

BIOGRACE II

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

The BioGrace Excel tools

General structure and comparison

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Purpose of the tools

- Create transparency regarding the calculation of default values
 - related to EU-RED and to Report on solid and gaseous biomass
- Allow correct and (relatively) easy actual calculations
 - Change input values
 - Modify pathways
 - Create new pathways
- Enable harmonised GHG calculation under regulations for biofuels as well as electricity and / or heat production

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- Easy direction to other sheets
- One calculation sheet per pathway
- Additional sheets:
 - LUC
 - e_{sca}
 - N₂O field emissions
 - Standard values
 - (Final conversion only)
 - (Net efficiencies)
 - (Co-digestion)

Production of Ethanol from Sugarbeet (steam from NG boiler)

Overview Results

| All results in g CO ₂ eq / MJ ethanol | Non- allocated results | Allocation factor | Allocated results | Total | Actual/Default | Default values RED Annex V.D |
|--|------------------------|-------------------|-------------------|-------------|----------------|------------------------------|
| Cultivation e_{cc} | | | | 11,5 | A | 12 |
| Cultivation of sugarbeet | 16,08 | 71,3% | 11,46 | | | 11,54 |
| Processing e_p | | | | 26,3 | A | 26 |
| Ethanol plant | 36,82 | 71,3% | 26,26 | | | 26,42 |
| Transport e_{td} | | | | 2,3 | A | 2 |
| Transport of sugarbeet | 1,11 | 71,3% | 0,79 | | | 0,84 |
| Transport of ethanol to de | 0,60 | 100,0% | 0,60 | | | 1,10 |
| Transport to filling station | 0,93 | 100,0% | 0,93 | | | 0,44 |
| Land use change e_l | 0,0 | 71,3% | 0,0 | 0,0 | | 0 |
| Bonus or e_{so3} | 0,0 | 100,0% | 0,0 | 0,0 | | 0 |
| e_{oor} + e_{oos} | 0,0 | 100,0% | 0,0 | 0,0 | | 0 |
| Totals | 55,6 | | | 40,1 | | 40 |

I. Overview results

Calculation per phase

Track changes: ON

When using this GHG calculation tool, the BioGrace The rules are included in the zip file in which you download

Cultivation of sugarbeet

Quantity of product

Yield

Sugar beet **68.860** kg ha⁻¹ year⁻¹
 Moisture content **75,0%**

Yield

280.605 MJ_{5,455,100,1} ha⁻¹ year⁻¹
 1,000 MJ / MJ_{5,455,100,1}
 0,451 kg_{5,455,100,1} / MJ_{5,455,100,1}

Energy consumption

Diesel **6.331** MJ ha⁻¹ year⁻¹

Agro chemicals

N-fertiliser (kg N) **119,7** kg N ha⁻¹ year⁻¹
 Manure **0,0** kg N ha⁻¹ year⁻¹

II. Calculation per phase

BIOGRACE II

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

BIOGRACE II

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

www.biograce.net



Production of electricity and/or heat, or cooling from wood chips from forestry residues

Overview Results

| Energy carrier | Don-allocated results | Total (allocated results) | Actual Default |
|---|-----------------------|---------------------------|----------------|
| All results in g CO_{2,eq} / MJ_{wood chips} | | | |
| Cultivation e_{non} | | 0,0 | A |
| Feedstock is a residue | 0,00 | 0,00 | |
| Processing e_{non} | | 2,95 | A |
| Forest residues collection | 1,96 | 1,96 | |
| Forest residues seasoning | 0,00 | 0,00 | |
| Chipping | 0,89 | 0,89 | |
| Transport e_{non} | | 3,26 | A |
| Transport of wood chips | 3,26 | 3,26 | |
| Land use change e_{non} | 0,0 | 0,0 | |
| Bonus or e _{non} | 0,0 | 0,0 | |
| e _{non} + e _{non} | 0,0 | 0,0 | |
| Totals | 6,1 | 6,1 | |

Default values EC report

To be published

Final energy

CH₄ and N₂O emissions at final conversion: 0,4 g CO_{2,eq} / MJ_{wood chips}

| Electricity | | Heat | |
|---|-------------------------------|-------------------|-----------------------------|
| All results in g CO _{2,eq} per MJ as indicated | | | |
| Allocation factor | Allocated results | Allocation factor | Allocated results |
| 100,0% | 6,6 per MJ _{chips} | 100,0% | 6,5 per MJ _{chips} |
| | 0,0 per MJ _{electr.} | | 0,0 per MJ _{heat} |

GHG emission reduction

| Electricity | Heat |
|-------------|------|
| 0% | 0% |

I. Overview results

General settings

Main output

Electricity

Heat

Cooling

Electricity and heat

Conversion efficiencies

| | |
|--|--|
| | |
| | |
| | |

Pathway configuration

Transport distance (chips): **1 - 500 km**

! When using this GHG calculation rules must be respected. (containing the complete tool)

Track changes

II. General settings

Calculation per phase

Values calculated from complete pathway

Overall yield per MJ input: **0,9024** MJ_{wood chips} / MJ_{forestry residues, input}

This value is used in the calculations below to convert MJ_{forestry residues, input} into MJ_{wood chips}. The purpose of this box is to facilitate copying rows or steps from one pathway to another, because this value is included in all pathways in cell C35.

| Feedstock is a residue | Quantity of product | Calculated emissions | | | |
|------------------------|--|-----------------------------|---|--------------------|----------------------|
| Yield | | Emissions per MJ wood chips | | | |
| | | g CO ₂ | g CH ₄ | g N ₂ O | g CO _{2,eq} |
| Forestry residues (FR) | 1,0 MJ | | | | |
| | 1,00 MJ _{FR, input} / MJ _{FR, input} | | | | |
| | | Result | g CO_{2,eq} / MJ_{chips} | | 0,00 |

III. Calculation per phase

Principle of calculation

Emission results
for this step

| Forest residues collection | | Quantity of product | | Calculated emissions | | | | |
|---|---|--|--|------------------------------------|--|--------------------|-----------------------|-------------|
| Yield | | | | Emissions per MJ wood chips | | | | |
| Forestry residues | 1,0 MJ _{FR} / MJ _{FR} | 1,00 MJ _{FR} / MJ _{FR, input} | | g CO ₂ | g CH ₄ | g N ₂ O | g CO _{2, eq} | |
| Moisture content | 45% | 0,106 kg _{FR, wet} / MJ _{Wood chips} | | | | | | |
| Energy consumption | | | | | | | | |
| Diesel | 0,0200 MJ / MJ _{Forestry residues} | | | 1,94 | 0,00 | 0,00 | 1,94 | |
| CH ₄ and N ₂ O emissions from use of diesel (forestry collection) | | | | 0,00 | 0,00 | 0,00 | 0,02 | |
| | | | | Total | 1,94 | 0,00 | 0,00 | 1,96 |
| | | | | Result | g CO_{2, eq} / MJ_{Chips} | | | 1,96 |

Input values

Yield related
conversion
factors

Principle of calculation

o Input data

o Standard values ("conversion factors")

| Forest residues collection | | Quantity of product | Calculated emissions | | | | |
|---|---|--|-----------------------------|-------------------|--------------------|---|-------------|
| Yield | | | Emissions per MJ wood chips | | | | |
| Forestry residues | 1,0 MJ _{FR} / MJ _{FR} | 1,00 MJ _{FR} / MJ _{FR, input} | g CO ₂ | g CH ₄ | g N ₂ O | g CO _{2,eq} | |
| Moisture content | 45% | 0,106 kg _{FR, wet} / MJ _{Wood chips} | | | | | |
| Energy consumption | | | | | | | |
| Diesel | 0,0200 MJ / MJ _{Forestry residues} | | 1,94 | 0,00 | 0,00 | 1,94 | |
| CH ₄ and N ₂ O emissions from use of diesel | (forestry collection) | | 0,00 | 0,00 | 0,00 | 0,02 | |
| | | | Total | 1,94 | 0,00 | 0,00 | 1,96 |
| | | | Result | | | g CO_{2,eq} / MJ_{Chips} | 1,96 |

STANDARD VALUES

| parameter: | GWP | | | | GHG emissio |
|------------|------------------------|----------------------|----------------------|----------------------|-------------------------|
| unit: | gCO _{2,eq} /g | gCO ₂ /kg | gCH ₄ /kg | gN ₂ O/kg | gCO _{2,eq} /kg |

List of standard values

| STANDARD VALUES | | GWP | | | GHG emissio | |
|---|-------|------------------------|----------------------|----------------------|----------------------|-------------------------|
| parameter: | unit: | gCO _{2,eq} /g | gCO ₂ /kg | gCH ₄ /kg | gN ₂ O/kg | gCO _{2,eq} /kg |
| <i>Global Warming Potentials (GWP's)</i> | | | | | | |
| CO ₂ | | 1 | | | | |
| CH ₄ | | 25 | | | | |
| N ₂ O | | 298 | | | | |
| <i>Agro inputs</i> | | | | | | |
| N-fertiliser (kg N) | | | 3794,0 | 7,93 | 7,3150 | 6172,1 |
| P ₂ O ₅ -fertiliser (kg P ₂ O ₅) | | | 991,2 | 1,40 | 0,0532 | 1042,1 |
| K ₂ O-fertiliser (kg K ₂ O) | | | 547,9 | 1,60 | 0,0129 | 591,8 |
| CaO-fertiliser (calculated as kg CaO) | | | 65,2 | 0,12 | 0,0029 | 69,0 |
| CaO-fertiliser (calculated as kg CaCO ₃) | | | 36,5 | 0,07 | 0,0016 | 38,7 |
| Pesticides | | | 10371,8 | 28,44 | 1,7145 | 11593,8 |
| Seeds- barley | | | 176,8 | 0,39 | 0,4005 | 305,9 |
| Seeds- corn | | | 176,8 | 0,39 | 0,4005 | 305,9 |
| Seeds- corn (whole plant) | | | 176,8 | 0,39 | 0,4005 | 305,9 |
| Seeds- cottonseed | | | | | | 0,0 |
| Seeds- jatropha | | | | | | 0,0 |

User defined standard values

| User Defined Standard Values | | | | | |
|---|----------|----------------------|----------------------|----------------------|-------------------------|
| parameter: unit: | Comments | GHG emissio | | | |
| | | gCO ₂ /kg | gCH ₄ /kg | gN ₂ O/kg | gCO _{2-eq} /kg |
| <i>User defined standard values</i> | | | | | |
| Example 1 (diesel from standard values) | | | | | 0 |
| Example 2 (methanol from standard values) | | | | | 0 |
| Example 3 (N-fertiliser from standard values) | | 2827,0 | 8,68 | 9,6418 | 5917,2313 |
| Ammonium nitrate | | 2900,0 | 0,00 | 0,0000 | 2900 |
| Urea | | 1707,0 | 0,00 | 0,0000 | 1707 |
| Compound | | 5376,0 | 0,00 | 0,0000 | 5376 |
| | | | | | 0 |



fill in actual data

Different units

| Calculated emissions | | | | | Info per kg residues g CO _{2,eq} |
|-----------------------------|---|-------------------|--------------------|----------------------|---|
| Emissions per MJ wood chips | | | | | |
| | g CO ₂ | g CH ₄ | g N ₂ O | g CO _{2,eq} | |
| | 1,94 | 0,00 | 0,00 | 1,94 | 18,31 |
| Total | 0,00 | 0,00 | 0,00 | 0,02 | 0,20 |
| | 1,94 | 0,00 | 0,00 | 1,96 | 18,51 |
| Result | g CO_{2,eq} / MJ_{Chips} | | | 1,96 | |



Results related to different units

Elements for verification

When actual calculations are done:

- The Biograces calculation rules must be followed
- Track changes must be switched on:
 - Highlights all changes
 - Shows editor's name and old values in the comment field

! When using this GHG calculation tool, the BioGrace calculation rules must be respected. The rules are included in the zip file (containing the complete tool) and also at www.BioGrace.net

Track changes: ON

Forest residues collection

Yield

Forestry residues

1,00

Moisture content

45%

Old value: 0,5
Date: 10-23-2013
Author:
SusanneKoeppen

Energy consumption

Diesel

0,0120

CH₄ and N₂O emissions from use of diesel

(residue collection)

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for Electricity, Heating and Cooling from Biomass



Differences between tools

- Final use of energy carriers
 - BG I: Liquid and gaseous **biofuels for transport**
 - BG II: Solid, gaseous (and liquid) bioenergy carriers for **electricity, heat and cooling**
 - ➔ Tools do not mirror the EU regulation / report!
- Final reference unit
 - BG I: MJ energy carrier (transport fuel)
 - BG II: MJ final energy (heat, electricity)
 - default values refer to MJ energy carrier
 - ➔ user always has to include own / actual conversion efficiency

BG II: General settings

| Main output | Conversion efficiencies | Pathway configuration |
|---|---|---|
| <input type="checkbox"/> Electricity <input type="checkbox"/> Heat <input type="checkbox"/> Cooling <input checked="" type="checkbox"/> Electricity and heat | Electrical efficiency: 15,0% Thermal efficiency: 60,0% 56,0% Temp of useful heat (°C): 150,0 | Heat provision in pellet production: Natural gas boiler Transport distance (pellets): 1 - 500 km |

Without filling this in,
NO GHG emissions
reductions will be
calculated !

Please note!

Please note !

When starting to use this Excel tool, you should first enter values in the "General settings" by choosing the main output, by entering the conversion efficiencies and by choosing the most appropriate pathway configuration (note that boiler/CHP settings and transport distances can always be adjusted to actual values further down this calculation sheet).

If you do not select the main output and enter conversion efficiencies, there will be no GHG emission reduction calculated for electricity, heat or cooling, which is the purpose of this tool. The tool can then be used for information purposes and will give a result in g CO₂,eq per MJ of energy carrier and (in the info boxes in column N) in g CO₂,eq per kg of energy carrier for solid and liquid biomass.

Do not show this screen any more

Close

BG II: Final conversion efficiency

Energy carrier

Final energy

Overview Results

Energy carrier

| All results in g CO _{2,eq} / MJ _{wood chips} | Non-allocated results | Total (allocated results) | Actual/Default |
|--|-----------------------|---------------------------|----------------|
| Cultivation e_{cc} | | 0,0 | A |
| Feedstock is a residue | 0,00 | 0,00 | |
| Processing e_{pr} | | 2,85 | A |
| Forest residues collection | 1,96 | 1,96 | |
| Forest residues seasoning | 0,00 | 0,00 | |
| Chipping | 0,89 | 0,89 | |
| Transport e_{tr} | | 3,26 | A |
| Transport of wood chips | 3,26 | 3,26 | |
| Land use change e _{lc} | 0,0 | 0,0 | |
| Bonus or e _{bn} | 0,0 | 0,0 | |
| e _{cc} + e _{pr} | 0,0 | 0,0 | |
| Totals | 6,1 | 6,1 | |

| Default values EC report |
|--------------------------|
| To be published |

Final energy

| CH ₄ and N ₂ O emissions at final conversion | | | |
|--|-------------------|---|-------------------|
| | 0,4 | g CO _{2,eq} / MJ _{wood chips} | |
| Electricity | | Heat | |
| <i>All results in g CO_{2,eq} per MJ as indicated</i> | | | |
| Allocation factor | Allocated results | Allocation factor | Allocated results |
| 100% | 6,5 per MJ chips | 100% | 6,5 per MJ chips |
| | 0,0 per MJ elect. | | 0,0 per MJ heat |
| GHG emission reduction | | | |
| Electricity | | Heat | |
| | 0% | | 0% |

Final conversion based on actual efficiency

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Differences between tools

- Differences in methodology

- BG I: Allocation of co-products based on lower heating values;
credits for surplus electricity from CHP (e_{ee})
- BG II: Allocation of co-products based on lower heating values;
Allocation in CHP based on exergy
→ two different allocation factors

BG I: Allocation between products and co-products

Allocation factors

Ethanol plant

71,3% to ethanol

28,7% to Sugar beet pulp



Allocation of by-products
and main products in
production chain:
Lower Heating Value

Use of CHP during pathway:

- Credit for surplus electricity

BG II: Two different allocations

Allocation factors & references

Allocation factors

Production chain

100,0% to energy carrier

0,0% to co-product(s)

CHP

100,0% to electricity

100,0% to heat

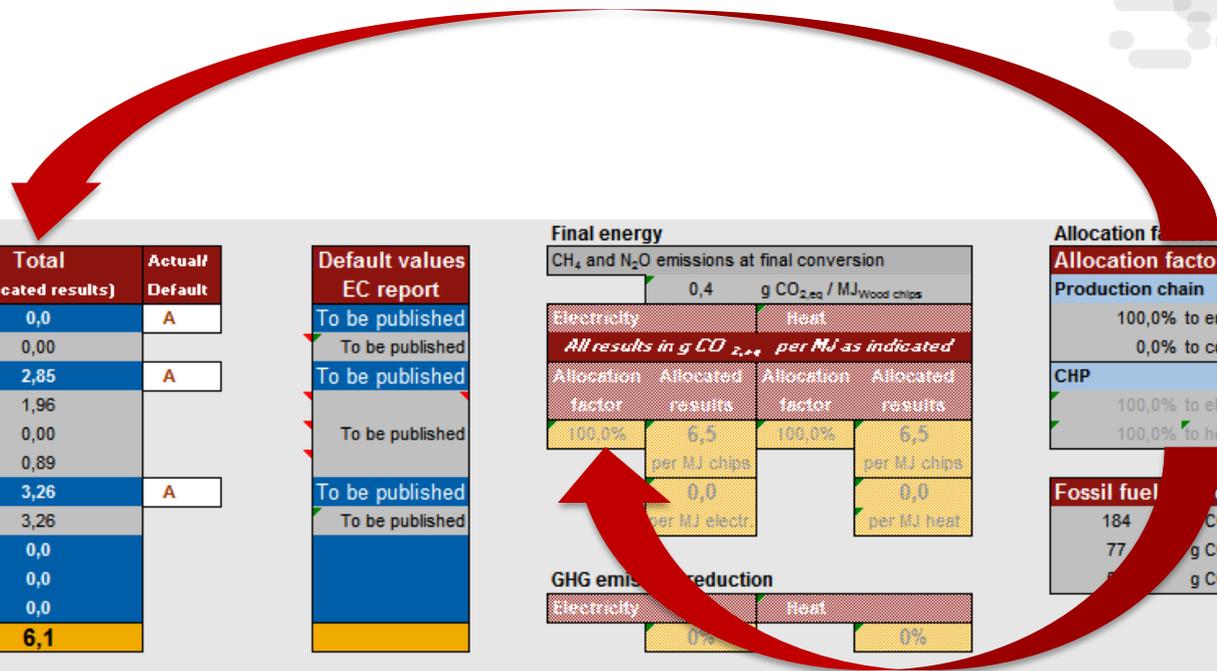
Allocation of by-products and main products in production chain:
Lower Heating Value

Allocation of electricity and heat (CHP) according to Carnot efficiency:

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

(along and at the end of pathway)

BG II: Two different allocations



| Energy carrier | Non-allocated results | Total (allocated results) | Actual/Default |
|---|-----------------------|---------------------------|----------------|
| <i>All results in g CO_{2,eq} / MJ_{Wood chips}</i> | | | |
| Cultivation e_{EC} | | 0,0 | A |
| Feedstock is a residue | 0,00 | 0,00 | |
| Processing e_p | | 2,85 | A |
| Forest residues collection | 1,96 | 1,96 | |
| Forest residues seasoning | 0,00 | 0,00 | |
| Chipping | 0,89 | 0,89 | |
| Transport e_{td} | | 3,26 | A |
| Transport of wood chips | 3,26 | 3,26 | |
| Land use change e_l | 0,0 | 0,0 | |
| Bonus or e_{sca} | 0,0 | 0,0 | |
| e_{CCR} + e_{OCCS} | 0,0 | 0,0 | |
| Totals | 6,1 | 6,1 | |

| Default values EC report |
|--------------------------|
| To be published |

| Final energy | | | |
|--|-------------------|---|-------------------|
| CH ₄ and N ₂ O emissions at final conversion | | | |
| | 0,4 | g CO _{2,eq} / MJ _{Wood chips} | |
| Electricity | | Heat | |
| <i>All results in g CO_{2,eq} per MJ as indicated</i> | | | |
| Allocation factor | Allocated results | Allocation factor | Allocated results |
| 100,0% | 6,5 | 100,0% | 6,5 |
| | per MJ chips | | per MJ chips |
| | 0,0 | | 0,0 |
| | per MJ electr. | | per MJ heat |
| GHG emission reduction | | | |
| Electricity | | Heat | |
| | 0% | | 0% |

| Allocation factors & references | |
|---------------------------------|---|
| Allocation factors | |
| Production chain | |
| 100,0% | to energy carrier |
| 0,0% | to co-product(s) |
| CHP | |
| 100,0% | to electricity |
| 100,0% | to heat |
| Fossil fuel references | |
| 184 | g CO _{2,eq} /MJ _{electricity} |
| 77 | g CO _{2,eq} /MJ _{heat} |
| 5 | g CO _{2,eq} /MJ _{cooling} |

Differences between tools

- Differences in methodology
 - BG I: Emissions from use of bioenergy carrier are zero
 - BG II: **CO₂** emissions from use are zero
 - CH₄ and N₂O emissions from final conversion are calculated

BG II: Emissions from final conversion

| Final conversion (CH ₄ and N ₂ O emissions only) | | | | | |
|--|--|---|------|------|------|
| Type of fuel used in end conversion | Wood chip | Please note: these emissions will not be added to the pathway emissions (which are expressed per MJ _{wood chips}) but will be added to the emissions per MJ _{heat} and per MJ _{electricity} in the result section | | | |
| Type of end conversion | Boiler | | | | |
| Include following emissions | CH ₄ and N ₂ O emissions from Wood chip Boiler | 0,00 | 0,00 | 0,00 | 0,41 |
| No emissions added to pathway emissions, emissions will be added in result section | | | | | 0,00 |

| Final energy | | | |
|--|-----------------------|---|---------------------|
| CH ₄ and N ₂ O emissions at final conversion | | | |
| | 0,4 | g CO _{2,eq} / MJ _{Wood chips} | |
| Electricity | | Heat | |
| <i>All results in g CO_{2,eq} per MJ as indicated</i> | | | |
| Allocation factor | Allocated results | Allocation factor | Allocated results |
| 100,0% | 6,5 per MJ chips | 100,0% | 6,5 per MJ chips |
| | 0,0 per MJ electr. | | 0,0 per MJ heat |
| GHG emission reduction | | | |
| Electricity | 0% | Heat | 0% |

Differences between tools

- Elements that will be included in BG I in next update
 - comment boxes with background information on calculation ways
 - variations included in drop downs (e.g. transport distances, process energy carriers)

BG II: Background information

| Forest residues collection | | Quantity of product | Calculated emissions | | | |
|----------------------------|---|---|-----------------------------|---|--------------------|-----------------------|
| Yield | | | Emissions per MJ wood chips | | | |
| Forestry residues | 1,0 MJ _{FR} / MJ _{FR} | 1,00 MJ _{FR} / MJ _{FR, input} | g CO ₂ | g CH ₄ | g N ₂ O | g CO _{2, eq} |
| Moistu | | /MJ _{Wood chips} | | | | |
| Energy | | | 1,94 | 0,00 | 0,00 | 1,94 |
| Diesel | | | 0,00 | 0,00 | 0,00 | 0,02 |
| CH ₄ an | | | 1,94 | 0,00 | 0,00 | 1,96 |
| | | | Result | g CO_{2,eq} / MJ_{Chips} | | 1,96 |

Help for the cell that is selected

Calculating the CH4 emissions

The CH4 emissions per MJ of final product are calculated in the following way:
 Result = [Amount of input] * [Pathway efficiency up to this step] * [CH4 emission coefficient of input] / [Overall pathway efficiency]

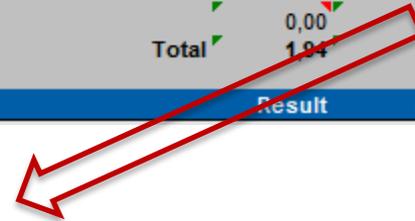
The units of the values used in this calculation are:

- [Amount of input] : MJ_{input} / MJ_(material produced in this step)
- [Pathway efficiency up to this step] : MJ_(material produced in this step) / MJ_(first feedstock in pathway)
- [CH4 emission coefficient of input] : g CH4 / MJ_{input}
- [Overall pathway efficiency] : MJ_(final product) / MJ_(first feedstock in pathway)

As a result, the unit of the calculation result is g CH4 / MJ_(final product).

Do not show this help box any more

Close



➔ Help boxes with information on calculation strategies and formulas / specific units used



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