. For actual calculations the actual amounts of digestate and other N-fertilisers used have to be taken into account at a concrete farm level. Usually this should lead to a similar indirect credit as the amount of N-fertiliser applied should consider the N-input via digestate application.

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<sup>7</sup>: JRC Report EUR 27215 EN (Version 2, 2017), page 59

## 6 Mass balance approach suspended for biogas from co-digestion of substrates

The RED-II applies the mass balanced approach. This approach means that physical mixing of products is allowed, but the products are kept administratively separated. However, in the RED-II it is also acknowledged that the mass balance approach may not apply for biogas plants that use a mixture of substrates.

The reason for suspending the mass balance approach for co-digestion plants is that the mass balance approach can create difficulties for the majority of co-digestion plants<sup>8</sup>. For this reason, the RED-II provides a formula generating a weighted average between several default values from single-feedstock biogas that operators may use to generate default values for any arbitrary mixture of the three substrates included in the JRC report<sup>9</sup>.

A weighing based on the mass of different substrates would be unfair, since different substrates produce different amounts of biogas, with different shares of methane. That is why the actual methane production is included in the weighing formula.

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<sup>8</sup>: Staff Working Document SWD(2014) 259

<sup>9</sup>: JRC Report EUR 27215 (version 2, 2017)

## 7 N<sub>2</sub>O emissions from soil – IPCC

For pathways with crop cultivation, field N<sub>2</sub>O emissions have to be included in the GHG calculation. These emissions occur during crop cultivation because of the microorganism activities in the soil. In the BioGrace-II Excel tool, two different methodologies are integrated:

- the Global Nitrous Oxide Calculator (GNOC) which has to be used for all crops that are covered by the calculator,
- for all other crops, the IPCC Tier 1 method has to be applied.

### 7.1 GNOC model

The IPCC Tier 1 method can be easily applied to calculate field N<sub>2</sub>O emissions. However, it does not take into account variations in environmental conditions. Therefore, JRC developed an approach that considers different soil conditions, climate aspects and management systems and their influences on N<sub>2</sub>O soil emissions. This approach can be applied to major crops in most regions of the world.

In that approach, the IPCC Tier 1 emission factor is replaced by Tier 2 emission factors. These factors are crop and site specific and take different environmental conditions into account. They have been developed by applying the statistical model developed by Stehfest & Bouwman, 2006<sup>10</sup>. The factors are applied for direct emissions from mineral fertiliser and manure application. For direct emissions from crop residues and organic soils as well as for all indirect emissions, the IPCC Tier 1 emission factors are still used. For details on the methodology refer to Edwards et al., 2019<sup>11</sup>.

This approach has been put into practice with an online calculation tool, the Global Nitrous Oxide Calculator, GNOC<sup>12</sup>. Detailed instructions are available in the GNOC user manual that can be downloaded from the GNOC website.

### 7.2 IPCC Tier 1 methodology

In its current state, the GNOC model only includes energy crops that are used for producing liquid bioenergy. Solid biomass feedstocks like eucalyptus and poplar as well as silage maize for biogas production are not included. For these crops the IPCC Tier 1 methodology is to be applied.

It covers the following emission sources:

- direct emissions from the application of mineral and organic fertiliser and from above and below ground residues,
- indirect emissions from these sources caused by volatilization and leaching / runoff.

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<sup>10</sup>: Stehfest, E., Bouwman, L., (2006). N<sub>2</sub>O and NO emission from agricultural fields and soils under natural vegetation: summarizing available measurement data and modeling of global annual emissions. *Nutrient Cycling in Agroecosystems* 74 (3), 207-228.

<sup>11</sup>: R. Edwards et al. (2019): Biofuels pathways. Input values and GHG emissions. Database (Directive 2018/2001). European Commission, Joint Research Centre (JRC) [Dataset] PID: <http://data.europa.eu/89h/e51f4304-7023-4fca-8900-7d206f89b914>

<sup>12</sup>: See <http://gnoc.jrc.ec.europa.eu/>

The emission factors are taken from the IPCC 2006 document (taking into account the 2019 update) and are implemented in a separate calculation sheet in the BioGrace-I and BioGrace-II Excel tools.

The IPCC document does not contain default values for crop residues from solid biomass (eucalyptus, poplar) and silage maize. In these cases the methodology was adapted as follows:

- Solid biomass (eucalyptus, poplar): Only direct and indirect emissions from mineral and organic fertiliser application are taken into account. Residues are not taken into account. This is insofar not a problem as in the cultivation of eucalyptus and poplar there are only small amounts of residues. In general, short rotation coppice is harvested every 3-5 years and regenerate from the stools. The latter are expected to survive five rotation periods. When a plantation is rejuvenated, the stools are removed from the field.
- Silage maize (whole crop): Most data are assumed to be the same as for maize cultivation (e.g. N contents in crop and residues). However, in contrast to maize, the whole crop is harvested and it is assumed that around 1 ton dry matter (above-ground) residues per hectare remain at the field. Below-ground crop residues are calculated according to IPCC guidelines. Furthermore, it is assumed that after digestion the digestate is returned to the field. Respective N contents and emissions thereof are calculated (see JRC 2017<sup>13</sup> for further details).

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<sup>13</sup>: JRC Report EUR 27215 (version 2, 2017)

## 8 Energy content / LHV

While making the GHG calculations, the energy content of wet biomass was calculated as follows. This is the same approach as applied by JRC (see the last page of JRC Report EUR 27215, Version 2, 2017):

- Results are presented on an energy basis considering the LHV of the dry fraction of the biomass fuel. This means that, compared to an LHV-calculation, the latent heat of vaporisation is neglected by using Formula 1 below when converting feedstock mass (e.g. kg rapeseed or kg poplar short rotation coppice) into its energy content, or when converting an amount of MJ's (e.g. wood chips, wood pellets, vegetable oil) into kg's for calculating the transport emissions. Formula 1 shows how the energy content can be calculated using the heating value of the dry part of the biomass. Formula 1 is used consistently for feedstocks (solid biomass), intermediary products, solid biomass energy carriers and also for biofuels, biogas and bioliquids;
- For allocation calculations the LHV of the whole product, not only the dry part, is used. For this calculation the available LHV values for the products and co-products can be used, or, in case the LHV on dry basis is available, Formula 2 below can be used.

The two formulas are:

$$\text{Energy content of wet biomass} = LHV_{dry} \cdot M_{wet\ biomass} \cdot (1 - [\text{mass \% of water}]/100) \quad (1)$$

$$LHV_{wet} = LHV_{dry} \cdot (1 - [\text{mass \% of water}]/100) - 2.441 \cdot [\text{mass \% of water}/100] \quad (2)$$

In which

- “Energy content of wet biomass” is the total amount of energy (MJ) of the dry fraction of the biomass (MJ)
- $M_{wet\ biomass}$  is the mass of the wet biomass (kg wet biomass)
- $LHV_{wet}$  is the lower heating value of the wet biomass (MJ per kg wet biomass)
- $LHV_{dry}$  is the lower heating value of the dry biomass (MJ per kg of dry biomass)
- [mass % of water] is the water content of the wet biomass, in percent of total mass of the wet biomass
- 2.441 is the latent heat of vaporisation of water at 25 °C expressed in MJ per kg water

The above mentioned approach is followed consistently for all BioGrace calculations: for solid and gaseous biomass to electricity, heat, cooling and biomethane, for bioliquids to electricity, heat and cooling and also for biofuels. In theory it would be appropriate to include the latent heat of combustion if the biomass is to be combusted, as including the latent heat of vaporisation will give an energy content that is actually available for generation of heat and electricity. However, some forms of biomass energy will not be combusted (e.g. wheat or sugar beet that will be fermented to produce ethanol, and e.g.



manure or biowaste to be digested to give biogas). Therefore, Formula 1 is always used because at forehand it is not always clear whether or not a certain biomass is to be combusted (e.g. wood and straw can be combusted but can also be pretreated and then fermented into ethanol (so called lignocellulosic ethanol) and residues or co-products like crude glycerine, fatty acids, used cooking oils and waste animal fats are both combusted as well as used for digestion or biodiesel production).

As a consequence, electrical and thermal efficiencies will also have to be calculated using the energy content of the biomass as determined by Formula 1. This is reflected in the BioGrace calculation rules on electrical and thermal efficiency.

## Annex – Methodology

This Annex includes the GHG accounting methodology presented in Annexes V.C and VI.B of the recast of the Renewable Energy Directive (further referred to as RED-II). The full name of this directive is “DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast)”.

The RED-II contains two methodological annexes:

1. A methodology for calculating the GHG impact of biofuels and bioliquids and their fossil fuel comparators (RED-II Annex V.C), with:
  - “biofuels” being defined as “liquid fuel for transport produced from biomass”; and
  - “bioliquids” being defined as “liquid fuel for energy purposes other than for transport, including electricity and heating and cooling, produced from biomass”; and
2. A methodology for calculating the GHG impact of biomass fuels and their fossil fuel comparators (RED-II Annex VI.B), with:
  - “biomass fuels” being defined as “gaseous and solid fuels produced from biomass”.

As these two methodological annexes are almost the same, the methodology as presented below is the combined methodology (so RED-II Annexes V.C and VI.B combined). Text marked *italics and grey* refers to parts in the methodology where Annex V.C and VI.B differ, in such cases a number of times the words “**For biofuels and bioliquids:**” or “**For biomass fuels:**” are added to provide clarity. RED Annex V.C is about “transport fuels, biofuels and bioliquids” whereas RED Annex VI.B is about “biomass fuels”. In the methodological annex below, these words are combined into “transport fuels, biofuels, bioliquids and biomass fuels”.

The methodology is an update of earlier GHG accounting methodologies as published (i) for biofuels and bioliquids in the RED from 2008, and (ii) for solid and gaseous biomass used in electricity, heating and cooling in the report of the European Commission *COM(2010)11* plus additions in the European Commission Staff Working Document *SWD(2014) 259*.

### Methodology for calculating the GHG impact of biofuels, bioliquids and biomass fuels and their fossil fuel comparators

1. Greenhouse gas emissions from the production and use of transport fuels, biofuels, bioliquids and biomass fuels shall be calculated as follows:
  - (a) greenhouse gas emissions from the production and use of biofuels and for the production and use of biomass fuels before conversion into electricity, heating and cooling, shall be calculated as:

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

where

$E$  = total emissions from the use of the biofuel or bioliquid or  
total emissions from the production of the biomass fuel before energy conversion;

$e_{ec}$  = emissions from the extraction or cultivation of raw materials;

$e_l$  = annualised 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 CO<sub>2</sub> capture and geological storage; and

$e_{ccr}$  = emission savings from CO<sub>2</sub> capture and replacement.

Emissions from the manufacture of machinery and equipment shall not be taken into account.

- (b) **For biomass fuels:** In the case of co-digestion of different substrates in a biogas plant for the production of biogas or biomethane, the typical and default values of greenhouse gas emissions shall be calculated as:

$$E = \sum_1^n S_n \cdot E_n$$

where

$E$  = greenhouse gas emissions per MJ biogas or biomethane produced from co-digestion of the defined mixture of substrates

$S_n$  = Share of feedstock n in energy content

$E_n$  = Emission in g CO<sub>2</sub>/MJ for pathway n as provided in Part D of RED-II Annex VI (\*)

$$S_n = \frac{P_n \cdot W_n}{\sum_1^n P_n \cdot W_n}$$

where

$P_n$  = energy yield [MJ] per kilogram of wet input of feedstock n (\*\*)

$W_n$  = weighting factor of substrate n defined as:

$$W_n = \frac{I_n}{\sum_1^n I_n} \cdot \left( \frac{1 - AM_n}{1 - SM_n} \right)$$

Where:

$I_n$  = Annual input to digester of substrate n [tonne of fresh matter]

$AM_n$  = Average annual moisture of substrate n [kg water / kg fresh matter]

$SM_n$  = Standard moisture for substrate n (\*\*\*).

- (\*) For animal manure used as substrate, a bonus of 45 g CO<sub>2</sub>eq/MJ manure (– 54 kg CO<sub>2</sub>eq/t fresh matter) is added for improved agricultural and manure management.

- (\*\*) The following values of  $P_n$  shall be used for calculating typical and default values:

P(Maize): 4.16 [MJ<sub>biogas</sub>/kg wet maize @ 65 % moisture]

P(Manure): 0.50 [MJ<sub>biogas</sub>/kg wet manure @ 90 % moisture]

P(Biowaste) 3.41 [MJ<sub>biogas</sub>/kg wet biowaste @ 76 % moisture]

(\*\*\*) The following values of the standard moisture for substrate SM<sub>n</sub> shall be used:

SM(Maize): 0.65 [kg water/kg fresh matter]

SM(Manure): 0.90 [kg water/kg fresh matter]

SM(Biowaste): 0.76 [kg water/kg fresh matter]

- (c) **For biomass fuels:** In the case of co-digestion of n substrates in a biogas plant for the production of electricity or biomethane, actual greenhouse gas emissions of biogas and biomethane are calculated as follows:

$$E = \sum_1^n S_n \cdot (e_{ec,n} + e_{td,feedstock,n} + e_{l,n} - e_{sca,n}) + e_p + e_{td,product} + e_u - e_{ccs} - e_{ccr},$$

where

$E$  = total emissions from the production of the biogas or biomethane before energy conversion;

$S_n$  = Share of feedstock n, in fraction of input to the digester

$e_{ec,n}$  = emissions from the extraction or cultivation of feedstock n;

$e_{td,feedstock,n}$  = emissions from transport of feedstock n to the digester;

$e_{l,n}$  = annualised emissions from carbon stock changes caused by land use change, for feedstock n;

$e_{sca}$  = emission savings from improved agricultural management of feedstock n (\*);

$e_p$  = emissions from processing;

$e_{td,product}$  = emissions from transport and distribution of biogas and/or biomethane;

$e_u$  = emissions from the fuel in use, that is greenhouse gases emitted during combustion;

$e_{ccs}$  = emission savings from CO<sub>2</sub> capture and geological storage; and

$e_{ccr}$  = emission savings from CO<sub>2</sub> capture and replacement.

(\*) For  $e_{sca}$  a bonus of 45 g CO<sub>2</sub>eq/MJ manure shall be attributed for improved agricultural and manure management in the case animal manure is used as a substrate for the production of biogas and biomethane.

- (d) <sup>14</sup> **For biofuels and bioliquids:** Greenhouse gas emissions from the production and use of bioliquids shall be calculated as for biofuels (E), but with the extension necessary for including the energy conversion to electricity and/or heat and cooling produced, as follows:

**For biomass fuels:** Greenhouse gas emissions from the use of biomass fuels in producing electricity, heating and cooling, including the energy conversion to electricity and/or heat or cooling produced, shall be calculated as follows:

<sup>14</sup>: Note: In RED-II Annex V.C, this is paragraph 1(b) as in Annex V.C the paragraphs on co-digestion (which are paragraphs 1(b) and 1(c) in RED-II Annex VI.B) are not included in RED Annex V.C.

- (i) For energy installations delivering only heat:

$$EC_h = \frac{E}{\eta_h}$$

- (ii) For energy installations delivering only electricity:

$$EC_{el} = \frac{E}{\eta_{el}}$$

Where:

$EC_{h,el}$  = Total greenhouse gas emissions from the final energy commodity.

$E$  = Total greenhouse gas emissions of the **bioliquid or fuel** before end-conversion.

$\eta_{el}$  = The electrical efficiency, defined as the annual electricity produced divided by the annual **bioliquid/fuel** input.

$\eta_h$  = The heat efficiency, defined as the annual useful heat output divided by the annual **bioliquid/fuel** input.

- (iii) For the electricity or mechanical energy coming from energy installations delivering useful heat together with electricity and/or mechanical energy:

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

For the useful heat coming from energy installations delivering heat together with electricity and/or mechanical energy:

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

Where:

$EC_{h,el}$  = Total greenhouse gas emissions from the final energy commodity.

$E$  = Total greenhouse gas emissions of the fuel before end-conversion.

$\eta_{el}$  = The electrical efficiency, defined as the annual electricity produced divided by the annual **fuel/energy** input, based on its energy content

$\eta_h$  = The heat efficiency, defined as the annual useful heat output divided by the annual **fuel/energy** input, based on its energy content.

$C_{el}$  = Fraction of exergy in the electricity, and/or mechanical energy, set to 100 % ( $C_{el} = 1$ ).

$C_h$  = Carnot efficiency (fraction of exergy in the useful heat).

The Carnot efficiency,  $C_h$ , for useful heat at different temperatures is defined as:

$$C_h = \frac{T_h - T_0}{T_h}$$

where

$T_h$  = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery.

$T_0$  = Temperature of surroundings, set at 273.15 kelvin (equal to 0 °C).

If the excess heat is exported for heating of buildings, at a temperature below 150 °C (423.15 kelvin),  $C_h$  can alternatively be defined as follows:

$C_h$  = Carnot efficiency in heat at 150 °C (423.15 kelvin), which is: 0.3546

For the purposes of this calculation, the following definitions shall apply:

- (a) ‘cogeneration’ shall mean the simultaneous generation in one process of thermal energy and electricity and/or mechanical energy;
- (b) ‘useful heat’ shall mean heat generated to satisfy an economical justifiable demand for heat, for heating and/or cooling purposes;
- (c) ‘economically justifiable demand’ shall mean the demand that does not exceed the needs for heat or cooling and which would otherwise be satisfied at market conditions.

2. Greenhouse gas emissions from biofuels, bioliquids and biomass fuels shall be expressed as follows:

- (a) greenhouse gas emissions from biofuels and biomass fuels,  $E$ , shall be expressed in terms of grams of CO<sub>2</sub> equivalent per MJ of fuel or biomass fuel, g CO<sub>2</sub>eq/MJ;
- (b) greenhouse gas emissions from bioliquids or from heating or electricity, produced from biomass fuels,  $E_C$ , shall be expressed in terms of grams of CO<sub>2</sub> equivalent per MJ of final energy commodity (heat or electricity), g CO<sub>2</sub>eq/MJ.

When heating and cooling are co-generated with electricity, emissions shall be allocated between heat and electricity (as under point 1(d)), irrespective if the heat is used for actual heating purposes or for cooling<sup>15</sup>.

Where the greenhouse gas emissions from the extraction or cultivation of raw materials  $e_{ec}$  are expressed in unit g CO<sub>2</sub>eq/dry-ton of feedstock, the conversion to grams of CO<sub>2</sub> equivalent per MJ of fuel, g CO<sub>2</sub>eq/MJ, shall be calculated as follows<sup>16</sup>:

<sup>15</sup>: Heat or waste heat is used to generate cooling (chilled air or water) through absorption chillers. Therefore, it is appropriate to calculate only the emissions associated to the heat produced, per MJ of heat, irrespective if the end-use of the heat is actual heating or cooling via absorption chillers.

<sup>16</sup>: The formula for calculating greenhouse gas emissions from the extraction or cultivation of raw materials  $e_{ec}$  describes cases where feedstock is converted into biofuels in one step. For more complex supply chains, adjustments are needed for calculating greenhouse gas emissions from the extraction or cultivation of raw materials  $e_{ec}$  for intermediate products.



$$e_{ec fuel_a} \left[ \frac{gCO_2eq}{MJ fuel} \right]_{ec} = \frac{e_{ec feedstock_a} \left( \frac{gCO_2eq}{t_{dry}} \right)}{LHV_a \left[ \frac{MJ feedstock}{t dry feedstock} \right]} \cdot Fuel feedstock factor_a \cdot Allocation factor fuel_a$$

where

$$Allocation factor fuel_a = \left[ \frac{Energy in fuel}{Energy fuel + Energy in co - products} \right]$$

Fuel feedstock factor<sub>a</sub> = [ Ratio of MJ feedstock required to make 1 MJ fuel ]

Emissions per dry-ton feedstock shall be calculated as follows:

$$e_{ec feedstock_a} \left[ \frac{gCO_2eq}{t_{dry}} \right] = \frac{e_{ec feedstock_a} \left[ \frac{gCO_2eq}{t_{moist}} \right]}{(1 - moisture content)}$$

3. Greenhouse gas emissions savings from **biofuels, bioliquids and biomass fuels** shall be calculated as follows:

- (a) greenhouse gas emissions savings from **biofuels and biomass fuels used as transport fuels**:

$$SAVING = (E_{F(t)} - E_B) / E_{F(t)}$$

where

E<sub>B</sub> = total emissions from **biofuel or biomass fuels used as transport fuels**; and

E<sub>F(t)</sub> = total emissions from the fossil fuel comparator for transport

- (b) greenhouse gas emissions savings from heat and cooling, and electricity being generated from **bioliquids and biomass fuels**:

$$SAVING = (E_{CF(h\&c,el)} - E_{CB(h\&c,el)}) / E_{CF(h\&c,el)},$$

where

EC<sub>B(h&c,el)</sub> = total emissions from the heat or electricity,

EC<sub>F(h&c,el)</sub> = total emissions from the fossil fuel comparator for useful heat or electricity.

4. The greenhouse gases taken into account for the purposes of point 1 shall be CO<sub>2</sub>, N<sub>2</sub>O and CH<sub>4</sub>. For the purpose of calculating CO<sub>2</sub> equivalence, those gases shall be valued as follows:

CO<sub>2</sub>: 1

N<sub>2</sub>O: 298

CH<sub>4</sub>: 25

5. Emissions from the extraction, **harvesting** or cultivation of raw materials, *e<sub>ec</sub>*, shall include emissions from the extraction, **harvesting** or cultivation process itself; from the collection, drying and storage of raw materials; from waste and leakages; and from the production of chemicals or products used in

extraction or cultivation. Capture of CO<sub>2</sub> in the cultivation of raw materials shall be excluded. Estimates of emissions from agriculture biomass cultivation may be derived from the use of regional averages for cultivation emissions included in the reports referred to in Article 31(4) of RED-II or the information on the disaggregated default values for cultivation emissions included in Annexes V and VI of RED-II, as an alternative to using actual values. In the absence of relevant information in those reports it is allowed to calculate averages based on local farming practises based for instance on data of a group of farms, as an alternative to using actual values.

Estimates of emissions from cultivation and harvesting of forestry biomass may be derived from the use of averages for cultivation and harvesting emissions calculated for geographical areas at national level, as an alternative to using actual values.

6. For the purposes of the calculation referred to in point 1(a), greenhouse gas emission savings from improved agriculture management, esca, such as shifting to reduced or zero-tillage, improved crop/rotation, the use of cover crops, including crop residue management, and the use of organic soil improver (e.g. compost, manure fermentation digestate), shall be taken into account only if solid and verifiable evidence is provided that the soil carbon has increased or that it is reasonable to expect to have increased over the period in which the raw materials concerned were cultivated while taking into account the emissions where such practices lead to increased fertiliser and herbicide use<sup>17</sup>.
7. Annualised emissions from carbon stock changes caused by land-use change,  $e_l$ , shall be calculated by dividing total emissions equally over 20 years. For the calculation of those emissions the following rule shall be applied:

$$e_l = (CS_R - CS_A) \times 3.664 \times 1/20 \times 1/P - e_B,^{18}$$

where

$e_l$  = annualised greenhouse gas emissions from carbon stock change due to land-use change (measured as mass (grams) of CO<sub>2</sub>-equivalent per unit biofuel, bioliquid or biomass fuel energy (megajoules)). ‘Cropland’<sup>19</sup> and ‘perennial cropland’<sup>20</sup> shall be regarded as one land use;

$CS_R$  = the carbon stock per unit area associated with the reference land use (measured as mass (tonnes) of carbon per unit area, including both soil and vegetation). The reference land use shall be the land use in January 2008 or 20 years before the raw material was obtained, whichever was the later;

$CS_A$  = the carbon stock per unit area associated with the actual land use (measured as mass (tonnes) of carbon per unit area, including both soil and vegetation). In cases where the carbon stock

<sup>17</sup>: Measurements of soil carbon can constitute such evidence, e.g. by a first measurement in advance of the cultivation and subsequent ones at regular intervals several years apart. In such a case, before the second measurement is available, increase in soil carbon would be estimated on the basis of representative experiments or soil models. From the second measurement onwards, the measurements would constitute the basis for determining the existence of an increase in soil carbon and its magnitude.

<sup>18</sup>: The quotient obtained by dividing the molecular weight of CO<sub>2</sub> (44.010 g/mol) by the molecular weight of carbon (12.011 g/mol) is equal to 3.664.

<sup>19</sup>: Cropland as defined by IPCC.

<sup>20</sup>: Perennial crops are defined as multi-annual crops, the stem of which is usually not annually harvested such as short rotation coppice and oil palm.

accumulates over more than one year, the value attributed to  $CS_A$  shall be the estimated stock per unit area after 20 years or when the crop reaches maturity, whichever the earlier;

- $P$  = the productivity of the crop (measured as biomass fuel energy per unit area per year); and  
 $e_B$  = bonus of 29 g CO<sub>2</sub>eq/MJ biomass fuel if biomass is obtained from restored degraded land under the conditions laid down in point 8.

8. The bonus of 29 g CO<sub>2</sub>eq/MJ shall be attributed if evidence is provided that the land::

- (a) was not in use for agriculture or any other activity in January 2008; and
- (b) is severely degraded land, including such land that was formerly in agricultural use.

The bonus of 29 g CO<sub>2</sub>eq/MJ shall apply for a period of up to 20 years from the date of conversion of the land to agricultural use, provided that a steady increase in carbon stocks as well as a sizable reduction in erosion phenomena for land falling under (b) are ensured.

9. ‘Severely degraded land’ means land that, for a significant period of time, has either been significantly salinated or presented significantly low organic matter content and has been severely eroded.

10. **For biofuels and bioliquids:** The Commission shall review, by 31 December 2020, guidelines for the calculation of land carbon stocks<sup>21</sup> drawing on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – volume 4 and in accordance with Regulation (EU) No 525/2013 and Regulation (EU) 2018/841 of the European Parliament and of the Council<sup>22</sup>. The Commission guidelines shall serve as the basis for the calculation of land carbon stocks for the purposes of this Directive.

**For biomass fuels:** In accordance with point 10 of Part C of Annex V to this Directive, Commission Decision 2010/335/EU<sup>21</sup>, which provides for guidelines for the calculation of land carbon stocks in relation to this Directive, drawing on the 2006 IPCC Guidelines for National Greenhouse Gas Inventories – volume 4, and in accordance with Regulations (EU) No 525/2013 and (EU) 2018/841, shall serve as the basis for the calculation of land carbon stocks.

11. Emissions from processing,  $e_p$ , shall include emissions from the processing itself; from waste and leakages; and from the production of chemicals or products used in processing, including the CO<sub>2</sub> emissions corresponding to the carbon contents of fossil inputs, whether or not actually combusted in the process.

In accounting for the consumption of electricity not produced within the **biofuel, bioliquid or solid or gaseous biomass fuel** production plant, the greenhouse gas emissions intensity of the production and distribution of that electricity shall be assumed to be equal to the average emission intensity of the

<sup>21</sup>: Commission Decision 2010/335/EU of 10 June 2010 on guidelines for the calculation of land carbon stocks for the purpose of Annex V to Directive 2009/28/EC (OJ L 151, 17.6.2010, p. 19).

<sup>22</sup>: Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (OJ L 156, 19.6.2018, p. 1).

production and distribution of electricity in a defined region. By way of derogation from this rule, producers may use an average value for an individual electricity production plant for electricity produced by that plant, if that plant is not connected to the electricity grid.

Emissions from processing shall include emissions from drying of interim products and materials where relevant.

12. Emissions from transport and distribution,  $e_{td}$ , shall include emissions from the transport of raw and semi-finished materials and from the storage and distribution of finished materials. Emissions from transport and distribution to be taken into account under point 5 shall not be covered by this point.
13. Emissions of CO<sub>2</sub> from fuel in use,  $e_u$ , shall be taken to be zero for **biofuels, bioliquids and biomass fuels**.  
**For bioliquids and biomass fuels:** Emissions of non-CO<sub>2</sub> greenhouse gases (CH<sub>4</sub> and N<sub>2</sub>O) from the fuel in use shall be included in the  $e_u$  factor.
14. Emission savings from CO<sub>2</sub> capture and geological storage,  $e_{ccs}$ , that have not already been accounted for in ep, shall be limited to emissions avoided through the capture and storage of emitted CO<sub>2</sub> directly related to the extraction, transport, processing and distribution of fuel if stored in compliance with Directive 2009/31/EC of the European Parliament and of the Council<sup>23</sup>.
15. Emission savings from CO<sub>2</sub> capture and replacement,  $e_{ccr}$ , shall be related directly to the production of **biofuel, bioliquid or biomass fuel** they are attributed to, and shall be limited to emissions avoided through the capture of CO<sub>2</sub> of which the carbon originates from biomass and which is used to replace fossil-derived CO<sub>2</sub> in production of commercial products and services.
16. Where a cogeneration unit – providing heat and/or electricity to a biomass fuel production process for which emissions are being calculated – produces excess electricity and/or excess useful heat, the greenhouse gas emissions shall be divided between the electricity and the useful heat according to the temperature of the heat (which reflects the usefulness (utility) of the heat). The useful part of the heat is found by multiplying its energy content with the Carnot efficiency,  $C_h$ , calculated as follows:

$$C_h = \frac{T_h - T_0}{T_h}$$

where

$T_h$  = Temperature, measured in absolute temperature (kelvin) of the useful heat at point of delivery.

$T_0$  = Temperature of surroundings, set at 273.15 kelvin (equal to 0 °C).

<sup>23</sup>: Directive 2009/31/EC of the European Parliament and of the Council of 23 April 2009 on the geological storage of carbon dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 (OJ L 140, 5.6.2009, p. 114).

If the excess heat is exported for heating of buildings, at a temperature below 150 °C (423.15 kelvin),  $C_h$  can alternatively be defined as follows:

$C_h$  = Carnot efficiency in heat at 150 °C (423.15 kelvin), which is: 0.3546

For the purposes of that calculation, the actual efficiencies shall be used, defined as the annual mechanical energy, electricity and heat produced respectively divided by the annual energy input.

For the purposes of that calculation, the following definitions apply:

- (a) ‘cogeneration’ shall mean the simultaneous generation in one process of thermal energy and electrical and/or mechanical energy;
- (b) ‘useful heat’ shall mean heat generated to satisfy an economical justifiable demand for heat, for heating or cooling purposes;
- (c) ‘economically justifiable demand’ shall mean the demand that does not exceed the needs for heat or cooling and which would otherwise be satisfied at market conditions.

17. Where a biofuel, bioliquid or biomass fuel production process produces, in combination, the fuel for which emissions are being calculated and one or more other products (‘co-products’), greenhouse gas emissions shall be divided between the fuel or its intermediate product and the co-products in proportion to their energy content (determined by lower heating value in the case of co-products other than electricity and heat). The greenhouse gas intensity of excess useful heat or excess electricity is the same as the greenhouse gas intensity of heat or electricity delivered to the biofuel, bioliquid or biomass fuel production process and is determined from calculating the greenhouse gas intensity of all inputs and emissions, including the feedstock and CH<sub>4</sub> and N<sub>2</sub>O emissions, to and from the cogeneration unit, boiler or other apparatus delivering heat or electricity to the biofuel, bioliquid or biomass fuel production process. In the case of cogeneration of electricity and heat, the calculation is performed following point 16.

18. For the purposes of the calculations referred to in point 17, the emissions to be divided shall be  $e_{ec} + e_l + e_{sca}$  + those fractions of  $e_p$ ,  $e_{ld}$ ,  $e_{ccs}$  and  $e_{ccr}$  that take place up to and including the process step at which a co-product is produced. If any allocation to co-products has taken place at an earlier process step in the life-cycle, the fraction of those emissions assigned in the last such process step to the intermediate fuel product shall be used for this purposes instead of the total of those emissions.

In the case of **biofuels, bioliquids, biogas and biomethane**, all co-products shall be taken into account for the purposes of that calculation. No emissions shall be allocated to wastes and residues. Co-products that have a negative energy content shall be considered to have an energy content of zero for the purposes of the calculation.

Wastes and residues, including tree tops and branches, straw, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined) and bagasse, shall be considered to have zero life-cycle greenhouse gas emissions up to the process of collection of those materials irrespectively of whether they are processed to interim products before being transformed into the final product.

In the case of biomass fuels produced in refineries, other than the combination of processing plants with boilers or cogeneration units providing heat and/or electricity to the processing plant, the unit of analysis for the purposes of the calculation referred to in point 17 shall be the refinery.



19. For biomass fuels used for the production of electricity, for the purposes of the calculation referred to in point 3, the fossil fuel comparator  $EC_{F(e)}$  shall be 183 g CO<sub>2</sub>eq/MJ electricity or 212 g CO<sub>2</sub>eq/MJ electricity for the outermost regions.

For bioliquids used for the production of electricity, for the purposes of the calculation referred to in point 3, the fossil fuel comparator  $EC_{F(e)}$  shall be 183 g CO<sub>2</sub>eq/MJ.

For bioliquids and biomass fuels used for the production of useful heat, as well as for the production of heating and/or cooling, for the purposes of the calculation referred to in point 3, the fossil fuel comparator  $EC_{F(h\&c)}$  shall be 80 g CO<sub>2</sub>eq/MJ heat.

For biomass fuels used for the production of useful heat, in which a direct physical substitution of coal can be demonstrated, for the purposes of the calculation referred to in point 3, the fossil fuel comparator  $EC_{F(h)}$  shall be 124 g CO<sub>2</sub>eq/MJ heat.

For biofuels and for biomass fuels used as transport fuels, for the purposes of the calculation referred to in point 3, the fossil fuel comparator  $E_{F(t)}$  shall be 94 g CO<sub>2</sub>eq/MJ.



## ***About the BioGrace GHG calculation tools***

### ***BioGrace-I***

*The BioGrace-I GHG calculation tool is managed by IFEU  
(Institut für Energie- und Umweltforschung).*

*The current version is version 4d from 2015.*

### ***BioGrace-II***

*The BioGrace-II GHG calculation tool is managed by  
The Netherlands Enterprise Agency (RVO).*

*The current version is “Version 4a” from February 2021.*

### ***History***

*The two BioGrace GHG calculation tools were originally  
developed in two European projects funded under the  
Intelligent Energy for Europe (IEE) programme.*

*The BioGrace-I project lasted from 2010 to 2012 and  
the BioGrace-II project lasted from 2012 to 2015.*

### ***More information:***

[www.biograce.net](http://www.biograce.net)

[info@biograce.net](mailto:info@biograce.net)