USER GUIDE

Biomass Carbon Calculator

Version 1.0

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Introduction

The 'Biomass Carbon Calculator' is a greenhouse gas (GHG) lifecycle emission tool developed by Drax for the purposes of accurately calculating wood pellet supply chain GHG emissions in accordance with the UK Renewables Obligation (RO) and 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 ("Directive (EU) 2018/2001")[1]. The Calculator has been independently verified against the methodology laid out in Annex VI of Directive (EU) 2018/2001 and independently reviewed against the RO regulatory guidance[2] (full verification against the methodology laid out in the RO will be completed following stakeholder consultation).

The Biomass Carbon Calculator has been developed by Drax to encourage improved reporting of lifecycle biomass emissions across industry by requiring users to use actual data from across the supply chain, thus reducing reliance on use of default values or typical data. The Calculator further provides a convenient platform for modelling complex supply chains, enabling the GHG emissions of up to 20 different biomass consignments and 10 different downstream distribution routes to be modelled simultaneously for a single biomass producer. The Calculator has several other notable benefits:

- All equations can be viewed by the user, providing absolute transparency
- Data input fields have a corresponding verification field, providing a platform suited for third-party auditing
- The Calculator structure is aligned to the Sustainable Biomass Program (SBP) audit report on energy and carbon data (SAR) for wood pellets version 2.0, providing a simple means of transferring supply chain information where the user is, or is utilising data from, an SBP-certified party

The Calculator is appropriate for modelling supply chain GHG emissions for most wood pellet supply chains, including wood pellet from forestry products, forestry residues, industrial processing residues and wood waste. For wood pellet supply chains derived from products, where land inputs such as fertilisers and pesticides are required (e.g. wood pellet from energy crops) or where land use change has

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[1] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC
[2] Ofgem. 2018. Renewables Obligation: Sustainability Criteria.

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occurred, the calculator must be used alongside other tools (e.g. Biograce II[3]; The UK Solid and Gaseous Biomass Carbon Calculator[4]) for determining full supply chain emissions.

The Calculator covers GHG emissions (CO_2, CH_4 & N_2O emissions) arising from all aspects of typical wood pellet supply chains including feedstock cultivation & harvesting, feedstock transport, feedstock processing, biomass transport & distribution and final use of the biomass.

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[3] https://www.biograce.net/biograce2/
[4] https://www.ofgem.gov.uk/publications-and-updates/uk-solid-and-gaseous-biomass-carbon-calculator

Calculator methodology

Calculation structure and alignment to the Renewables Obligation methodology

Definition of supply chain

The calculator is structured to represent the supply chain activities of typical wood pellet supply chains, comprising the activities represented below:
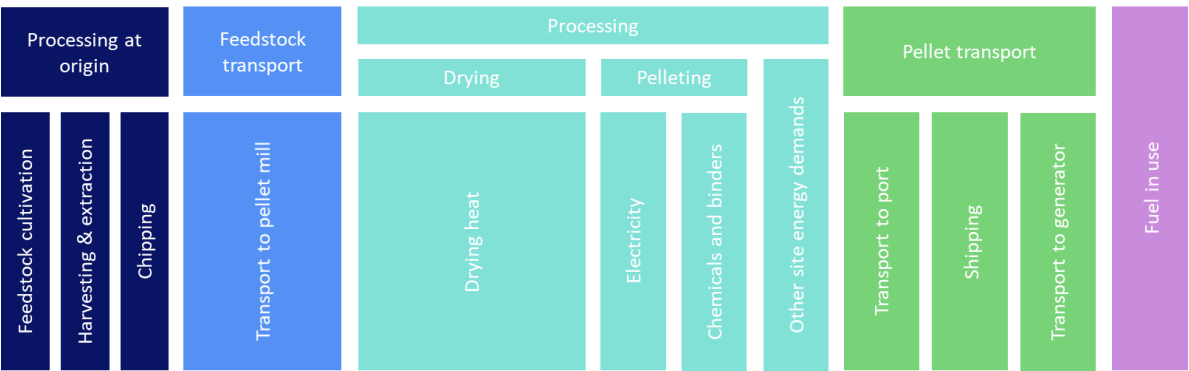
All upstream processing of feedstock is considered within a single module to reduce complexity of the calculator. This necessitates that energy requirements for cultivation, harvesting, extraction and other upstream emissions are stated per MJ of feedstock as delivered to the processing plant[5].

While drying and pelleting (and all other pellet plant energy demands) are considered under the 'processing' module, feedstock consignments often require different amounts of energy for drying, depending on the initial moisture content of the feedstock. The calculator therefore separates the

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[5] All typical values for diesel use in cultivation, harvesting, extraction and chipping used by the JRC in its policy report 'Solid and gaseous bioenergy pathways: input values and GHG emissions' Version 2 provide diesel emissions in this way, assuming wood chip to be the output product from the forest. These values are provided in the calculator and can be used by users in the absence of actual data.

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calculations for drying emissions from pelleting and other site processes, as outlined in the "Allocation of drying heat emissions" Section.

It is also possible that consignments may require different amounts of other site energy such as electricity or diesel due to differing processing requirements at the pellet plant (e.g. chipping/debarking). However, rarely is this information metered/recorded at a sufficiently disaggregated level to allow allocation of these inputs to individual consignments. Equally, the energy demands for these processes are usually small when compared to those for drying (where allocation is performed) and pelleting (which is necessary for all consignments). Emissions relating to all pellet plant processes other than drying are therefore applied proportionally across the entire pellet output of the plant.

Identify the output of each module

The outputs of each module are defined as follows:

MODULE	OUTPUT
PROCESSING AT ORIGIN	Raw biomass feedstock (e.g. logs, wood chips, sawdust); gate of origin
FEEDSTOCK TRANSPORT	Raw biomass feedstock (e.g. logs, wood chips, sawdust); delivered to pellet mill
PROCESSING	Wood pellet; pellet plant gate
PELLET TRANSPORT	Wood pellet; delivered to generator
FUEL IN USE	Electricity and/or heat

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Identify the inputs of each module

The inputs that could influence the final carbon intensity of the biomass by 1% or more are defined as follows:

MODULE		INPUT
PROCESSING AT ORIGIN		Diesel used in cultivation, harvesting, extraction and chipping
FEEDSTOCK TRANSPORT		Fuel used in feedstock transport
PROCESSING	Drying	Heat from fossil fuel boiler/burner Heat from fossil fuel CHP Heat from biomass fuel boiler/burner Heat from biomass CHP
	Pelleting	Grid electricity Onsite electricity (CHP/wind/solar etc.) Fossil fuel for other site energy demands Chemicals and binders
PELLET TRANSPORT		Fuel used in pellet transport to port; Fuel used in shipping; Fuel used in pellet transport to generator Electricity used for pellet handling; Fuel used for pellet handling;
FUEL IN USE		Combustion non-CO_2 emissions

Emissions relating to fertilisers, pesticides and land use change are also likely to contribute more than 1% of biomass lifecycle emissions where they are applicable. However, as these inputs are largely irrelevant for most wood pellet supply chains, they be calculated separately in instances where they apply and included in the "Other upstream emissions" field (See Upstream Section for further details).

Identify appropriate emission factors

Emission factors for the model are taken from credible resources approved by the EU. In the first instance, emission factors are taken from 'Solid and gaseous bioenergy pathways: input values and GHG

emissions' Version 2[6]. Additional factors not available in the report are taken from [Biograce II, Biograce additional standard values](link)[7] and the [UK Solid and Gaseous Biomass Carbon calculator V2.0 (Build 36)](link)[8].

Emission factors for biomass fuels diverted from feedstock input groups are derived from the total upstream emissions (in $gCO_{2eq}/t_{dry\ matter}$) for the relative feedstock consignment.

Multiply inputs by emissions factors

All inputs to the pellet process are required on an absolute basis for the reporting year, to allow for simple verification against operator system records (e.g. metering data, weighbridge tickets).Emissions are calculated on an absolute basis (i.e. total $kgCO_{2eq}$ for the reporting period) by multiplying the input by the total pellet output and its emission factor, as follows:

$$Input\ emissions\ (kgCO2eq) = \frac{Input\ (unit) \times Emission\ factor\ \left(\frac{gCO2eq}{unit}\right)}{1,000}$$

Where supply chain activities also result in production of CH_4 or N_2O combustion emissions (e.g. transport or fuel systems), emissions are calculated in accordance with the equation below:

$$Input\ emissions\ (kgCO2eq)$$
$$= \frac{Input\ (unit) \times Emission\ factor\ \left(\frac{gCO2eq}{unit}\right) + Input\ (unit) \times CH4\ \&\ N2O\ combustion\ emissions\ \left(\frac{gCO2eq}{unit}\right)}{1,000}$$

Accounting for co-products in conversion modules

Wood pellet supply chains rarely produce co-products after the initial harvest. Therefore, the calculator does not support co-product allocation.

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[6] [JRC. 2017. Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2](link)
[7] [https://www.biograce.net/app/webroot/files/file/BioGrace_additional_standard_values_-_version_1_-_Public.pdf](link)
[8] [https://www.ofgem.gov.uk/publications-and-updates/uk-solid-and-gaseous-biomass-carbon-calculator](link)

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Identify the efficiency of modules

To provide alignment with EU Commission recommendations[9] and the Directive (EU) 2018/2001[10], 'Feedstock factors' are used for determining supply chain efficiencies instead of 'module efficiencies'. Feedstock factors are the inverse of efficiencies and equal to:

$$Feedstock\ factor = \frac{MJ\ input}{MJ\ output}$$

Total energy contents for each consignment's inputs and outputs are calculated on a dry mass basis, in line with the Commission recommendations. To allocate the output pellet energy to each input consignment, the following set of equations are used[11]:

$$Consignment\ delivered\ (MJ) = Consignment\ delivered\ (kg\ dry\ matter) \times Consignment\ LHV\ (\frac{MJ}{kg}\ dry\ matter)$$

$$Consignment\ for\ hog\ fuel\ (MJ)$$
$$= Consignment\ for\ hog\ fuel\ (kg\ dry\ matter)\ \times Consignment\ LHV\ (\frac{MJ}{kg}\ dry\ matter)$$

$$Consignment\ input\ (MJ) = Consignment\ delivered\ (MJ) - Consignment\ for\ hog\ fuel\ (MJ)$$

$$Consignment\ output\ (MJ) = \frac{Consignment\ input\ (MJ)}{\sum Consignment\ input\ (MJ)^{12}} \times Total\ pellet\ output\ (MJ)$$

For calculating the 'Consignment input (MJ)' and ''Consignment output (MJ)' terms, the calculator assumes the dry matter LHV of all feedstock to be equal to the final dry matter of the LHV pellet output.

The processing ('Fuel') feedstock factor is calculated using the following equation:

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[9] European Commission. 2015. Note on the conducting and verifying actual calculations of GHG emissions savings.

[10] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG&toc=OJ:L:2018:328:TOC

[11] The latter three equations are also conducted on a mass basis in the calculator to be used in other calculations (e.g. determining drying heat emissions allocations)

[12] The total MJ input for all consignments

$$Fuel\ feedstock\ factor = \frac{\sum Consignment\ input\ (MJ)}{\sum Consignment\ output\ (MJ)}$$

In the event of incorrect data entry, such that the MJ of consignment output exceeds the MJ of consignment input, a warning message will show in the header on the dashboard.

For processing and pellet transport modules, feedstock factors are assumed as 1 in line with assumptions from JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report and Biograce II. However, users have the option to overwrite these feedstock factors on the 'Typical values' page in the event losses occur during transport.

Calculating the carbon intensity of each module

Total carbon emissions for each input are then calculated per tonne of dry biomass output using the following equation:

$$Input\ emissions\left(\frac{kgCO2eq}{tonne\ output\ (dry\ matter)}\right) = \frac{Input\ emissions\ (kgCO2eq)}{tonnes\ output\ (dry\ matter)}$$

Module emissions are calculated using the following equation:

$$Module\ emissions\left(\frac{kgCO2eq}{tonne\ output\ (dry\ matter)}\right) = \sum Input\ emissions\left(\frac{kgCO2eq}{tonne\ output\ (dry\ matter)}\right)$$

The contribution of the module[13] to overall emissions is then calculated using the following equation:

$$Module\ emissions\left(\frac{gCO2eq}{MJ\ output\ (dry\ matter)}\right)$$
$$= \frac{Module\ emissions\left(\frac{gCO2eq}{kg\ output\ (dry\ matter)}\right)^{14}}{Output\ LHV\left(\frac{MJ}{kg\ (dry\ matter)}\right)} \times \prod downstream\ feedstock\ factors$$

This equation is equivalent to that provided in Table 6; Section 5 of the Renewables Obligation Sustainability Criteria guidance, with irrelevant terms excluded:

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[13] Calculations for processing emissions are separated into drying emissions and processing other site processing emissions due to the heat allocation approach taken for estimating heat emissions on a consignment basis

[14] This term is stated in the calculator as $kgCO_{2eq}/t_{dry\ matter}$, which is equivalent to $gCO_{2eq}/kg_{dry\ matter}$

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- Wood fuel supply chains do not typically produce co-products, the 'Allocation factor fuel' is absent from the equation when compared to the equation published by the Commission i.e. in all instances the allocation factor is equal to 1 and so can be ignored from the calculation.
- The calculator does not provide a function to calculate 'emission savings for modules' as this is unlikely to be relevant for most wood pellet supply chains.

Calculating the carbon intensity of the supply chain and converting into relevant units

The carbon intensity of the entire supply chain is calculated on the 'Dashboard' by summing all the module emission contributions stated in $gCO_{2eq}/MJ_{dry\ matter}$[15].

Calculating the carbon intensity of electricity generation

The carbon intensity of final electricity generation is calculated in accordance with the following equation:

$$Electricity\ carbon\ intensity \left(\frac{gCO2eq}{MJ}\right) = \frac{Biomass\ carbon\ intensity \left(\frac{gCO2eq}{MJ}\right)}{\eta el} \times \frac{Cel \times \eta el}{Cel \times \eta el + Ch \times \eta h}$$

Where:

η_{el}, the electrical efficiency, defined as the annual electricity produced divided by the annual fuel input, based on its energy content

η_h, the heat efficiency, defined as the annual useful heat output divided by the annual fuel input, based on its energy content

C_{el}, the fraction of exergy in electricity, equal to 1

C_h, the fraction of exergy in heat (Carnot efficiency for heat), defined as:

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[15] The RO Sustainability Criteria guidance indicates emissions should be provided in $kgCO_{2eq}$/unit before converting to gCO_{2eq}/MJ. However, this does not align with either its instructions for calculating the carbon intensity of each module (in gCO_{2eq}/MJ) or with EU Commission recommendations

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$$\frac{Temperature\ of\ delivered\ heat\ (K) - Temparature\ of\ surroundings(K)}{Temperature\ of\ delivered\ heat\ (K)}$$

Where:

Temperature of surroundings is set to 273.15K (0°C)

For heat delivered at a temperature below 423.15K (150°C), the C_h is assumed at 0.3546.

For generators producing only electricity, $\frac{Cel \times \eta el}{Cel \times \eta el + Ch \times \eta h} = 1$.

Calculating the carbon intensity of heat generation

The carbon intensity of final heat generation is calculated in accordance with the following equation:

$$Heat\ carbon\ intensity\ \left(\frac{gCO2eq}{MJ}\right) = \frac{Biomass\ carbon\ intensity\ \left(\frac{gCO2eq}{MJ}\right)}{\eta h} \times \frac{Ch \times \eta h}{Cel \times \eta el + Ch \times \eta h}$$

For generators producing only heat, $\frac{Ch \times \eta h}{Cel \times \eta el + Ch \times \eta h} = 1$.

Calculator allocations

Allocation of CHP emissions between heat and electricity providing process inputs

Emissions relating to CHP systems providing inputs to the pellet production process are allocated to their heat and electricity outputs based on the total, useable energy of the output in accordance with the methodologies outlined in the Directive (EU) 2018/2001 Annex VI, the Renewables Obligation and the Renewable Heat Incentive.

Allocation of CHP electricity emissions is performed using the following equation:

$$Electricity\ emissions\ (kgCO2eq)$$
$$= \big((Fuel\ emissions\ (kgCO2eq) + Flue\ emissions(kgCO2eq)\,)\big) \times \frac{Cel \times \eta el}{Cel \times \eta el + Ch \times \eta h}$$

Allocation of CHP heat emissions is performed using the following equation:

$$Heat\ emissions\ (kgCO2eq) = \big((Fuel\ emissions\ (kgCO2eq) + Flue\ emissions\ (kgCO2eq)\big) \times \frac{Ch \times \eta h}{Cel \times \eta el + Ch \times \eta h}$$

Allocation of heat between drying and other site processes

In some circumstances, a fuel system may provide heat to drying, other site processes and/or exported demands[16]. The total heat emissions for each fuel system are therefore allocated to drying using the following equation:

$$Drying\ heat\ emissions\ (kgCO2eq) = Heat\ emissions\ (kgCO2eq) \times \frac{Heat\ for\ drying\ (kWh)}{Total\ useable\ heat\ output\ (kWh)}$$

Total heat emissions are allocated to heat for other onsite wood pellet processing using the following equation:

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[16] Either non-processing heat demands or processing demands of neighbouring facility with operations unrelated to production of the wood pellet

$$Other\ processing\ heat\ emissions\ (kgCO2eq) = Heat\ emissions\ (kgCO2eq)\ \times \frac{Heat\ for\ other\ processing\ (kWh)}{Total\ useable\ heat\ output\ (kWh)}$$

Any difference between the total heat emissions and the processing heat emissions (heat for drying + heat for other processing) of the burner/boiler or CHP represents emissions allocated to heat used outside the system and is therefore excluded from the lifecycle emissions of the wood pellet.

Allocation of electricity between site processes and export

In some circumstances, a fuel system may provide electricity to site processes and export the remaining electricity to the grid or a neighbouring demand. The total electricity emissions for each fuel system are allocated to site processing using the following equation:

$$Processing\ electricity\ \ emissions\ (kgCO2eq)$$
$$= Electricity\ emissions\ (kgCO2eq) \times \frac{Electricity\ for\ processing\ (kWh)}{Total\ electricity\ output\ (kWh)}$$

Any difference between the total electricity emissions and the processing electricity emissions of the CHP represents emissions allocated to exported electricity and are therefore excluded from the lifecycle emissions of the wood pellet.

Allocation of drying heat emissions to each consignment

Pellet plants provide several complexities from a GHG accounting perspective. They will typically accept a range of different feedstocks to which emissions require allocating to in accordance with the mass balance rules of the Renewable Energy Directive and will often use consignments requiring different processing requirements. For instance, dry sawmill residues may require very little processing to be converted to pellets (e.g. drying and other processing may not be required). Meanwhile, wet stemwood may require a lot of energy to convert the material to pellets (e.g. debarking, chipping and drying all required). Moreover, some biomass may be diverted to 'hog fuel', in which case the material delivered to the site will not be equal to the feedstock input for pellet production.

To ensure pellet plant drying heat emissions are accurately calculated, emissions are allocated to each consignment based on the relative amount of water removed by the drying process. This is determined by calculating the total water content of the feedstock as received onsite and the total water content of the material after the dryer outlet. For instance, if one consignment requires removal of 1,000 tonnes of

water and a second 3,000 tonnes of water, 25% of drying emissions will be allocated to the first consignment and 75% of drying emissions allocated to the second[17].

The following set of equations are used for performing the allocation of heat drying emissions:

$Consignment\ input\ (tonnes\ fresh\ matter)$
$$= \frac{Consignment\ delivered\ (tonnes\ dry\ matter) - Consignment\ for\ hog\ fuel\ (tonnes\ dry\ matter)}{100\% - consignment\ moisture\ content\ at\ dryer\ inlet\ (\%)}$$

$Water\ removed\ by\ drying\ (tonnes)$
$$= \frac{Consignment\ input\ (tonnes\ fresh\ matter) - Consignment\ input\ (tonnes\ dry\ matter)}{100\% - moisture\ at\ dryer\ outlet\ (\%)}$$

$$\%\ total\ heat\ for\ drying = \frac{Water\ removed\ by\ drying\ (tonnes)}{\sum Water\ removed\ by\ drying\ (tonnes)^{18}}$$

$Drying\ heat\ emissions\ \left(\frac{gCO2eq}{tonne\ pellet\ (dry\ matter)}\right)$
$$= \frac{\sum Drying\ heat\ emissions\ (gCO2eq)^{19} \times \%\ total\ heat\ for\ drying}{Consignment\ output\ (tonnes\ dry\ matter)}$$

The calculator assumes that any material losses (i.e. any difference between the 'Consignment input' and 'Consignment output' terms) at the pellet plant occur during the pelleting process. Where losses at the pellet mill occur upstream of pelleting, this will result in an overestimate of the material entering and exiting the dryer and ultimately the total amount of water removed by drying. However, it is reasonable to assume any losses are likely to be both small and relatively consistent across consignments and will thus have a negligible impact on the allocation of drying heat emissions. It is also important to note that regardless of any losses, this approach applies a percentage to the total heat emissions for each consignment (with the total sum of these percentages equalling 100%), ensuring all emissions are accounted for when considering all outputs of the pellet plant.

Co-product allocation

As wood pellet supply chains typically only produce a single product (wood pellet), the calculator does not allow allocation of emissions to co-products.

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[17] 1,000/(1,000 + 3,000) x 100 = 25%; 3,000/(1,000 + 3,000) x 100 = 75%
[18] The total water removed across all consignments
[19] The total drying heat emissions across all fuel systems

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Additional calculations

Lower heating values

Lower heating values for feedstock consignments are calculated from the moisture content of the consignment and lower heating value (LHV) of the pellet on a dry basis in accordance with the following equation:

$$Biomass\ LHV\ \left(\frac{MJ}{kg}fresh\ matter\right)$$
$$= Biomass\ LHV\ \left(\frac{MJ}{kg}dry\ matter\right) \times \left(100\% - Biomass\ moisture\ (\%)\right)$$
$$- Biomass\ moisture(\%) \times \Delta Hvap$$

Where:

> *ΔHvap (Latent heat of evaporation for water under standard temperature and pressure) = 2.441 MJ/kg*

The inverse equation is also used within the calculator for determining the LHV of dry biomass based on its moisture content and LHV (on a fresh basis) using the following equation:

$$Biomass\ LHV\ \left(\frac{MJ}{kg}dry\ matter\right) = \frac{Biomass\ LHV\ \left(\frac{MJ}{kg}fresh\ matter\right) + Biomass\ moisture(\%) \times \Delta Hvap}{100\% - Biomass\ moisture\ (\%)}$$

Output contribution

The percentage of total pellet output attributable to each consignment ('Output contribution') is calculated using the following equation:

$$Output\ contribution\ (\%) = \frac{Consignment\ output\ (MJ\ dry\ matter)}{\sum Consignment\ output\ (MJ\ dry\ matter)[20]}$$

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[20] The total MJ output for all consignments (i.e. the total MJ wood pellet output)

Guide to inputting data

Dashboard

The dashboard is the main landing page of the calculator, providing the user with the ability to make scenario selections and view the outputs to the calculator.

Reporting information

The following reporting information to assist verifying parties can be entered in the header of the dashboard:

- **Pellet plant**: Name of the pellet plant for which supply chain emissions are being calculated
- **Start of period**: The start date of the reference period (i.e. the period for which operational data is collected for analysis of supply chain emissions)
- **End of period**: The end date of the reference period, typically one year from the start of the period.

Transport route selections

A scenario selection tool is available in the header of the dashboard offering the user to select different transport route options for both the delivery of feedstock to the pellet mill and downstream distribution of the pellet:

- **Feedstock travel distance**: For many consignments, feedstock will be transported from a variety of different origins, which will inevitably be different distances from the pellet mill. The 'Upstream' page allows users to enter feedstock travel distance information for the maximum travel distance and the weighted average distance. The scenario selection tool allows the user the option to switch between the two transport options. ***If an option is not chosen, the maximum distance will automatically be assumed.***
- **Route identifier**: The wood pellet output to a pellet plant may be distributed to a variety of end users or distributed the same end user via different routes. The 'pellet transport' page allows the

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input of transport data for up to 10 different downstream distribution routes. The scenario selection tool allows the user the option to switch between these different routes based on the 'route identifier'. *An option must be chosen for GHG emissions to be fully calculated.*

End user

Where the calculator is required for determining the carbon intensity of heat or electricity, the user should select whether the end user is an electricity generator, heat generator or CHP generator. Clicking the 'add' button next to the list of generators will unhide relevant fields to the type of generator selected (columns M:N on the 'dashboard' and rows 11-13 on the 'End use' page).

Users can reset the end user data by clicking the 'Reset' button.

Warning – the reset function will delete all data entered by the user on the 'end user' page.

Consignments

The calculator allows users to select up to 20 different feedstock 'consignments' by selecting the necessary number in 'Number of feedstock consignments' field and clicking the 'Add' button. Users can reset the consignment data by clicking the 'Reset' button.

Warning – the reset function will delete all consignment data entered by the user on the 'feedstock' and 'upstream' pages.

Summary table

The dashboard provides a summary table of supply chain emissions in gCO_{2eq}/MJ pellet$_{dry\ matter}$, showing the relevant contribution of 'Processing at origin', 'Feedstock transport', 'Drying', 'Pelleting and other processing', 'Pellet transport' and 'Fuel in use' to overall emissions. This breakdown of emissions is shown in the graph. The table also shows the final emissions for the pellet, emissions for heat and/or electricity generation, the total pellet output for each consignment and the contribution of each consignment towards the output of the plant.

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Feedstock

Consignments

Before inputting information on the 'Feedstock' page, users should first ensure they have added the necessary number of consignments on the 'Dashboard' to ensure that enough rows of input data are available.

Options available in the dropdown lists for Feedstock Group, Origin and Physical Description fields align to those provided in the SBP SAR for wood pellets v2.0. While it is not vital for all these fields to be completed for the calculation of emissions, they are valuable for the auditor for ensuring the input data aligns to the source evidence.

The total amount of each consignment processed during the reporting period should be input into in the 'Consignment delivered' field, with values provided on a fresh tonne basis. This includes all feedstock entering the pellet production process, including any material diverted to hog fuel. Biomass sourced specifically for hog fuel can either be reported here as a separate consignment # (where upstream data is available for the fuel)[21] or in the imported fuel tables on the 'pellet plant' page.

The moisture content as received is the weighted average moisture content for the feedstock as initially received onsite and is input as a percentage.

Users are also required to state whether consignments are fed to a dryer at the plant by selecting 'yes' or 'no' in the 'Drying required at plant?" field.

The moisture content at the dryer inlet is the weighted average moisture content for the feedstock as delivered to the dryer. This will typically be the same as the moisture content as received. However, if a feedstock consignment is air dried onsite prior to drying, the moisture content of the feedstock will be lower than as received. This is important to document to ensure drying emissions are not over-allocated

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[21] Users must ensure that the fuel group is then reported in the 'Biomass boiler/burner inputs - diverted from pellet production process' or 'Biomass CHP inputs - diverted from pellet production process' table on the pellet plant page, rather than the diverted fuel tables.

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to the consignment by the calculator. If a feedstock consignment does not enter the dryer or is not air dried onsite the user need not enter a value in this field (or can enter "N/A").

Notes

Should the user wish to provide additional notes for justifying the input data used, this can be provided in the 'Notes' section at the bottom of the page.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly.

Upstream

The upstream page covers all supply chain activities upstream of the pellet mill, including the 'processing at origin' and 'feedstock transport' modules.

Diesel use

As users will often rely on the use of typical values for forestry operations (e.g. from the JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report or Biograce II), all upstream diesel processing requirements have been included in a single field to reduce the complexity of the calculator, covering cultivation, harvesting, extraction and chipping. A tool is provided on the right-hand side of the header to enable the user to look up typical values. It is important to ensure that diesel use for forestry operations are adjusted for any process losses occurring prior to feedstock transport (e.g. during seasoning or chipping), otherwise diesel emissions will be underestimated.

Other upstream emissions

For wood pellet supply chains derived from products (i.e. not wastes or residues) and where land inputs such as fertilisers and pesticides are required (e.g. wood pellet from energy crops), the calculator must

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be used alongside other tools (e.g. Biograce II; The UK Solid and Gaseous Biomass Carbon Calculator) for calculating upstream emissions[22].

Any emissions resulting from land use change or use of additional inputs should be calculated in accordance with rules of the relevant legislation (e.g. Renewables Obligation or Directive (EU) 2018/2001) and stated in $kgCO_{2eq}/t_{output}$. It is important to ensure that emissions are adjusted for any process losses occurring prior to feedstock transport to site (e.g. during seasoning or chipping).

A corresponding table is provided on the 'Typical values' page to allow the user to keep a record of any upstream emissions regularly used in its calculations.

Feedstock transport

For each consignment, the calculator allows users to select the mode of transport, the transport fuel used, the weighted average distance and the maximum distance for up to two separate journeys for the transport of feedstock from its origin to the pellet mill. In the event transport modes or fuels are not available from the drop-down lists, users can input their own values on the 'Standard values' page ('Transport' and 'Transport fuels' tables). However, this will require users to source their own input data (e.g. transport efficiencies and exhaust emission) to ensure emissions are fully accounted for.

Diesel use lookup

The table provides aggregated and disaggregated values for diesel use in cultivation, harvesting, extraction and chipping, taken from the JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report.

For aggregated values ('Diesel for collection of forestry residues including stump harvesting and chipping' and 'Diesel for cultivation, harvesting and chipping of stemwood'), yield adjustments are accounted for.

Users must note that the typical values are provided in $litre/t_{dry\ matter}$ and must be converted to a fresh matter basis by multiplying by the dry matter content (i.e. 100% - moisture content) of the relevant

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[22] The necessary calculations for these inputs (e.g. determining changes in carbon stock from land use change or N_2O emissions from fertiliser application) are omitted on account they would significantly increase the complexity of the calculator if included yet are rarely required for wood pellet supply chains

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consignment. Where consignment data is already entered, the user can determine the litre/t$_{fresh\ matter}$ input value by selecting the relevant process and consignment in the lookup table.

The underlying data for the lookup table is provided in the 'Typical values' page.

Notes

Should the user wish to provide additional notes for justifying the input data used, this can be provided in the 'Notes' section at the bottom of the page.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly.

Pellet plant

Pellet plant output

Output information for the pellet plant is required in the top section of the page. Output volumes of pellet should be entered on a fresh matter basis (i.e. should include moisture content). The pellet lower heating value (LHV) should also be on a fresh matter basis. Where this value is unavailable, the user may estimate this from default values using the lower heating value calculator on the 'Standard values' page.

The moisture of the feedstock after drying ('moisture at the dryer outlet %') and final moisture content of the pellet also require entering. Where the moisture at the dryer outlet is unknown, it is appropriate to use the final pellet moisture in this field.

Fuel system inputs

The calculator allows users to add up to 4 different fuel systems:

- Fossil fuel boiler/burner
- Fossil fuel CHP
- Biomass boiler/burner
- Biomass CHP

The relevant fuel system should be selected in the listbox and the 'Add' button pressed to unhide the necessary input data for the system selected. Users can reset the fuel system data by clicking the 'Reset' button.

Warning – the reset function will delete all fuel system data entered by the user.

It is important to note that this selection tool is a hide/unhide function. This means that use of the 'reset' button will not delete any data already entered in the calculator but will instead hide any rows unnecessary to the user.

For fossil fuel systems, users can insert consumption data in either kg or MJ, depending on how the information is collected onsite (typically MJ for gases or kg for solids and liquids). Where users need to convert from one unit into another, a 'Unit converter' assistance tool is provided in the right-hand side of the page header. If a fuel used in the system is not available from the drop-down list, users can input their own values on the 'Standard values' page ('Fossil fuels' table). However, this will require users to source their own input data (e.g. emission factors) to ensure emissions are fully accounted for.

For biomass systems, users are required to provide input tonnages for hog fuel on a fresh tonne basis. For each fuel system, there are two separate tables for reporting hog fuels:

DIVERTED HOG FUEL

Hog fuel taken from input consignments listed on the 'Feedstock' page should be reported in the biomass input tables labelled 'diverted from pellet production process'. ***Importantly, users must state from which feedstock consignment # the hog fuel is derived*** to ensure the mass balance for the site is accurately calculated.

If the hog fuel is taken after a process that results in mixing of multiple consignments (e.g. drying), the percentage of each consignment contributing to the mix should be manually calculated on a ***dry mass basis*** based on the relative input contribution. The fuel system consumption for each consignment

should then be determined by multiplying the total fuel system consumption of the feedstock mix by the contributing percentage.

For instance, if 1,000 tonnes of stemwood chips at 50% moisture and 2,000 tonnes of sawdust at 25% moisture are added to a dryer, of which 300 tonnes of the dried output (at 10% moisture) is used as hog fuel, the following calculations should be performed:

$$1,000 \times (100\% - 50\%) = 500 \; dry \; tonnes \; stemwood \; chips$$

$$2,000 \times (100\% - 25\%) = 1,500 \; dry \; tonnes \; sawdust$$

$$\frac{500}{500 + 1500} = \; 25\% \; hog \; fuel \; as \; stemwood \; chips$$

$$\frac{1,500}{500 + 1500} = \; 75\% \; hog \; fuel \; as \; sawdust$$

$$300 \times 25\% = \; 75 \; tonnes \; stemwood \; chips \; for \; hog \; fuel \; at \; 10\% \; moisture$$

$$300 \times 75\% = \; 225 \; tonnes \; sawdust \; for \; hog \; fuel \; at \; 10\% \; moisture$$

An assistance tool for performing such calculations is provided on the 'Assisting calculations' page.

IMPORTED HOG FUEL

For imported hog fuel that has been sourced specifically for providing fuel to the biomass process and which has not been reported on the 'Feedstock' page, users must enter data in the relevant biomass input tables labelled 'imported fuels'. Default emission values are used for these fuels, derived from Directive (EU) 2018/2001. Users may provide their own emission values for imported hog fuels by providing a new set of user values in the 'Biomass fuels' table on the 'Standard values' page. Users must also complete the corresponding 'Biomass CHP flue gas emissions' and 'Biomass boiler flue gas emissions' tables to ensure stack CH_4 and N_2O emissions are accounted for.

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Fuel system outputs

By default, the calculator applies all heat output of the fuel systems to drying. Therefore, in situations where heat is applied only to drying but output is unknown (e.g. direct air heating) certain fields can be left blank. For boiler/burner systems, all output fields can be left empty where the entire heat output is used for drying. For CHP systems, 'Heat for drying' and 'Heat for processing' fields may be left empty. However, the user must input information for 'Total usable heat output' to ensure emissions are correctly allocated between heat and electricity outputs.

Fields for fuel system outputs are defined as below:

- '**Total useable heat output**' is the total kWh_{th} of heat generated by the fuel system to satisfy an economical justifiable demand for heat, for heating or cooling purposes[23]; it should not include any heat output produced by the fuel system that is 'wasted'
- '**Heat for drying**' is the total kWh_{th} heat output from the installation used for drying feedstock
- '**Heat for other site processing**' is the total kWh_{th} heat output from the installation used for wood pellet production processes other than drying
- '**Heat exported**' is the total kWh_{th} heat output of the fuel system exported to an external demand, either to ancillary facilities or to a neighbouring demand unrelated to the pellet plant operation. This value is automatically calculated by deducting heat for drying and heat for other processing from the total heat output of the CHP and is shown only for completeness.
- '**Temperature of heat at point of delivery**' is the temperature of the energy vector (e.g. hot water, steam) in °C when delivered to the process
- '**Total electricity output**' is the total electricity output of the fuel system in kWh_e
- '**Electricity for processing**' is the total electricity output of the fuel system in kWh_e that is used for onsite processing (e.g. pelleting). It should not include any electricity that is exported to an external demand, either to ancillary facilities, the grid or by direct wire to a neighbouring operation
- '**Electricity exported**' is the total electricity output of the fuel system in kWh_e exported to an external demand, either to ancillary facilities, the grid or by direct wire to a neighbouring

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[23] 'Economical justifiable demand' is defined as the demand that does not exceed the needs for heat or cooling and which would otherwise be satisfied at market conditions

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operation. This value is automatically calculated by deducting processing electricity from the total electricity output of the CHP and is shown only for completeness.

Electricity inputs

Electricity consumption should include all processes at the site.

Users have the facility to input data for electricity consumed from both grid or onsite sources in the event electricity is derived from multiple sources. For grid electricity, the relevant region should be selected by the user. Standard data for grid carbon intensities at the EU level are taken from the JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report, and at the national level from Biograce additional standard values. However, users have the facility to input their own data on the 'Standard values' page ('Electricity – Grid' table) should they have access to more up-to-date values (e.g. The annual IEA Emissions Factors publication[24]).

Electricity from onsite fossil fuel or biomass CHP is shown in the 'Onsite electricity inputs' fields and is automatically taken from the 'Electricity for processing' fields in the Fuel System section and is shown here only for completeness.

For electricity supplied by direct wire from a neighbouring facility, data should be entered into the 'Onsite electricity inputs' field. Where the source is not solar or wind, the user is required to calculate the carbon intensity of the electricity supplied and include the emission factor in the 'Electricity – Onsite' table on the 'Standard values' page.

Additional inputs

Any additional pellet plant fossil requirements (e.g. diesel use for moving feedstock) should be recorded in this section. Equally, any non-feedstock binding agents or chemicals used in the process should also be added. It is important that the user provides their own emission factor for binders or chemicals on the 'Standard values' page ('Binders/chemicals' table), as default emission factors for relevant inputs are not widely available.

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[24] E.g. http://data.iea.org/payment/products/122-emissions-factors-2018-edition.aspx

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Unit converter

A 'Unit converter' assistance tool is provided in the right-hand side of the page header. This allows users to convert from kg, t, litre, m^3, MJ, GJ, MWh, GWh and mmBTU to MJ and kg, provided all necessary information (mass density and lower heating value) is included on the 'Standard values' page ('Fossil fuels' table).

Notes

Should the user wish to provide additional notes for justifying the input data used, this can be provided in the 'Notes' section at the bottom of the page.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly.

Pellet transport

Distribution routes

The pellet produced by a mill may be distributed by a variety of different end routes. Each distribution route is labelled with a 'route identifier'. The number of distribution routes can be chosen by selecting the necessary number (up to a maximum of 10) and clicking the 'Add' button. Data can be deleted by clicking the 'Reset' button.

The 'Route definition' provides a free text field which the user can use to describe the distribution route and which can be used to assist auditors for verification. For instance, the following could be used for route definition:

Pellet mill location – Load port – Disport – Generator location

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The 'Route identifier' provides a free text field where the user can use a reference code to describe the route. For instance, generators using the SBP certification scheme can use production batch ID codes for describing each route. ***This field must be completed to allow selection of route on the dashboard page.***

Each distribution route allows users to input up to 6 different journeys:

- 2 journeys from the pellet mill to the port of dispatch (Journey 1 & Journey 2)
- 2 shipping journeys from the port of dispatch to the port of receipt (Shipping 1 & Shipping 2)
- 2 journeys from the port of receipt to the generator (Journey 3 & Journey 4)

Users can use any different combination of fields to describe the distribution route. For instance, if a route requires three land journeys but does not require shipping, it is appropriate to input information for 'Journey 1', 'Journey 2' and 'Journey 3' while leaving other fields blank.

In the event transport modes or fuels are not available from the drop-down lists, users can input their own values on the 'Standard values' page ('Transport', 'Transport fuels' and 'Shipping' tables). However, this will require users to source their own input data (e.g. transport efficiencies and exhaust emission) to ensure emissions are fully accounted for.

Handling energy requirements

Input fields for storage & handling electricity and fuel requirements are provided for each distribution route. Where electricity is required in two different countries (e.g. the port of loading and the port of arrival) consumption should be entered separately for each demand, with the correct region identified.

Unit converter

A 'Unit converter' assistance tool is provided in the right-hand side of the page header. This allows users to convert from miles or nautical miles to km.

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Notes

Should the user wish to provide additional notes for justifying the input data used, this can be provided in the 'Notes' section at the bottom of the page.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly.

End use

Fuel type

The fuel type of the biomass is required to be selected for determining combustion non-CO_2 (CH_4 and N_2O) emissions. The calculator automatically calculates these emissions based on the fuel type selected using default values for these emissions derived from Directive (EU) 2018/2001. Where actual CH_4 and N_2O emissions are known, users can enter a new fuel type on the 'Standard values' page and insert their own fuel (e.g. 'Wood pellet (user value)') and include their own values for combustion non-CO_2 emissions.

Electrical efficiency

The electrical efficiency of the end generator is the annual electricity produced divided by the annual fuel input, in MJ of electricity per MJ of pellet.

Heat efficiency

The heat efficiency of the end generator is the annual *useful* heat produced divided by the annual fuel input, in MJ of heat per MJ of pellet. Any heat that is ultimately wasted should not be included in determining the heat efficiency of the generator.

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Temperature of heat at point of delivery

The temperature of the *useful* heat at point of delivery to its end use application.

Notes

Should the user wish to provide additional notes for justifying the input data used, this can be provided in the 'Notes' section at the bottom of the page.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly.

Emissions

All calculations, as described in the 'Calculation structure and alignment to the Renewables Obligation methodology' Section, are conducted here. There are no input fields on this page.

Standard values

Standard values

This page contains all standard values (e.g. conversion factors, fuel properties, transport efficiencies and emission factors) used in the calculator, largely derived from the JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report and Biograce II.

For each table, users can include their own values using the rows labelled '*User value – insert data*'. Users are recommended to make it clear when they have input and used their own values in the calculator to assist the verification process, for instance, by suffixing the name of each new fuel or transport mode etc. added with '_user value'.

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It is important that users input information for all relevant fields when adding new values to ensure emissions are calculated correctly.

However, there are several exceptions:

- Density in the 'Fossil fuels' and 'Transport fuels' table is not required as the value is only used for converting from volume to mass/energy values in the unit converted on the 'Pellet plant' page
- Density in the 'Biomass fuels' table is not currently used in the calculator
- LHV is not required for electricity in the 'Transport fuels' table
- Exhaust CH_4 and N_2O emissions in the 'Shipping' table unless these values are known, insofar as these emissions are assumed to be 0 in Biograce II

User entered standard values should comply with the relevant regulatory guidelines and should be appropriately referenced. References should be numbered, with full details provided on the 'References' page.

Users are prevented from overwriting standard values (with exception of transport feedstock factors – see below). They must instead include any new values as a new row in the relevant table in accordance with the guidance above.

For instance, if the user wishes to input a new emission factor for natural gas used as a transport fuel, they must use one of the additional rows available to insert the new fuel name, insert the new value and copy any other standard values for information the user does not wish to change (see example below).

Transport fuels						
Fuel	Density kg/m³	LHV MJ/kg 0% water	Emission factor gCO₂eq/MJ	[N/A.]	Reference	Notes
Diesel	832	43.1	95.1		2,1	
Gasoline	745	43.2	92.4		2	
Heavy fuel oil	970	970.0	94.2		2,1	
Natural gas	N/A	49.2	66.0		2,1	Biograce II value not suitable as represents marginal supply rather than
LPG	N/A	46.0	73.3		2	
Electricity - EU HV	N/A	N/A	136		3	
Electricity - US	N/A	N/A	180		3	
Electricity - Canada	N/A	N/A	55		3	
Electricity - Russia	N/A	N/A	172		3	
Electricity - UK	N/A	N/A	165.5		3	
Natural gas - User value	N/A	49.2	62.0		2,6	LHV taken from Biograce II; Emission factor taken from reference 6

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Should users need to use their own values in the 'Biomass CHP flue gas emissions' or 'Biomass boiler flue gas emissions' tables, they must first include the new fuel in the 'Biomass fuels' table. Equally, if users need to use their own values in the 'Fossil CHP flue gas emissions' or 'Fossil boiler flue gas emissions' tables, they must first include the new fuel in the 'Fossil fuels' table.

Transport feedstock factors

The standard values page contains default 'Transport feedstock factors' for feedstock and wood pellet transport. These values are directly used in calculating module emission contributions (by accounting for supply chain losses) and by default are set to 1, in accordance with the default values outlined in JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report. If the modelled supply chains suffer supply chain losses during transport, users can overwrite these default factors.

Lookup tables

The page further contains lookup tables for 'Feedstock groups', 'Feedstock origins', 'Physical descriptions', 'Fuel supply options', 'Consignment numbers' and 'Countries of Origin'. Additional countries of origin for feedstock can be added by the user by overwriting the 'User value - insert data' fields.

Notes

Additional notes for justifying the input data used is provided in the 'Notes' column for each table.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly.

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Typical values

Typical values

This page contains typical values (e.g. process energy demands) taken from the JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report and Biograce II. These values are not directly used in the calculator and are only provided as a point of reference where their use may be required by the user in place of actual input data:

- the 'Wood handling and processing energy requirements for wood chip production from forestry feedstocks' can be looked up on the 'Upstream' page and used in the absence of measured supply chain data
- the 'Wood handling and processing energy requirements for pellets from fresh forest chips' are used in the 'assisting calculations' page if the tool is being used to model supply chain data in the absence of pellet plant operational data
- the 'Wood processing feedstock factors' are used for determining typical values in the 'Wood handling and processing energy requirements for wood chip production from forestry feedstocks' table
- the 'Upstream emissions table' allows the user to keep a record of any upstream emissions regularly used in its calculations.

Notes

Additional notes for justifying the input data used is provided in the 'Notes' column for each table.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly.

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References

This page contains the list of references used for provision of standard values on the 'Standard values' page. Where users have input their own standard values, references should be appropriately documented here and should include author, date, title and where available, a link to the resource.

Notes

Should the user wish to provide additional notes for justifying the reference used, this can be provided in the 'Notes' section at the bottom of the page.

Verification

The page provides additional input fields on the right-hand side for verification of the calculations (e.g. when used in third party audits). The auditor can record when the input data in each row has been verified (or where more information is needed) and can provide additional comments accordingly

Change log

The change log documents all updates to the calculator by the developer following first approval.

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Assisting calculations

Assistance for modelling pellet mill mass balance based on different fuel systems

This section is for users wishing to estimate the amount of feedstock required by a pellet plant, based on the pellet output of the plant and the fuel system used. ***The outputs from this page should only be used in the calculator to provide a provisional estimate of supply chain emissions and should not be used in place of actual data.***

Users are required to provide data for the total output of pellet, the fuel system used, pellet Lower heating value and moisture content, the electrical and heat efficiencies of the fuel systems and the initial moisture content of the feedstock[25]. The tool uses typical values from the JRC 'Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2' report to provide estimates of:

- Total heat demand for drying
- Total electricity demand for pelleting
- Total fuel consumption for each fuel system (in MJ for fossil fuels; in MJ and dry tonnes for biomass fuels)
- Total heat and electricity output for each fuel system
- The total amount of grid electricity required for pelleting (where CHP electricity is insufficient to meet demand)
- The total amount of dry and fresh tonnes of feedstock required to fulfil site feedstock and energy demands (assuming the feedstock also provides hog fuel or biomass fuel systems)

This tool can only be used to estimate feedstock requirements on a fresh tonne basis for consignments of equivalent moisture content. Where consignments of different moisture content are required, users should conduct their own mass balance from the dry tonne requirements to estimate the tonnage of fresh biomass needed.

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[25] Placeholder data is provided, with all values taken from JRC. 2017. Solid and gaseous bioenergy pathways: input values and GHG emissions: Version 2, with exception of fossil CHP efficiencies, which are taken from US EPA data

Assistance for determining relative contributions of biomass within a feedstock mixture

This section is for users to calculate the relative contribution of each biomass consignment within a feedstock mix and the estimated tonnage of each consignment where a portion of the mixture is used as a processing fuel (e.g. where the output to a biomass dryer is re-used as fuel for the system).

Users are required to enter data for:

- Tonnes of biomass mixture
- Moisture of biomass mixture
- Consignment # for each consignment contributing to the mixture
- Tonnes for each consignment entering the mixture
- Moisture % for each consignment entering the mixture

The tonnage of each biomass consignment in the fuel mix used is provided on both a dry basis (0% moisture) and fresh basis (moisture % of the biomass mixture).

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