



TVER-TOOL-02-02
Tool to Calculation for Project Emission and Leakage Emissions
from Biomass
Version 01
Entry into force on 1 March 2023

1. Introduction

This document is a tool for calculating greenhouse gas emissions from biomass for project activity and outside the project's boundary including measuring and monitoring procedure which consists of

- 1) Procedure for calculating greenhouse gas emissions from project activity which consists of greenhouse gas emissions from biomass cultivation in specific plantations biomass, processing and residual biomass processing, and the transport of biomass and the rest of biomass.
- 2) Procedure for calculating greenhouse gas emissions outside the project's boundary which consists of greenhouse gas emissions arising outside the project scope due to changes in pre-project activities resulting from biomass cultivation in specific plantations, processing of residual biomass from other uses, residual biomass transport emissions, and residual biomass processing.
- 3) Methods for monitoring project performance identify the methods/sources of parameters that do not require monitoring and that need to be monitored through project activity. The details are as follows.

2. Definition

- **Biomass cultivation site** - The cultivation of energy crops for the purpose of producing biomass, such as napier grass, giant acacia, sugarcane, cassava, oil palm, etc.
- **Biomass residues** - Waste materials from harvesting or processing agricultural products such as rice husks, sugarcane residues, straw, corncobs, etc., or wood and wood chips that can be used to produce fuel.
- **Indirect land use change** - is land-use change that may be induced on land areas not included in the project boundary as a result of shifting of pre-project activities;
- **Organic soil**¹ soils are organic if it satisfies the requirements (i) and (ii), or (i) and (iii) below:
 - (i) Thickness of 10 cm or more. A horizon less than 20 cm thick must have 12

¹ As defined in "Annex A: Glossary" of the 2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry

- per cent or more organic carbon when mixed to a depth of 20 cm;
- (ii) If the soil is never saturated with water for more than 2 days, and contains more than 20 per cent (by weight) organic carbon (about 35 per cent organic matter);
 - (iii) If the soil is subject to water saturation episodes and has either:
 - a. At least 12 per cent (by weight) organic carbon (about 20 per cent organic matter) if it has no clay; or
 - b. At least 18 per cent (by weight) organic carbon (about 30 per cent organic matter) if it has 60 per cent or more clay; or
 - c. An intermediate, proportional amount of organic carbon for intermediate amounts of clay;
- **Pre-project activities** - the land use prior to the implementation of the project activity, considering both land use practices and the primary and final products of the practices. This includes, for example, grazing, cultivation of crops, agroforestry, collection of biomass;
 - **Project region** – area within a radius of 250km around the project activity;
 - **Stratum** - area of land with uniform properties;
 - **Wetland**¹ - this category includes land that is covered or saturated by water for all or part of the year (e.g. peatland) and that does not fall into the forest land, cropland, grassland or settlements categories. This category can be subdivided into managed and unmanaged according to national definitions. It includes reservoirs as a managed sub-division and natural rivers and lakes as unmanaged sub-divisions;

3. Applicability and Conditions of use

This tool shall be applied in conjunction with the methodology that refers to this tool.

- 1) For project activities which include biomass cultivation:

¹ As defined in “Annex A: Glossary” of the 2003 IPCC Good Practice Guidance for Land Use, Land-Use Change and Forestry.

- (a) The land in which biomass is cultivated:
 - (i) Does not contain wetlands;
 - (ii) Does not contain organic soils as defined in section 2
 - (iii) Is not subjected to flood irrigation.
 - (b) The land in which biomass is cultivated:
 - (i) Does not contain forest nor contained forest since **25 May 2022**; or
 - (ii) Contains a forest plantation that before the start of the project will be harvested and the land would be neither reforested nor will regenerate on its own into a forest in the absence of the project activity.
- 2) In case the land contains a forest plantation, the project participants shall demonstrate that before the start of the project activity the plantation will be finally harvested and regeneration to forestland (according to the respective national definition) will not take place. In doing so, the project proponent shall:
- (a) Identify realistic and credible alternatives with regard to the possible land use scenarios that would occur in the absence of the project activity, including but not limited to
 - (i) The forest plantation continues under the current management practice;
 - (ii) The forest plantation is harvested and the land is replanted;
 - (iii) The forest plantation is harvested and the land is abandoned;
 - (b) Assess the economic attractiveness of the existing forest plantation by TVER-TOOL-01-01 “Determination of baseline emission and proof of operations in addition to normal operations for forestry project activities”.
 - (c) Confirm, based on the plantation management practices in the region for the considered species, that the situation referred to in 1) (b)(ii) is the common practice; and
 - (d) Use relevant credible evidence, including but not limited to official land use maps, satellite images/aerial photographs, cadastral information, official land use records.
- 3) The tool is also applicable if biomass residues are consumed in a project activity, and the biomass residues can be utilized after processing or without processing. These could be:

- (a) Procured by the project proponents; or
- (b) The result of an agro-industrial process under the control of the project proponents.

4. Determination of project emission from biomass

Calculation of greenhouse gas emissions from biomass from project implementation Based on the calculation method of the CDM project, Tool16 : Project and leakage emissions from biomass, Version 05, which is the calculation of greenhouse gas emissions from the project implementation from biomass cultivation. biomass transport biomass processing residual biomass transport and the remaining biomass processing According to the biomass value chain, as shown in Figure 1 , Where;This tool calculates the amount of greenhouse gas emissions from the project implementation of the given parameters. as shown in Table 1

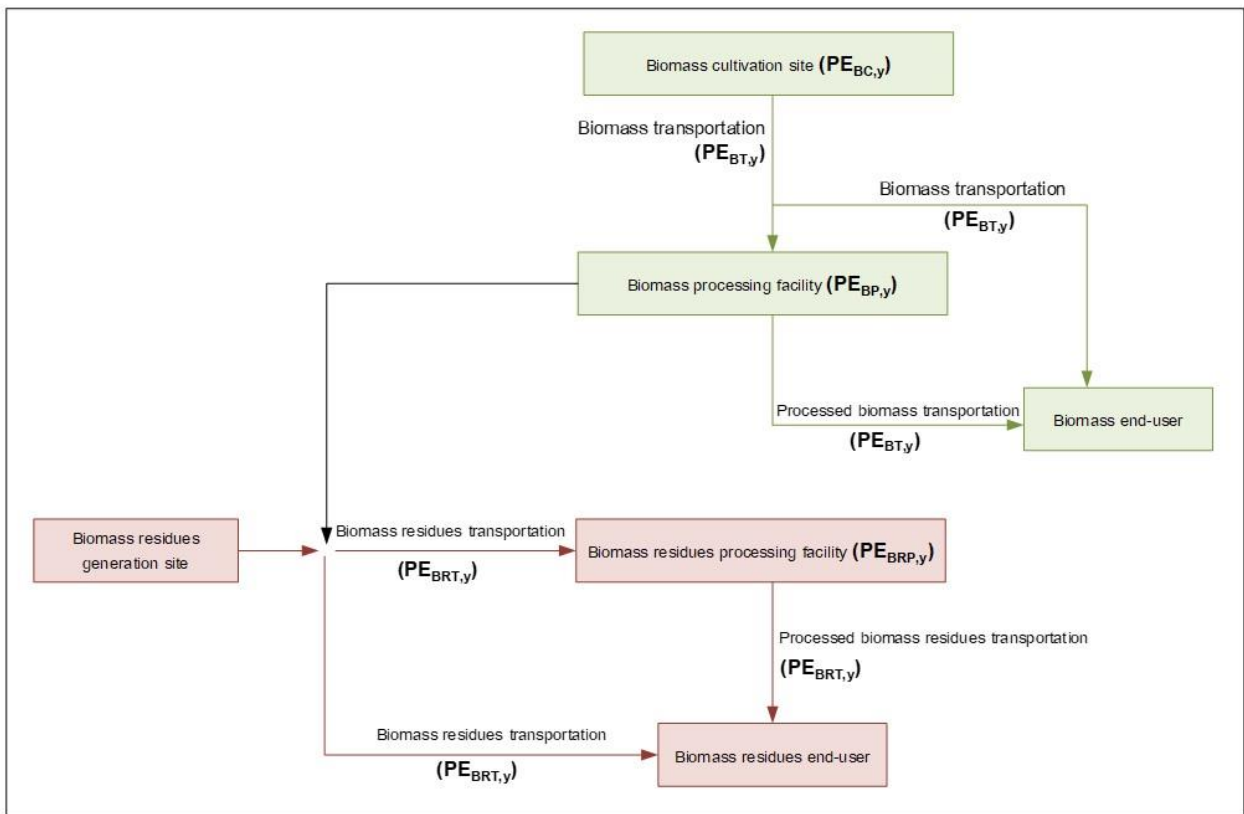


Figure 1 below provides an overview of the project emission sources over the value chain of the biomass and biomass residues:

Table 1 Parameters determined

| Parameter | Unit | Description |
|-----------------|--------------------|--|
| $PE_{BC,y}$ | tCO ₂ e | Project emissions resulting from cultivation of biomass in a dedicated plantation in year y (Section 4.1) |
| $PE_{BT,y}$ | tCO ₂ e | Project emissions resulting from transportation of biomass in year y (Section 4.2) |
| $PE_{BRT,y}$ | tCO ₂ e | Project emissions resulting from transportation of biomass residues in year y (Section 4.2) |
| $PE_{BP,y}$ | tCO ₂ e | Project emissions resulting from processing of biomass in year y (Section 4.3) |
| $PE_{BRP,y}$ | tCO ₂ e | Project emissions resulting from processing of biomass residues in year y (Section 4.3) |
| $LE_{BC,y}$ | tCO ₂ e | Leakage due to shift of pre-project activities resulting from cultivation of biomass in a dedicated plantation in year y (Section 5.1) |
| $LE_{BR,Div,y}$ | tCO ₂ e | Leakage due to diversion of biomass residues from other applications in year y (Section 5.2) |
| $LE_{BRT,y}$ | tCO ₂ e | Leakage due to the transportation of biomass residues outside of the project boundary in year y (Section 5.3) |
| $LE_{BRP,y}$ | tCO ₂ e | Leakage due to processing of biomass residues outside the project boundary in year y (Section 5.4) |

The methodology that refers to this tool shall indicate which of the emission sources listed in Table 1 above are to be included or omitted in the calculation of project emissions. Unless allowed by the methodology, only positive leakage, i.e. increased emissions outside the project boundary, can be accounted under this tool. If the result of the leakage calculation is negative, assume a value equals to zero.

4.1. Project emissions resulting from cultivation of biomass in a dedicated plantation in year y ($PE_{BC,y}$)

Project emissions resulting from cultivation of biomass in a dedicated plantation are estimated as follows:

$$PE_{BC,y} = PE_{SOC,y} + PE_{SM,y} + PE_{BSH,EC,y} + PE_{BB,y} \quad \text{Equation (1)}$$

Where;

$PE_{SOC,y}$ = Project emissions resulting from loss of soil organic carbon in year y (tCO₂e)

$PE_{SM,y}$ = Project emissions resulting from soil management in year y (tCO₂e)

$PE_{BSH,EC,y}$ = Project emissions resulting from energy electricity and fuel consumption for biomass seeding and harvesting in year y (tCO₂e)

$PE_{BB,y}$ = Project emissions resulting from clearance or burning of biomass in year y (tCO₂e)

Biomass originating from land areas included in registered afforestation/reforestation (A/R) project activities may be considered to have no project emissions.

4.1.1 Project emissions resulting from loss of soil organic carbon ($PE_{SOC,y}$)

To estimate emissions resulting from loss of soil organic carbon, the areas of land are stratified according to:

- (a) Climate region and soil types given in Table 1 from Appendix 1;
- (b) Land-use and land management activities on croplands given in Tables 2 and 3 from Appendix 1; and
- (c) Land-use and land management activities on grasslands given in Table 4 from Appendix 1. This also applies to abandoned land.

For each stratum of the areas of land which is subjected to soil disturbance attributable to project activity and for which the total area disturbed is less than 10% of the area of the stratum, emissions resulting from loss of soil organic carbon may be accounted as zero. Emissions resulting from loss of soil organic carbon are estimated as follows:

$$PE_{SOC,y} = \text{Max} \left(\frac{44}{12} \times \frac{1.179}{T} \times \sum_i \Delta SOC_i, 0 \right) \quad \text{Equation (2)}$$

Where;

T = Length of the first crediting period of the project in years

ΔSOC_i = Loss of soil organic carbon in land stratum i (tC)

- $\frac{44}{12}$ = Factor for converting units from tC to tCO₂e; dimensionless
 1.179 = Factor to account for soil N₂O emissions associated with loss of soil organic carbon¹ dimensionless
 i = Strata of areas of land

Loss of soil organic carbon in a stratum is estimated as follows:

$$\Delta SOC_i = 1.21 \times A_{SOC,i} \times SOC_{REF,i} \times (f_{LUB,i} \times f_{MGB,i} \times f_{INB,i} - f_{LUP,i} \times f_{MGP,i} \times f_{INP,i}) \quad \text{Equation (3)}$$

Where;

- $A_{SOC,i}$ = Area of land stratum i (ha);
 $SOC_{REF,i}$ = Reference SOC stock applicable to land stratum i (t C/ha);
 $f_{LUB,i}$ = Relative stock change factor for land-use in the baseline in stratum i;
 $f_{MGB,i}$ = Relative stock change factor for land management in the baseline in stratum i;
 $f_{INB,i}$ = Relative stock change factor for input in the baseline in stratum i;
 $f_{LUP,i}$ = Relative stock change factor for land-use in the project in stratum i;
 $f_{MGP,i}$ = Relative stock change factor for land management in the project in stratum i;
 $f_{INP,i}$ = Relative stock change factor for input in the project in stratum i;
 i = Strata of areas of land;
 1.21 = Conservativeness factor accounting for the uncertainties in the values in Tables 2 to 4 from Appendix 1;²

The values of relative stock change factors shall be determined according to Tables 2 to 4 from Appendix 1 of this tool.³

¹ Based on the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

For details, see Appendix 3.

² According to FCCC/SBSTA/2003/10/Add.2/6. For details, see Appendix 3.

³ Project proponents are encouraged to suggest revisions for this tool with alternative procedures (e.g. monitoring) to determine the relative stock change. Where the land contains a forest plantation in its last rotation in the baseline, or contains a forest plantation in the project activity, the relative stock change factors for land-use, land management and inputs each shall be assumed as 1.00, i.e. forest plantation is a reference scenario for the purpose of soil organic carbon.

After the first crediting period of the project, the value of $PE_{SOC,y}$ shall be 0.

4.1.2 Project emissions resulting from soil management in year y ($PE_{SM,y}$)

Emissions resulting from soil management are estimated as follows:

$$PE_{SM,y} = PE_{SF,y} + PE_{SA,y} \quad \text{Equation (4)}$$

Where;

$PE_{SF,y}$ = Project emissions resulting from of soil fertilization and management in year y (tCO₂e)

$PE_{SA,y}$ = Project emissions resulting from soil amendment in year y (tCO₂e)

4.1.2.1 Project emissions resulting from soil fertilization and management ($PE_{SF,y}$)

Emissions resulting from soil fertilisation and management are estimated as follows:

$$PE_{SF,y} = q_{N,y} \times A_{FTM,y} \times EF_{FT} \quad \text{Equation (5)}$$

Where;

$q_{N,y}$ = Rate of nitrogen applied in year y (tN/rai)

$A_{FTM,y}$ = Area of land subjected to soil fertilization and management in year y (rai)

EF_{FT} = Aggregate emission factor for N₂O and CO₂ emissions resulting from production and application of nitrogen (t CO₂e/(t N)). A default value of 11.29 t CO₂e/(t N)¹ shall be used;

4.1.2.2 Project emissions resulting from soil amendment ($PE_{SA,y}$)

Emissions resulting from soil amendment (liming) are estimated as follows:

$$PE_{SA,y} = \sum q_{SA,i,y} \times A_{SA,i,y} \times EF_{SA,i,y} \quad \text{Equation (6)}$$

Where;

$q_{SA,i,y}$ = Rate of application of soil amendment agent type i in year y (t/rai);

¹ According to FCCC/SBSTA/2003/10/Add.2/6. For details, see Appendix 3

- $A_{SA,i,y}$ = Area of land in which soil amendment agent type i is applied in year y (rai);
 $EF_{SA,i,y}$ = Emission factor for CO₂ emissions from application of soil amendment agent type i (t CO₂e/t). (Default values for limestone is 0.12 tCO₂e/t¹, dolomite is 0.13 t CO₂e/t², and urea is 0.20 tCO₂e/t³)

4.1.3 Project emissions resulting from energy consumption (electricity and fuel) for biomass seeding and harvesting ($PE_{BSH,EC,y}$)

Emissions resulting from fuel and electricity consumption for biomass seeding and harvesting (e.g. fuel consumed by tractors and harvesters, and electricity consumed for irrigation water pumping) are estimated, unless otherwise required in the relevant methodology, by the equation below:

$$PE_{BSH,EC,y} = PE_{BSH,electricity} + PE_{BSH,fuel,y} \quad \text{Equation (7)}$$

Where;

- $PE_{BSH,electricity}$ = Project emissions from the consumption of electricity for biomass seeding and harvesting in year y (tCO₂e)
 $PE_{BSH,fuel,y}$ = Project emissions from the consumption of fossil fuels for biomass seeding and harvesting in year y (tCO₂e)

4.1.3.1 Project emissions from the consumption of electricity for biomass seeding and harvesting ($PE_{BSH,electricity,y}$)

Project emissions from the consumption of electricity for biomass seeding and harvesting ($PE_{BSH,electricity,y}$) can be calculate as follow:

$$PE_{BSH,electricity,y} = \sum_j EC_{PJ,j,y} \times EF_{EF,j,y} \times (1 + TDL_{j,y}) \quad \text{Equation (8)}$$

¹ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 4, Ch 11, Eq 11.12.

² Ibid.

³ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 4, Ch 11, Eq 11.13.

Where;

- $PE_{BSH,electricity,y}$ = Project emissions from the consumption of electricity for biomass seeding and harvesting in year y (tCO₂/year)
- $EC_{P,j,y}$ = Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/year)
- $EF_{EF,j,y}$ = Emission factor for electricity generation for source j in year y (tCO₂/MWh)
- $TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to source j in year y
- j = Sources of electricity consumption in the project

4.1.3.2 Project emissions from the consumption of fossil fuels for biomass seeding and harvesting ($PE_{BSH,fuel,y}$)

To calculate Project emissions from the consumption of fossil fuels for biomass seeding and harvesting, use the Calculation Tool of TVER-TOOL-02-01 "Calculating Greenhouse Gas Emissions from the Burning of Fossil Fuels from Project Emission and Leakage Emission", latest edition. The parameter $PE_{BSH,fuel,y}$ corresponds to the parameter $PE_{FF,i,y}$.

4.1.4 Project emissions resulting from clearance or burning of biomass ($PE_{BB,y}$)

Emissions resulting from clearance or burning of biomass are estimated as follows:

$$PE_{BB,y} = \frac{44}{12} \times 0.47 \times \sum_i A_{FR,i,z} \times b_i \times (1.06 + R_i) \quad \text{Equation (9)}$$

Where;

- $\frac{44}{12}$ = Factor for converting units from t C to t CO₂e; dimensionless
- 0.47 = Default value of carbon fraction of biomass burnt; ¹
- 1.06 = Factor to account for non-CO₂ emissions from biomass clearance or burning ² If biomass is cleared without using open fire, then this factor is set

¹ IPCC 2006 Guidelines for National Greenhouse Gas Inventories, Vol 4, Ch 4 Table 4.3.

² Based on 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. For details, see Appendix 3.

- equal to 1 (one);
- $A_{FR,i,z}$ = Area of stratum i of land subjected to clearance or fire in year y (rai)
- b_i = Fuel biomass consumption per hectare in stratum i of land subjected to clearance or fire (t dry matter/rai);
- R_i = Root-shoot ratio (i.e. ratio of below-ground biomass to above-ground biomass) for stratum i of land subjected to clearance or fire;
- i = Strata of areas of land.

4.2 Project emissions resulting from transportation of biomass ($PE_{BT,y}$) and Project emissions resulting from transportation of biomass residues ($PE_{BRT,y}$)

Project emissions resulting from transportation of biomass ($PE_{BT,y}$) and Project emissions resulting from transportation of biomass residues ($PE_{BRT,y}$) are estimated as follows:

4.2.1 Project emissions resulting from transportation of biomass ($PE_{BT,y}$)

Project emissions resulting from transportation of biomass are estimated as follows:

$$PE_{BT,y} = \sum_f D_{f,m} \times FR_{f,m} \times EF_{CO_2,f} \times 10^{-6} \quad \text{Equation (10)}$$

Where;

- $PE_{BT,y}$ = Project emissions resulting from transportation of biomass in period m (tCO₂)
- $D_{F,m}$ = Return trip distance between the origin and destination of freight transportation activity f in monitoring period m (km)
- $F_{Rf,m}$ = Total mass of freight transported in freight transportation activity f in monitoring period m (t)
- $EF_{CO_2,f}$ = Default CO₂ emission factor for freight transportation activity f (g CO₂/t km)
- f = Freight transportation activities conducted in the project activity in monitoring period m

By $D_{F,m}$, considering the following transport routes;

- (i) If the biomass produced is utilized without further processing, the route shall include only the transport of the biomass between the biomass production site and the

biomass utilization facility;

- (ii) If the biomass is processed before being utilized, the routes shall include the transport between (i) the biomass production site and the biomass processing facility, and (ii) the biomass processing facility and the biomass utilization facility;

4.2.2 Project emissions resulting from transportation of biomass residues ($PE_{BRT,y}$)

Project emissions resulting from transportation of biomass residues are estimated as follows:

$$PE_{BRT,y} = \sum_f D_{f,m} \times FR_{f,m} \times EF_{CO_2,f} \times 10^{-6} \quad \text{Equation (11)}$$

Where;

- $PE_{BRT,y}$ = Project emissions resulting from transportation of biomass residues in period m (tCO₂)
- $D_{F,m}$ = Return trip distance between the origin and destination of freight transportation activity f in monitoring period m (km)
- $F_{Rf,m}$ = Total mass of freight transported in freight transportation activity f in monitoring period m (t)
- $EF_{CO_2,f}$ = Default CO₂ emission factor for freight transportation activity f (g CO₂/t km)
- f = Freight transportation activities conducted in the project activity in monitoring period m

By $D_{F,m}$, considering the following transport routes;

- (i) If the biomass residues are consumed without further processing, the route shall include only the transport of the biomass residues between the biomass processing facility or the biomass generation site and the biomass residues utilization facility;
- (ii) If the biomass residues are processed before being utilized, the routes shall include the transport between (i) the biomass processing facility or the biomass generation site and the biomass residues processing facility, and (ii) the biomass residues processing facility and the biomass residues utilization facility.

As an alternative to the monitoring of the parameters needed to calculate the emissions from the transportation, project proponents may apply the following options:

1) For microscale and small-scale project activities, apply a default emission factor of 0.0142 tCO₂/tonne of biomass

Note; Determined assuming that 1 tonne of biomass is transported using heavy duty vehicles (with an associated specific emission factor of 129 gCO₂/tkm according to the Data/Parameter table 1 from the TOOL12) through a round-trip distance of 110 km

2) For large-scale project activities, apply a net-to-gross adjustment of 10%, i.e. multiply the emission reductions determined based on the applied methodology by 0.9 to determine the final amount of emission reductions that can be claimed.

Note; Determined as the ratio between (i) the emissions to transport 1 tonne of biomass and (ii) the emission reductions from the electricity generated by 1 tonne of biomass, based on the following assumptions of a hypothetical project

(a) The biomass is sourced from a distance of 200 km and the transport is made using heavy duty vehicles. These assumptions are conservative since:

(i) 110 km is observed in monitoring reports of registered CDM project activities as a typical distance of transport;

(ii) The transport of biomass is made using heavy duty vehicles, which is the vehicle type with the higher specific emission factor of the Data/Parameter table 1 from the TOOL12 (129 gCO₂/tkm);

(b) The type of biomass consumed is black liquor, the electricity is generated by a technology with 35% efficiency and is exported to a grid with an emission factor of 0.5 tCO₂/MWh. These assumptions are also conservative since:

(i) Black liquor is the type of biomass that has the lowest value of NCV among the types included in Table 1.2 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (5.9 TJ/Gg);

(ii) The technology with a 35% efficiency is the one with the lowest value between the biomass technologies listed in Table 2 from the Appendix of CDM

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(iii) The the grid emission factors in non-Annex I countries currently reported is typically above 0.69 tCO₂/MWh (e.g.as observed from the IGES Database);

The emissions to transport 1 tonne of biomass are determined by multiplying the distance travelled (200 km) by the emission factor of the heavy duty vehicles to transport 1 tonne of biomass (129 gCO₂/tkm, or 129 x 10⁻⁶ tCO₂/tkm), which is equal to 0.0258 tCO₂/tbiomass.

4.3 Project emissions resulting from processing of biomass (PE_{BP,y}) and Project emissions resulting from processing of biomass residues (PE_{BRP,y})

4.3.1 Project emissions resulting from processing of biomass (PE_{BP,y})

Project emissions resulting from processing of biomass (PE_{BP,y}) are estimated as follows:

$$PE_{BP,y} = PE_{BP,electricity,y} + PE_{BP,fuel,y} + PE_{BP,CH4,y} + PE_{BP,comp,y} + PE_{BP,AD,y} + PE_{BP,ww,y} + PE_{BP,additives,y} \quad \text{Equation (12)}$$

Where;

- PE_{BP,y} = Project emissions resulting from processing of biomass in year y (tCO₂e/year)
- PE_{BP,electricity,y} = Project emissions resulting from electricity consumption from processing of biomass in year y (tCO₂e)
- PE_{BP,fuel,y} = Project emissions resulting from fossil fuels consumption from processing of biomass in year y (tCO₂e)
- PE_{BP,CH4,y} = Project emissions resulting from the decay of biomass under anaerobic conditions from processing of biomass in year y (tCO₂e)
- PE_{BP,comp,y} = Project emissions resulting from composting from processing of biomass in year y (tCO₂e)
- PE_{BP,AD,y} = Project emissions resulting from the anaerobic digester from processing of biomass in year y (tCO₂e)
- PE_{BP,ww,y} = Project emissions resulting from wastewater treatment from processing of biomass in year y (tCO₂e)
- PE_{BP,additives,y} = Project emissions resulting from the use of additives from processing of biomass in year y (tCO₂e)

4.3.2 Project emissions resulting from processing of biomass residues ($PE_{BRP,y}$)

Project emissions resulting from processing of biomass residues ($PE_{BRP,y}$) are estimated as follows:

$$PE_{BRP,y} = PE_{BRP,electricity,y} + PE_{BRP,fuel,y} + PE_{BRP,CH_4,y} + PE_{BRP,comp,y} + PE_{BRP,AD,y} + PE_{BRP,ww,y} + PE_{BRP,additives,y} \quad \text{Equation (13)}$$

Where;

- $PE_{BRP,y}$ = Project emissions resulting from processing of biomass residues in year y (tCO₂e/year)
- $PE_{BRP,electricity,y}$ = Project emissions resulting from electricity consumption from processing of biomass residues in year y (tCO₂e)
- $PE_{BRP,fuel,y}$ = Project emissions resulting from fossil fuels consumption from processing of biomass residues in year y (tCO₂e)
- $PE_{BRP,CH_4,y}$ = Project methane emissions resulting from the decay of biomass residues under anaerobic conditions from processing of biomass residues in year y (tCO₂e)
- $PE_{BRP,comp,y}$ = Project emissions resulting from composting from processing of biomass residues in year y (tCO₂e)
- $PE_{BRP,AD,y}$ = Project emissions resulting from the anaerobic digester from processing of biomass residues in year y (tCO₂e)
- $PE_{BRP,ww,y}$ = Project emissions resulting from wastewater treatment from processing of biomass residues in year y (tCO₂e)
- $PE_{BRP,additives,y}$ = Project emissions resulting from the use of additives from processing of biomass residues in year y (tCO₂e)

4.3.3 Project emissions resulting from electricity consumption from processing of biomass ($PE_{BP,electricity,y}$) and Project emissions resulting from electricity consumption from processing of biomass residues ($PE_{BRP,electricity,y}$)

Project emissions resulting from electricity consumption from processing of biomass ($PE_{BP,electricity,y}$) and Project emissions resulting from electricity consumption from processing of biomass residues ($PE_{BRP,electricity,y}$) are estimated as follows:

$$PE_{BP,electricity,y} = \sum_j EC_{PJ,j,y} \times EF_{EF,j,y} \times (1 + TDL_{j,y}) \quad \text{Equation (14)}$$

$$PE_{BPP,electricity,y} = \sum_j EC_{PJ,j,y} \times EF_{EF,j,y} \times (1 + TDL_{j,y}) \quad \text{Equation (15)}$$

Where;

$PE_{BP,electricity,y}$ = Project emissions resulting from electricity consumption from processing of biomass in year y (tCO₂e/year)

$EC_{PJ,j,y}$ = Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/year)

$EF_{EF,j,y}$ = Emission factor for electricity generation for source j in year y (tCO₂/MWh)

$TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to source j in year y

j = Sources of electricity consumption in the project

4.3.4 project emissions from fossil fuel consumption from processing of biomass ($PE_{BP,fuel,y}$) and project emissions from fossil fuel consumption from processing of biomass residues ($PE_{BRP,fuel,y}$)

To calculate project emissions from fossil fuel consumption from processing of biomass and biomass residues, use the Calculation Tool of TVER-TOOL-02-01 "Calculating Greenhouse Gas Emissions from the Burning of Fossil Fuels from Project Emission and Leakage Emission", latest edition. The parameter $PE_{BP,fuel,y}$ corresponds to the parameter $PE_{BRP,fuel,y}$

4.3.5 Project emissions resulting from the decay of biomass residues under anaerobic conditions from processing of biomass ($PE_{BP,CH_4,y}$) and Project emissions resulting from the decay of biomass residues under anaerobic conditions from processing of biomass residues ($PE_{BRP,CH_4,y}$)

Project emissions resulting from the decay of biomass residues under anaerobic conditions from processing of biomass ($PE_{BP,CH_4,y}$) and Project emissions resulting from the decay of biomass residues under anaerobic conditions from processing of biomass residues ($PE_{BRP,CH_4,y}$), use the Calculation Tool of TVER-TOOL-02-03 " Tool to calculate Emissions from solid waste disposal sites ", latest edition.

4.3.6 Project emissions resulting from composting from processing of biomass ($PE_{BP,COMP,y}$) and Project emissions resulting from composting from processing of biomass residues ($PE_{BRP,COMP,y}$)

Project emissions resulting from composting from processing of biomass ($PE_{BP,COMP,y}$) and Project emissions resulting from composting from processing of biomass residues ($PE_{BRP,COMP,y}$) are estimated as follows:

$$PE_{BP,COMP,y} = PE_{EC,y} + PE_{FC,y} + PE_{CH_4,y} + PE_{N_2O,y} + PE_{RO,y} \quad \text{Equation (16)}$$

$$PE_{BRP,comp,y} = PE_{EC,y} + PE_{FC,y} + PE_{CH_4,y} + PE_{N_2O,y} + PE_{RO,y} \quad \text{Equation (17)}$$

Where;

$PE_{BP,COMP,y}$ = Project emissions resulting from composting from processing of biomass in year y (tCO₂e)

$PE_{BRP,comp,y}$ = Project emissions resulting from composting from processing of biomass residues in year y (tCO₂e)

$PE_{EC,y}$ = Project emissions from electricity consumption associated with composting in year y (tCO₂e)

$PE_{FC,y}$ = Project emissions from fossil fuel consumption associated with composting in year y (tCO₂e)

$PE_{CH_4,y}$ = Project emissions of methane from the composting process in year y (tCO₂e)

$PE_{N_2O,y}$ = Project emissions of nitrous oxide from the composting process in year y (tCO₂e)

$PE_{RO,y}$ = Project emissions of methane from run-off wastewater associated with co-composting in year y (tCO₂e)

4.3.6.1 Determination of the quantity of waste composted

The quantity of waste composted is a parameter required in the determination of emissions associated with each source of project emissions. There are two options to determine the quantity of waste composted in year y (Q_y). In case of co-composting, wastewater is not accounted for in the estimation of (Q_y).

1) Option 1: Procedure using a weighing device

Monitor the weight of waste delivered to the composting installation using an on-site

weighbridge or any other applicable and calibrated weighing device (e.g. belt-scales).

2) Option 2: Procedure without using a weighing device

This procedure shall only be applied in the case that there is no weighbridge or any other applicable and calibrated weighing device available on site. Under this procedure Q_y is calculated based on the carrying capacity of each truck delivering waste to the composting installation in year y ($CT_{t,y}$), as follows;

$$Q_y = \sum_t CT_{t,y} \quad \text{Equation (18)}$$

Where;

- Q_y = Quantity of waste composted in year y (t / yr)
- $CT_{t,y}$ = Carrying capacity of truck t used in year y to deliver waste to the composting installation (t)
- t = Waste deliveries in trucks to the composting installation in year y

4.3.6.2 Determination of project emissions from electricity consumption ($PE_{EC,y}$)

Where the composting activity involves electricity consumption from the grid or from a fossil fuel fired on-site power plant, the $PE_{EC,y}$ can be calculated as follows;

$$PE_{EC,y} = \sum_j EC_{PJ,j,y} \times EF_{EF,j,y} \times (1 + TDL_{j,y}) \quad \text{Equation (19)}$$

Where;

- $EC_{PJ,j,y}$ = Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/year)
- $EF_{EF,j,y}$ = Emission factor for electricity generation for source j in year y (tCO₂/MWh)
- $TDL_{j,y}$ = Average technical transmission and distribution losses for providing electricity to source j in year y
- j = Sources of electricity consumption in the project

4.3.6.3 Determination of project emissions from fossil fuel consumption ($PE_{FC,y}$)

Where the composting activity involves fossil fuel consumption, project participants use the Calculation Tool of TVER-TOOL-02-01 "Calculating Greenhouse Gas Emissions from the Burning of Fossil Fuels from Project Emission and Leakage Emission", latest edition. where the project emission

source j referred to in the tool is composting.

4.3.6.4 Determination of project emissions of methane ($PE_{CH_4,y}$)

Project emissions of methane from composting ($PE_{CH_4,y}$) are determined as follows:

$$PE_{CH_4,y} = Q_y \times EF_{CH_4,y} \times GWP_{CH_4} \quad \text{Equation (20)}$$

Where;

| | | |
|---------------|---|--|
| $PE_{CH_4,y}$ | = | Project emissions of methane from the composting process in year y (tCO ₂ e/yr) |
| Q_y | = | Quantity of waste composted in year y (t/yr) |
| $EF_{CH_4,y}$ | = | Emission factor of methane per tonne of waste composted valid for year y (tCH ₄ /t) |
| GWP_{CH_4} | = | Global Warming Potential of CH ₄ (tCO ₂ e/tCH ₄) |

There are two options which project participants may choose for determining $EF_{CH_4,y}$

Option 1: Procedure using monitored data

$EF_{CH_4,y}$ is determined based on measurements of the methane emissions during a composting cycle ($ECC_{CH_4,c}$) as follows:

$$EF_{CH_4,y} = \frac{\sum_{c=1}^x ECC_{CH_4,c} / Q_c}{x} \quad \text{Equation (21)}$$

Where;

| | | |
|----------------|---|--|
| $EF_{CH_4,y}$ | = | Emission factor of methane per tonne of waste composted valid for year y (tCH ₄ /t) |
| $ECC_{CH_4,c}$ | = | Methane emissions from composting during the composting cycle c (tCH ₄) |
| Q_c | = | Quantity of waste composted in composting cycle c (t) |
| c | = | Composting cycles for which measurements were undertaken |
| x | = | Number of composting cycles c for which emissions were measured in year y |

Option 2: Procedure using default values

A default value is used: $EF_{CH_4,y} = EF_{CH_4,default}$. The default value is provided in the “Data and parameters not monitored” section of this tool.

4.3.6.5 Determination of project emissions of nitrous oxide ($PE_{N_2O,y}$)

Project emissions of nitrous oxide from composting ($PE_{N_2O,y}$) are determined as follows:

$$PE_{N_2O} = Q_y \times EF_{N_2O,y} \times GWP_{N_2O} \quad \text{Equation (22)}$$

Where;

- PE_{N_2O} = Project emissions of nitrous oxide from composting in year y (tCO₂e/yr)
- Q_y = Quantity of waste composted in year y (t/yr)
- $EF_{N_2O,y}$ = Emission factor of nitrous oxide per tonne of waste composted valid for year y (tN₂O/t)
- GWP_{N_2O} = Global Warming Potential of N₂O (tCO₂e/tN₂O)

There are two options which project participants may choose for determining $EF_{N_2O,y}$

1) Option 1: Procedure using monitored data

$EF_{N_2O,y}$ is determined based on measurements of the emissions during a composting cycle (ECC_{N_2O}), as follows:

$$EF_{N_2O,y} = \frac{\sum_{c=1}^x ECC_{N_2O,c} / Q_c}{x} \quad \text{Equation (23)}$$

Where;

- $EF_{N_2O,y}$ = Emission factor of nitrous oxide per tonne of waste composted valid for year y (tN₂O/t)
- $ECC_{N_2O,c}$ = Nitrous oxide emissions from composting during the composting cycle c (tN₂O)
- Q_c = Quantity of waste composted in composting cycle c (t)
- c = Composting cycles for which measurements were undertaken

x = Number of composting cycles c for which emissions were measured in year y (at least three)

2) Option 2: Procedure using default values

A default value is used: $EF_{N_2O,y} = EF_{N_2O,default}$. The default value is provided in the “Data and parameters not monitored” section of this tool.

4.3.6.6 Determination of project emissions from run-off wastewater ($PE_{RO,y}$)

Project emissions of methane from run-off wastewater ($PE_{RO,y}$) are calculated only for the case of co-composting. Moreover, if run-off wastewater is collected and re-circulated to the composting process, then $PE_{RO,y}$ is assumed to be zero (for example, this is the case for tunnel co-composting technology). Otherwise, $PE_{RO,y}$ is calculated based on the quantity and chemical oxygen demand (COD) of run-off wastewater as follows:

$$PE_{RO,y} = Q_{COD,y} \times B_{0,ww} \times MCF_{ww,treatment} \times \varphi \times GWP_{CH_4} \quad \text{Equation (24)}$$

Where;

- $PE_{RO,y}$ = Project emissions of methane from run-off wastewater associated with co-composting in year y (tCO₂e/yr)
- $Q_{COD,y}$ = Quantity of COD of the run-off wastewater from the co-composting installation in year y (tCOD/yr)
- $B_{0,ww}$ = Default methane producing capacity of the run-off wastewater (tCH₄/tCOD)
- $MCF_{ww,treatment}$ = Default methane correction factor for the wastewater treatment system where the run-off wastewater is treated
- φ = Default model correction factor to account for model uncertainties of methane emissions from run-off wastewater
- GWP_{CH_4} = Global Warming Potential of methane (tCO₂e/tCH₄)

Project participants may choose between two options to calculate $Q_{COD,y}$ based on monitoring the quantity and COD of the run-off wastewater or the quantity and COD of the wastewater co-composted:

1) Option 1: Procedure monitoring quantity and COD of the run-off wastewater

In this option, $Q_{\text{COD},y}$ is determined as follows:

$$Q_{\text{COD},y} = Q_{\text{RO},y} \times \text{COD}_{\text{RO},y} \quad \text{Equation (25)}$$

Where;

- $Q_{\text{COD},y}$ = Quantity of COD of the run-off wastewater from the co-composting installation in year y (tCOD/yr)
- $Q_{\text{RO},y}$ = Volume of run-off wastewater from the co-composting installation in year y (m^3/yr)
- $\text{COD}_{\text{RO},y}$ = Average COD of the run-off wastewater from the co-composting installation valid for year y (tCOD/ m^3)

2) Option 2: Procedure monitoring quantity and COD of the wastewater co-composted

In this option, $Q_{\text{COD},y}$ is estimated using a default factor and monitoring the quantity and COD of the wastewater co-composted. This option is given as a potential simplification, because the quantity and COD of the wastewater may already be monitored due to requirements in the methodology that is referring to this tool

$$Q_{\text{COD},y} = Q_{\text{wastewater},y} \times \text{COD}_{\text{wastewater},y} \times \text{DF}_{\text{COD,RO}} \quad \text{Equation (26)}$$

Where;

- $Q_{\text{COD},y}$ = Quantity of COD of the run-off wastewater from the co-composting installation in year y (tCOD/yr)
- $Q_{\text{wastewater},y}$ = Volume of wastewater co-composted in year y (m^3/y)
- $\text{COD}_{\text{wastewater},y}$ = Average COD of the wastewater co-composted valid for year y (tCOD/ m^3)
- $\text{DF}_{\text{COD,RO}}$ = Default factor for the ratio of the amount of COD in run-off wastewater and wastewater co-composted

4.3.7 Project emissions resulting from the anaerobic digester from processing of biomass ($\text{PE}_{\text{BP,AD},y}$) and Project emissions resulting from the anaerobic digester from processing of biomass residues ($\text{PE}_{\text{BRP,AD},y}$)

Project emissions resulting from the anaerobic digester from processing of biomass ($\text{PE}_{\text{BP,AD},y}$) and Project emissions resulting from the anaerobic digester from processing of biomass residues

$(PE_{BRP,AD,y})$, are determined as follows:

$$PE_{BP,AD,y} = PE_{EC,y} + PE_{FC,y} + PF_{CH_4,y} + PE_{flare,y} \quad \text{Equation (27)}$$

$$PE_{BRP,AD,y} = PE_{EC,y} + PE_{FC,y} + PF_{CH_4,y} + PE_{flare,y} \quad \text{Equation (28)}$$

Where;

$PE_{BP,AD,y}$ = Project emissions resulting from the anaerobic digester from processing of biomass in year y (tCO₂e)

$PE_{BRP,AD,y}$ = Project emissions resulting from the anaerobic digester from processing of biomass residues in year y (tCO₂e)

$PE_{EC,y}$ = Project emissions from electricity consumption associated with the anaerobic digester in year y (tCO₂e)

$PE_{FC,y}$ = Project emissions from fossil fuel consumption associated with the anaerobic digester in year y (tCO₂e)

$PF_{CH_4,y}$ = Project emissions of methane from the anaerobic digester in year y (tCO₂e)

$PE_{flare,y}$ = Project emissions from flaring of biogas in year y (tCO₂e)

Step 1: Determination of the quantity of methane produced in the digester ($Q_{CH_4,y}$)

There are two different procedures to determine the quantity of methane produced in the digester in year y ($Q_{CH_4,y}$). For large scale projects only Option 1 shall be used. For small scale projects, project participants may choose between Option 1 or Option 2.

Option 1: Procedure using monitored data

$Q_{CH_4,y}$ shall be measured using “TVER-TOOL-02-05 Tool to calculate the mass flow of a greenhouse gas in a gaseous stream”. When applying the tool, the following applies:

- (a) The gaseous stream to which the tool is applied is the biogas collected from the digester;
- (b) CH₄ is the greenhouse gas i for which the mass flow should be determined; and
- (c) The flow of the gaseous stream should be measured on an hourly basis or a smaller time interval; and then accumulated for the year y. Please note that units need to be converted to tons.

Option 2: Procedure using a default value

Under this option, the flow of the biogas is measured and a default value is used for the fraction of methane in the biogas, as follows:

$$Q_{CH_4,y} = Q_{biogas,y} \times f_{CH_4,default} \times p_{CH_4} \quad \text{Equation (29)}$$

Where;

| | | |
|--------------------|---|--|
| $Q_{CH_4,y}$ | = | Quantity of methane produced in the digester in year y (tCH ₄) |
| $Q_{biogas,y}$ | = | Amount of biogas collected at the digester outlet in year y (Nm ³ Biogas) |
| $f_{CH_4,default}$ | = | Default value for the fraction of methane in the biogas (m ³ CH ₄ / m ³ Biogas) |
| p_{CH_4} | = | Density of methane at normal conditions (tCH ₄ /Nm ³ CH ₄) |

If missing data of $Q_{biogas,y}$, it may be substituted by following the instruction from paragraph 3 of Appendix to the 'Methodological tool: Tool to determine the mass flow of a greenhouse gas in a gaseous stream'. This provision is applicable for project activities or PoAs, where end users of the subsystems or measures are households/communities/small and medium enterprises (SMEs).

Step 2: Determination of project emissions from electricity consumption ($PE_{EC,y}$)

This step is applicable if the anaerobic digester consumes electricity, such as for mixing, recirculation of digestate, or processing of feed material. If the electricity consumed is generated on-site using biomass residues, wind, hydro or geothermal power, then $PE_{EC,y} = 0$. Otherwise, the project participants may choose between the following two options to calculate $PE_{EC,y}$

Step 3: Determination of project emissions from fossil fuel consumption ($PE_{FC,y}$)

Where the anaerobic digester facility uses fossil fuels, project participants shall calculate $PE_{FC,y}$ using the TVER-TOOL-02-01 "Calculating Greenhouse Gas Emissions from the Burning of Fossil Fuels from Project Emission and Leakage Emission", latest edition. The project emission source j referred to in the tool is fossil fuel consumption associated with the anaerobic digestion facility (not including fossil fuels consumed for transportation of feed material and digestate or any other on-site transportation).

Step 4: Determination of project emissions of methane from the anaerobic digester ($PE_{CH_4,y}$)

Project emissions of methane from the anaerobic digester include emissions during maintenance of the digester, physical leaks through the roof and side walls, and release through safety

valves due to excess pressure in the digester. These emissions are calculated using a default emission factor ($EF_{CH_4, default}$), as follows:

$$PE_{CH_4, y} = Q_{CH_4, y} \times EF_{CH_4, default} \times GWP_{CH_4} \quad \text{Equation (30)}$$

Where;

$PE_{CH_4, y}$ = Project emissions of methane from the anaerobic digester in year y (t CO₂e)

$Q_{CH_4, y}$ = Quantity of methane produced in the anaerobic digester in year y (tCH₄)

$EF_{CH_4, default}$ = Default emission factor for the fraction of CH₄ produced that leaks from the anaerobic digester (fraction)

GWP_{CH_4} = Global warming potential of CH₄ (tCO₂/tCH₄)

Step 5: Determination of project emissions from flaring of biogas ($PE_{flare, y}$)

If the project activity includes flaring of biogas, then project emissions from flaring of biogas ($PE_{flare, y}$) shall be estimated using the TVER-TOOL-02-04 " Tool to calculate project emissions from flaring " latest edition.

- (a) For small scale projects, project participants may adopt a default value for the fraction of methane in the biogas ($f_{CH_4, default}$) in applying the tool; and
- (b) The tool provides default factors for the flare efficiency, which can be used for large or small scale projects as described in the tool.

4.3.8 Project emissions from the wastewater treatment anaerobic digester due to thermo-chemical, biological and mechanical processing of biomass ($PE_{BP, ww, y}$) and Project emissions from the wastewater treatment anaerobic digester due to thermo-chemical, biological and mechanical processing of biomass residues ($PE_{BRP, ww, y}$)

This emission source shall be estimated in cases where wastewater originating from the processing of the biomass and biomass residues is (partly) treated under anaerobic conditions and where methane from the wastewater is not captured and flared or combusted. Project emissions from wastewater are estimated as follows:

$$PE_{BP, ww, y} = GWP_{CH_4} \times V_{BP, ww, y} \times COD_{BP, ww, y} \times B_{o, ww} \times MCF_{BP, ww} \quad \text{Equation (31)}$$

Where;

- $PE_{BP,ww,y}$ = Project emissions from the wastewater treatment anaerobic digester due to thermo-chemical, biological and mechanical processing of biomass (tCO₂e/year)
- GWP_{CH_4} = Global warming potential for methane (tCO₂/tCH₄)
- $V_{BP,ww,y}$ = Quantity of wastewater generated from the processing of biomass in year y (m³)
- $COD_{BP,ww,y}$ = Average chemical oxygen demand of the wastewater generated from the processing of biomass in year y (tCOD/m³)
- $B_{o,ww}$ = Methane generation potential of the wastewater (tCH₄/tCOD)
- $MCF_{BP,ww}$ = Methane correction factor for the treatment of wastewater generated from the processing of biomass in year y

$$PE_{BRP,ww,y} = GWP_{CH_4} \times V_{BRP,ww,y} \times COD_{BRP,ww,y} \times B_{o,ww} \times MCF_{BRP,ww} \quad \text{Equation (32)}$$

Where;

- $PE_{BRP,ww,y}$ = Project emissions from the wastewater treatment anaerobic digester due to thermo-chemical, biological and mechanical processing of biomass residues (tCO₂e/year)
- GWP_{CH_4} = Global warming potential for methane (tCO₂/tCH₄)
- $V_{BRP,ww,y}$ = Quantity of wastewater generated from the processing of biomass residues in year y (m³)
- $B_{o,ww}$ = Methane generation potential of the wastewater (tCH₄/tCOD)
- $COD_{BRP,ww,y}$ = Average chemical oxygen demand of the wastewater generated from the processing of biomass residues in year y (tCOD/m³)
- $MCF_{BRP,ww}$ = Methane correction factor for the treatment of wastewater generated from the processing of biomass residues in year y

4.3.9 Project emissions from the use of additives to process the biomass ($PE_{BP,additives,y}$) and project emissions from the use of additives to process the biomass residues ($PE_{BRP,additives,y}$)

$$PE_{BP,additives,y} = PE_{BP,additives,transport,y} + PE_{BP,additives,electricity,y} + PE_{BP,additives,FF,y} \quad \text{Equation (33)}$$

$$PE_{BRP,additives,y} = PE_{BRP,additives,transport,y} + PE_{BRP,additives,electricity,y} + PE_{BRP,additives,FF,y} \quad \text{Equation (34)}$$

Where;

- $PE_{BP,additives,transport,y}$ = Project emissions from the transportation of the additives from the production site to the biomass processing facility (tCO₂)
- $PE_{BP,additives,electricity,y}$ = Project emissions from the consumption of electricity to produce the additives used by the biomass processing facility (tCO₂)
- $PE_{BP,additives,FF,y}$ = Project emissions from the consumption of fossil fuels to produce the additives used by the biomass processing facility (tCO₂)
- $PE_{BRP,additives,transport,y}$ = Project emissions from the transportation of the additives from the production site to the biomass residues processing facility (tCO₂)
- $PE_{BRP,additives,electricity,y}$ = Project emissions from the consumption of electricity to produce the additives used by the biomass residues processing facility (tCO₂)
- $PE_{BRP,additives,FF,y}$ = Project emissions from the consumption of fossil fuels to produce the additives used by the biomass residues processing facility (tCO₂)

4.3.9.1 Project emissions from the transportation of the additives from the production site to the biomass processing facility ($PE_{BP,additive,transport,y}$) and Project emissions from the transportation of the additives from the production site to the biomass residues processing facility ($PE_{BRP,additive,transport,y}$)

$$PE_{BP,additive,transport,y} = \sum_f D_{f,m} \times FR_{f,m} \times EF_{CO_2,f} \times 10^{-6} \quad \text{Equation (35)}$$

$$PE_{BRP,additive,transport,y} = \sum_f D_{f,m} \times FR_{f,m} \times EF_{CO_2,f} \times 10^{-6} \quad \text{Equation (36)}$$

Where;

- $PE_{BP,additive,transport,y}$ = Project emissions from the transportation of the additives from the production site to the biomass processing facility in period m (tCO₂)
- $PE_{BRP,additive,transport,y}$ = Project emissions from the transportation of the additives from the production site to the biomass residues processing facility in period m (tCO₂)
- $D_{f,m}$ = Return trip distance between the origin and destination of freight transportation activity f in monitoring period m (km)

| | | |
|---------------|---|---|
| $F_{Rf,m}$ | = | Total mass of freight transported in freight transportation activity f in monitoring period m (t) |
| $EF_{CO_2,f}$ | = | Default CO ₂ emission factor for freight transportation activity f (g CO ₂ /t km) |
| f | = | Freight transportation activities conducted in the project activity in monitoring period m |

As an alternative to the monitoring of the parameters needed to calculate the emissions from the transportation, project proponents may apply the following options:

- For microscale and small-scale project activities, apply a default emission factor of 0.0142 tCO₂/tonne of biomass.
- For large-scale project activities, apply a net-to-gross adjustment of 10%, i.e. multiply the emission reductions determined based on the applied methodology by 0.9 to determine the final amount of emission reductions that can be claimed.

4.3.9.2 Project emissions from the consumption of electricity to produce the additives used by the biomass processing facility ($PE_{BP,additives,electricity,y}$) and Project emissions from the consumption of electricity to produce the additives used by the biomass residues processing facility ($PE_{BPP,additive,electricity,y}$)

$$PE_{BP,additives,electricity,y} = \sum_j EC_{PJ,j,y} \times EF_{EF,j,y} \times (1 + TDL_{j,y}) \quad \text{Equation (37)}$$

$$PE_{BPP,additive,electricity,y} = \sum_j EC_{PJ,j,y} \times EF_{EF,j,y} \times (1 + TDL_{j,y}) \quad \text{Equation (38)}$$

Where;

- | | | |
|---------------|---|--|
| $EC_{PJ,j,y}$ | = | Quantity of electricity consumed by the project electricity consumption source j in year y (MWh/year) |
| $EF_{EF,j,y}$ | = | Emission factor for electricity generation for source j in year y (tCO ₂ /MWh) |
| $TDL_{j,y}$ | = | Average technical transmission and distribution losses for providing electricity to source j in year y |
| j | = | Sources of electricity consumption in the project |

4.3.9.3 Project emissions from the consumption of fossil fuels to produce the additives used by the biomass processing facility ($PE_{BP,additives,FF,y}$) and Project emissions from the consumption of fossil fuels to produce the additives used by the biomass residues processing facility ($PE_{BRP,additives,FF,y}$)

To calculate Project emissions from the consumption of fossil fuels to produce the additives used by the biomass processing facility and Project emissions from the consumption of fossil fuels to produce the additives used by the biomass residues processing facility, use the Calculation Tool of T-VER-TOOL-02-01 "Calculating Greenhouse Gas Emissions from the Burning of Fossil Fuels from Project Emission and Leakage Emission", latest edition. The parameter $PE_{BP,additives,FF,y}$ and $PE_{BRP,additives,FF,y}$ corresponds to the parameter $PE_{FF,i,y}$

As an alternative to the monitoring of the parameters needed to calculate $PE_{BP,additives,y}$ and $PE_{BRP,additives,y}$, project proponents may apply the following options:

- (a) If the ratio between the additive consumed and the biomass or biomass residue processed (mass or volume basis) is below or equal to 2%, these emission sources may be neglected;
- (b) If the ratio between the additive consumed and the biomass or biomass residue processed (mass or volume basis) is above 2% and below or equal to 10%, only the emissions from the consumption of electricity and fuel to produce the additives may be accounted. Project proponents may determine these emission sources based on literature such as peer reviewed studies.
- (c) If the ratio between the additive consumed and the biomass or biomass residue processed (mass or volume basis) is above 2% and below or equal to 10%, only the emissions from the consumption of electricity and fuel to produce the additives may be accounted. Project proponents may determine these emission sources based on literature such as peer reviewed studies.

5. Leakage emission

Leakage emission may occur outside of the project boundary and may involve emissions due to shift of pre-project activities, diversion of biomass residues from other applications and due to processing and transportation of biomass residues outside of the project boundary.

5.1 Leakage emission due to shift of pre-project activities resulting from cultivation of biomass in a dedicated plantation ($LE_{BC,y}$)

This section is applicable only if the project activity utilizes biomass cultivated in a dedicated plantation. Project proponents are advised to avoid pre-project activities from being shifted outside the project boundary, to avoid indirect land use changes as a result of the project activity. Rather, project proponents are encouraged to include in the project boundary the land in which the pre-project activities will take place after the project implementation.

No leakage emission due to shift of pre-project activities occurs if one of the following two conditions applies:

- (a) The plantation area was or would have been abandoned land prior to the implementation of the project activity;
- (b) The plantation area was used prior to the implementation of the project area but the pre-project land use of the plantation area will be accommodated for, providing at least the same level of service during the project activity, within the land area included in the project boundary. The project area may be expanded to accommodate for this condition. This could be achieved, inter alia, in the following ways:
 - (i) At least the same number of cattle as prior to the implementation of the project activity will continue being grazed during the project activity within the land area included in project boundary;
 - (ii) Due to more efficient farming practice, the pre-project crops can be grown on a smaller area, which is included in the land area included in the project boundary, to achieve the same level of annual production of crops, freeing land for the dedicated plantation;
 - (iii) Settlements are not removed from the land area included in the project boundary.

Project participants should assess the possibility of leakage from the displacement of activities or people by monitoring the following indicators:

- (a) Percentage of families/households of the community involved in or affected by the project activity displaced (from within to outside of the project boundary) due to the project activity;
- (b) Percentage of total production of the main product (e.g. meat, corn) within the project boundary displaced due to the cultivation of biomass.

For project activities which fall above the small-scale threshold, no shift of pre-project activities is allowed

For project activities which fall below the small-scale threshold:

- (a) If the value of both indicators is lower than 10 per cent, then leakage from this source is assumed to be zero;
- (b) If the value of any of the two indicators is higher than 10 per cent and less than or equal to 50 per cent, then leakage shall be equal to 15 per cent of the difference between baseline emissions and project emissions;
- (c) If the value of either of these two indicators is larger than 50 per cent, then this tool is not applicable and a new procedure must be submitted for the approval of the Board.

5.2 Leakage emission due to diversion of biomass residues from other applications ($LE_{BR,DIV,y}$)

This section is applicable for project activities which utilise biomass residues. It quantifies leakage due to diversion of biomass residues to the project to be used as either fuel or feedstock. These biomass residues could have been used outside the project boundary in competing applications, and due to the implementation of the project activity these competing application might be forced to use inputs which are not carbon neutral.

5.2.1 Determination of the alternative scenario of the biomass residues in absence of the project activity

Determining the alternatives of the remaining biomass in the absence of project activities, there are four options:

- (a) B1: The biomass residues are dumped or left to decay mainly under aerobic conditions. This applies, for example, to dumping and decay of biomass residues on fields;
- (b) B 2: The biomass residues are dumped or left to decay under clearly anaerobic conditions. This applies, for example, to landfills which are deeper than five meters. This does not apply to biomass residues that are stock-piled or left to decay on fields;
- (c) B3: The biomass residues are burnt in an uncontrolled manner without utilizing it for energy purposes;
- (d) B4: The biomass residues are used for energy or non-energy applications, or the primary

source of the biomass residues and/or their fate cannot be clearly identified.¹

Project proponents may choose to combine some or all relevant biomass types into one category when determining the fate of biomass residues, and treat the combined types as one, for instance in the biomass availability determination. These combinations shall be documented transparently in the PDD and remain consistent throughout the crediting period

When defining plausible and credible alternative scenarios for the use of biomass residues, the guidance below shall be followed:

- (a) If the biomass residues processing (drying, pelletization, shredding, briquetting, etc.) is not included in the project boundary, the processed biomass obtained from that plant should be considered as B4 above;
- (b) The alternative scenario for the categories of biomass residues identified according to paragraphs 50 and 51 above should be separately identified, covering the whole amount of biomass residues supposed to be used in the project activity along the crediting period;
- (c) A category of biomass residues is defined by three attributes: (1) its type or types (i.e. bagasse, rice husks, empty fruit bunches, etc.); (2) its source (e.g. produced on-site, obtained from an identified biomass residues producer, obtained from a biomass residues market, etc.); and (3) its alternative scenario in the absence of the project activity (scenarios B1 to B4 above);
- (d) Explain and document transparently in PDD, using a table similar to Table 1 from Appendix 2, what quantities of which biomass residues categories are used in which installation(s) under the project activity and what is their alternative scenario;
- (e) For biomass residues categories for which scenarios B1, B2 or B3 are deemed a plausible alternative scenario, the following procedures should be applied for the combined amount of biomass identified:
 - (i) Demonstrate that there is an abundant surplus of the biomass residue in the project region which is not utilized. For this purpose, demonstrate that the total quantity of that type of biomass residues annually available in the project region is at least 25

¹ For example, this scenario can be used if biomass residues are purchased from a market, or biomass residues retailers, or if processed biomass is purchased from biomass processing plants which are not included in the project boundary.

per cent larger than the quantity of biomass residues which is utilized annually in the project region (e.g. for energy generation or as feedstock), including the project facility;

- (ii) Demonstrate for the sites from where biomass residues are sourced that the biomass residues have not been collected or utilized (e.g. as fuel, fertilizer or feedstock) but have been dumped and left to decay, land-filled, left in the field to decay after harvest,¹ or burnt without energy generation (e.g. field burning). This approach is only applicable to biomass residues categories for which project participants can clearly identify the site from where the biomass residues are sourced;
- (iii) In case surplus of biomass residues in the project region cannot be demonstrated, the alternative use of the biomass shall be considered unknown (B4) and result in leakage emissions.

If during the crediting period, new categories of biomass residues of the type B1, B2 or B3 are used in the project activity which were not listed at the validation stage, for example due to new sources of biomass residues, the alternative scenario for those types of biomass residues should be assessed using the procedures outlined in this tool for each new category of biomass residues.

5.2.2 Calculation of leakage emission due to diversion of biomass residues

The main potential source of leakage due to biomass residues is an increase in emissions from fossil fuel combustion or other sources due to diversion of biomass residues from other uses to the project plant as a result of the project activity. The alternative scenario for biomass residues for which this potential leakage is relevant is B4.

The actual leakage emissions in each of these cases may differ significantly and depend on the specific situation of each project activity. For that reason, a simplified approach is used in this tool: it is assumed that an equivalent amount of fossil fuels, on energy basis, would be used if biomass residues are diverted from other users, no matter what the use of biomass residues would be in the alternative scenario.

Therefore, for the categories of biomass residues whose alternative scenario has been identified as B4, project participants shall calculate leakage emissions as follows:

¹ Project proponents shall demonstrate the fraction of biomass which exceeds the function of refertilising the soil, as only this part of the biomass may be considered unutilised.

$$LE_{BR,Div,y} = EF_{CO_2,LE} \times \sum BR_{PJ,n,yn} \times NCV_{n,y} \quad \text{Equation (39)}$$

Where;

$LE_{BR,Div,y}$ = Leakage emissions due to the diversion of biomass residues from other applications in year y (tCO₂)

$EF_{CO_2,LE}$ = CO₂ emission factor of the most carbon intensive fossil fuel (kgCO₂/TJ)

$BR_{PJ,n,yn}$ = Quantity of biomass residues of category n used in facilities which are located at the project site and included in the project boundary in year y (tonnes on dry-basis)

$NCV_{n,y}$ = Net calorific value of the biomass residues of category n in year y (GJ/tonne of dry matter)

n = Categories of biomass residues for which B4 has been identified as the alternative scenario

The determination of $BR_{PJ,n,y}$ shall be based on the monitored amounts of biomass residues used in facilities included in the project boundary.

5.3 Leakage emission due to the transportation of biomass residues outside of the project boundary ($LE_{BRT,y}$)

Leakage due to the transportation of biomass residues outside of the project boundary ($LE_{BRT,y}$) are estimated as follows:

$$LE_{BRT,y} = \sum_f D_{f,m} \times FR_{f,m} \times EF_{CO_2,f} \times 10^{-6} \quad \text{Equation (40)}$$

Where;

$LE_{BRT,y}$ = Project emissions resulting from transportation of biomass residues in period m (tCO₂)

$D_{F,m}$ = Return trip distance between the origin and destination of freight transportation activity f in monitoring period m (km)

$F_{Rf,m}$ = Total mass of freight transported in freight transportation activity f in monitoring period m (t)

- $EF_{CO_2,f}$ = Default CO₂ emission factor for freight transportation activity f (g CO₂/tkm)
 f = Freight transportation activities conducted in the project activity in monitoring period m

By $D_{F,m}$, considering the following transport routes

- (i) If the biomass produced is utilized without further processing, the route shall include only the transport of the biomass between the biomass production site and the biomass utilization facility;
- (ii) If the biomass is processed before being utilized, the routes shall include the transport between (i) the biomass production site and the biomass processing facility, and (ii) the biomass processing facility and the biomass utilization facility;

As an alternative to the monitoring of the parameters needed to calculate the emissions from the transportation, project proponents may apply the following options:

- (a) For microscale and small-scale project activities, apply a default emission factor of 0.0142 tCO₂/tonne of biomass
- (b) For large-scale project activities, apply a net-to-gross adjustment of 10%, i.e. multiply the emission reductions determined based on the applied methodology by 0.9 to determine the final amount of emission reductions that can be claimed.

5.4 Leakage emission due to processing of biomass residues outside the project boundary ($LE_{BRP,y}$)

If processing of biomass residues is done outside the project boundary, the requirements and equations in Section 4.3.1 and 4.3.2 shall be followed for estimation of leakage emissions, where:

- (a) The parameter $PE_{BRP,electricity,y}$ corresponds to $LE_{EC,y}$
- (b) The parameter $PE_{BRP,fuel,y}$ corresponds to $PE_{FC,j,y}$
- (c) The parameter $PE_{BRP,CH_4,y}$ corresponds to $LE_{CH_4,SWDS,y}$
- (d) The parameter $PE_{BRP,COMP,y}$ corresponds to $LE_{COMP,y}$
- (e) The parameter $PE_{BRP,AD,y}$ corresponds to $LE_{AD,y}$

6. Monitoring Plan

6.1 Data and parameters not monitored

6.1.1 Data and parameters not monitored from biomass cultivation.

| | |
|-------------------------|---|
| Parameter: | Pre-project land use |
| Data unit; | Dimensionless |
| Description; | Service level of the pre-project land use |
| Source of data: | Land management records, records of the relevant local authority, stakeholders' interviews etc. |
| Measurement procedures: | - |
| Any comment; | - |

6.1.2 Data and parameters not monitored from biomass residuals.

| | |
|-------------------------|--|
| Parameter: | Biomass residues categories and quantities used in the project activity |
| Data unit; | (a) Type (i.e. bagasse, rice husks, empty fruit bunches, etc.); (b) Source (e.g. produced on-site, obtained from an identified biomass residues producer, obtained from a biomass residues market, etc.); (c) Fate in the absence of the project activity (Scenario B); (d) Use in the project scenario |
| Description; | <p>Explain and document transparently in the PDD, using a table similar to table 1 from Appendix 2 which quantities of which biomass residues categories are used in which installation(s) under the project activity and what is their alternative scenario.</p> <p>The last column of table 1 from Appendix 2 corresponds to the quantity of each category of biomass residues (tonnes on dry-basis). These quantities should be updated every year of the crediting period. This reflects the actual use of biomass residues in the project scenario. These updated values should be used for leakage calculations if the determined alternative fate indicates associated leakage emissions. Along the crediting period, new categories of biomass residues (i.e. new types, new sources, with different fate) can be used in the project activity. In this case, a new line should be added to the table. If those new categories are of the type B1, B2 or B3, the alternative scenario for those types of biomass residues should be assessed using the procedures outlined in the guidance provided in the procedure for the determination of the alternative scenario</p> |
| Measurement procedures: | - |
| Any comment; | - |

| | |
|-------------------------|--|
| Parameter: | $B_{0,ww}$ |
| Data unit; | t_{CH_4}/t_{COD} |
| Description; | Maximum methane producing capacity, expressing the maximum amount of CH ₄ that can be produced from a given quantity of chemical oxygen demand (COD) |
| Source of data: | Table 6.8 from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| Measurement procedures: | No measurement procedures. The default IPCC values for B ₀ from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories shall be properly justified |
| Any comment; | - |

6.3.2 Data and parameters not monitored from transportation.

| Parameter: | $EF_{CO_2,f}$ | | | | | | |
|-------------------------|---|---------------|--|----------------|-----|----------------|-----|
| Data unit; | gCO_2/tkm | | | | | | |
| Description; | Default CO ₂ emission factor for freight transportation activity f | | | | | | |
| ค่าที่ใช้ | <table border="1"> <thead> <tr> <th>Vehicle class</th> <th>Emission factor (g CO₂/tkm)</th> </tr> </thead> <tbody> <tr> <td>Light vehicles</td> <td>245</td> </tr> <tr> <td>Heavy vehicles</td> <td>129</td> </tr> </tbody> </table> | Vehicle class | Emission factor (g CO ₂ /tkm) | Light vehicles | 245 | Heavy vehicles | 129 |
| Vehicle class | Emission factor (g CO ₂ /tkm) | | | | | | |
| Light vehicles | 245 | | | | | | |
| Heavy vehicles | 129 | | | | | | |
| Source of data: | - | | | | | | |
| Measurement procedures: | - | | | | | | |
| Any comment; | <p>Applicable to Option B. The default CO₂ emission factors take into account emissions generated by loaded outbound trips and empty return trips. The default emission factors have been obtained from two sources. For light vehicles, the emission factor was obtained from empirical data from European vehicles.⁴ For heavy vehicles, the emission factor has been derived based on custom design transient speed-time-gradient drive cycle (adapted from the international FIGE cycle), vehicle dimensional data, mathematical analysis of loading scenarios, and dynamic modelling based on engine power profiles, which, in turn, are a function of gross vehicle mass (GVM), load factor, speed/acceleration profiles and road gradient. The following assumptions on key parameters have been made: an average driving speed of 30 km/h, an average gradient of 1%, and a load factor attained when biomass⁵ is transported were assumed.</p> <p>Note:</p> <p>¹ CO₂ emissions by French heavy goods vehicles between 1996 and 2006 increased less rapidly than volumes transported. General Commission for Sustainable Development. #25, 2009.</p> | | | | | | |

| | |
|--|---|
| | <p>² Biomass is commonly transported material in existing CDM projects where transportation is not the main project activity. Due to a low bulk density of biomass, volumetric loading was used to derive the emission factor assuming that project proponents will extend the height of side panels to the height of 2.4 m to maximize their trip efficiency.</p> |
|--|---|

6.3.4 Data and parameters not monitored from composting

| | |
|----------------------|---|
| Parameter: | $B_{0,ww}$ |
| Data unit; | t CH ₄ / t COD |
| Description; | Default methane producing capacity of the wastewater |
| Source of data: | IPCC 2006 Guidelines for National Greenhouse Gas Inventories |
| Value to be applied: | 0.25 |
| Any comment; | Applicable to the step "Determination of project emissions from run-off wastewater ($PE_{RO,y}$)" |

| | |
|----------------------|--|
| Parameter: | $EF_{CH4,default}$ |
| Data unit; | tCH ₄ /t |
| Description; | Default emission factor of methane per tonne of waste composted (wet basis) |
| Source of data: | The emission factor was selected based on studying published results of emission measurements from composting facilities, literature reviews on the subject and published emission factors. Data from recent, high quality sources was analyzed and a value conservatively selected from the higher end of the range in results. |
| Value to be applied: | 0.002 |
| Any comment; | Applicable to Option 2 in the step "Determination of methane and nitrous oxide emissions from the composting process" |

| | |
|----------------------|---|
| Parameter: | $EF_{N2O,default}$ |
| Data unit; | tN ₂ O/t |
| Description; | Default emission factor of nitrous oxide per tonne of waste composted (wet basis) |
| Source of data: | The emission factor was selected based on studying published results of emission measurements from composting facilities, literature reviews on the subject and published emission factors. Data from recent, high quality sources was analyzed and a value conservatively selected from the higher end of the range in results |
| Value to be applied: | 0.0002 |

| | |
|--------------|---|
| Any comment; | Applicable to Option 2 in the step "Determination of methane and nitrous oxide emissions from the composting process" |
|--------------|---|

| | |
|----------------------|--|
| Parameter: | $SEC_{COMP, default}$ |
| Data unit; | MWh/t |
| Description; | Default value for the specific quantity of electricity consumed per tonne of waste composted |
| Source of data: | Based on a review of information from relevant validation reports of CDM projects |
| Value to be applied: | 0.01 |
| Any comment; | Applicable to the step "Determination of project emissions from electricity consumption ($PE_{EC,y}$)" |

| Parameter: | $MCF_{ww, treatment}$ | | | | | | | | | | | | | | | | | | |
|--|--|--|-----------|---|-----|---------------------------------|-----|---|-----|--|-----|--|-----|---|-----|--|-----|---------------|-----|
| Data unit; | - | | | | | | | | | | | | | | | | | | |
| Description; | Default methane correction factor for the wastewater treatment system where the | | | | | | | | | | | | | | | | | | |
| Source of data: | Default values from chapter 6 of volume 5. Waste in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (see Table 2 below) | | | | | | | | | | | | | | | | | | |
| Value to be applied: | <p>Use the default values below corresponding to the type of wastewater treatment system. If this is not possible, then as a conservative estimation, waste water treatment can be assumed to take place under completely anaerobic conditions, where $MCF_{ww, treatment}$ equals to 1.</p> <p>Table 2: IPCC default values for MCF</p> <table border="1"> <thead> <tr> <th>Type of wastewater treatment and discharge pathway or system</th> <th>MCF value</th> </tr> </thead> <tbody> <tr> <td>Discharge of wastewater to sea, river or lake</td> <td>0.1</td> </tr> <tr> <td>Aerobic treatment, well managed</td> <td>0.0</td> </tr> <tr> <td>Aerobic treatment, poorly managed or overloaded</td> <td>0.3</td> </tr> <tr> <td>Anaerobic digester for sludge without methane recovery</td> <td>0.8</td> </tr> <tr> <td>Anaerobic reactor without methane recovery</td> <td>0.8</td> </tr> <tr> <td>Anaerobic shallow lagoon (depth less than 2 metres)</td> <td>0.2</td> </tr> <tr> <td>Anaerobic deep lagoon (depth more than 2 metres)</td> <td>0.8</td> </tr> <tr> <td>Septic system</td> <td>0.5</td> </tr> </tbody> </table> | Type of wastewater treatment and discharge pathway or system | MCF value | Discharge of wastewater to sea, river or lake | 0.1 | Aerobic treatment, well managed | 0.0 | Aerobic treatment, poorly managed or overloaded | 0.3 | Anaerobic digester for sludge without methane recovery | 0.8 | Anaerobic reactor without methane recovery | 0.8 | Anaerobic shallow lagoon (depth less than 2 metres) | 0.2 | Anaerobic deep lagoon (depth more than 2 metres) | 0.8 | Septic system | 0.5 |
| Type of wastewater treatment and discharge pathway or system | MCF value | | | | | | | | | | | | | | | | | | |
| Discharge of wastewater to sea, river or lake | 0.1 | | | | | | | | | | | | | | | | | | |
| Aerobic treatment, well managed | 0.0 | | | | | | | | | | | | | | | | | | |
| Aerobic treatment, poorly managed or overloaded | 0.3 | | | | | | | | | | | | | | | | | | |
| Anaerobic digester for sludge without methane recovery | 0.8 | | | | | | | | | | | | | | | | | | |
| Anaerobic reactor without methane recovery | 0.8 | | | | | | | | | | | | | | | | | | |
| Anaerobic shallow lagoon (depth less than 2 metres) | 0.2 | | | | | | | | | | | | | | | | | | |
| Anaerobic deep lagoon (depth more than 2 metres) | 0.8 | | | | | | | | | | | | | | | | | | |
| Septic system | 0.5 | | | | | | | | | | | | | | | | | | |
| Any comment; | Applicable to the step "Determination of emissions from run-off wastewater ($PE_{RO,y}$)" | | | | | | | | | | | | | | | | | | |

| | |
|------------|-----------|
| Parameter: | φ |
|------------|-----------|

| | |
|----------------------|--|
| Data unit; | - |
| Description; | Default model correction factor to account for model uncertainties of methane emissions from run-off wastewater |
| Source of data: | Default value from Draft Decisions on Methodological Issues Relating To Articles 5, 7 And 8 Of The Kyoto Protocol (Agenda Item 4 (B)) (FCCC/SBSTA/2003/10/Add.2, page 25) |
| Value to be applied: | 1.12 |
| Any comment; | An assigned uncertainty band of 40 % was assumed when selecting this default value from the source referenced above. Applicable to the step "Determination of emissions from run-off wastewater ($PE_{RO,y}$)" |

| | |
|----------------------|---|
| Parameter: | $DF_{COD,RO}$ |
| Data unit; | - |
| Description; | Default factor for the ratio of the amount of COD in run-off wastewater and wastewater co-composted |
| Source of data: | Based on a review of data in validated CDM projects |
| Value to be applied: | 0.02 |
| Any comment; | Applicable to Option 2 of the step "Determination of emissions from run-off wastewater ($PE_{RO,y}$)" |

6.3.5 Data and parameters not monitored from anaerobic digesters

| | |
|----------------------|---|
| Parameter: | $f_{CH_4,default}$ |
| Data unit; | $m^3 CH_4 / m^3$ biogas corrected to Reference conditions are defined as 0°C (273.15 K, 32°F) and 1 atm (101.325 kN/m ² , 101.325 kPa, 14.69 psia, 29.92 in Hg, 760 torr). |
| Description; | Default value for the fraction of methane in the biogas |
| Source of data: | The default value was derived based on reported values from registered projects and research papers (Davidsson, 2007) |
| Value to be applied: | 0.6 |
| Any comment; | Use this value for Option 2 of the step "Determination of the quantity of methane produced in the digester" |

| | |
|--------------|---|
| Parameter: | ρ_{CH_4} |
| Data unit; | $tCH_4 / m^3 CH_4$ |
| Description; | Density of methane at normal conditions |

| | |
|----------------------|---|
| Source of data: | 'Thermophysical properties of fluids. II. Methane, Ethane, Propane, Isobutane and Normal Butane' by B.A. Younglove, J.F. Ely < https://www.nist.gov/sites/default/files/documents/srd/jpcrd331.pdf > |
| Value to be applied: | 0.00067 |
| Any comment; | corrected to reference conditions |

| | |
|----------------------|--|
| Parameter: | $EF_{CH_4, default}$ |
| Data unit; | tCH ₄ leaked/tCH ₄ produced |
| Description; | Default emission factor for the fraction of CH ₄ produced that leaks from the anaerobic digester |
| Source of data: | IPCC (2006), Flesch et al. (2011) and Kurup (2003) |
| Value to be applied: | Use the default value corresponding to the type of digester used in the project activity. The digester type shall be identified by manufacturer information. If this is not possible, then the factor 0.1 shall be applied (upper range of the IPCC values). (a) 0.028: Digesters with steel or lined concrete or fiberglass digesters and a gas holding system (egg shaped digesters) and monolithic construction; (b) 0.05: UASB type digesters, floating gas holders with no external water seal; (c) 0.10: Digesters with unlined concrete/ferrocement/brick masonry arched type gas holding section; monolithic fixed dome digesters, covered anaerobic lagoon |
| Any comment; | Applicable to the step "Determination of project emissions of methane from the anaerobic digester" |

| | |
|----------------------|---|
| Parameter: | B_o |
| Data unit; | tCH ₄ /tCOD |
| Description; | Maximum CH ₄ producing capacity of the COD applied |
| Source of data: | 2006 IPCC Guidelines |
| Value to be applied: | 0.25 |
| Any comment; | - |

6.2 Data and parameters to be monitored

6.2.1 Data and parameters to be monitored from project emission and leakage emissions from biomass

| | |
|------------|-------------|
| Parameter: | $A_{SOC,i}$ |
| Data unit; | rai |

| | |
|-------------------------|---|
| Description; | Area of land stratum I |
| Source of data: | Measurement by project participants |
| Measurement procedures: | Standard land area measurement methods applicable in the host party |
| Monitoring frequency: | Annual |
| QA/QC procedures: | Check that standard land area measurement methods applicable in the host party country are used |
| Any comment; | - |

| | |
|-------------------------|--|
| Parameter: | $q_{N,y}$ |
| Data unit; | tN/rai |
| Description; | Rate of nitrogen applied in year y |
| Source of data: | Land management records maintained by project participants and fertilizer composition information from supplier, study or independent laboratory. Alternatively, the default conservative value of 0.20 t N/rai per year may be used |
| Measurement procedures: | - |
| Monitoring frequency: | Annual |
| QA/QC procedures: | Cross-check records of applied quantities with purchase receipts and inventory |
| Any comment; | Nitrogen applied through the following methods shall be added up to arrive at this value: (i) synthetic fertilisers; (ii) organic manure; (iii) return of the residues or cover crops |

| | |
|-------------------------|---|
| Parameter: | $A_{FTM,y}$ |
| Data unit; | rai |
| Description; | Area of land subjected to soil fertilization and management in year y |
| Source of data: | Measurement by project participants |
| Measurement procedures: | Standard land area measurement methods applicable in the host party |
| Monitoring frequency: | Annual |
| QA/QC procedures: | Check that standard land area measurement methods applicable in the host party are used |
| Any comment; | - |

| | |
|-----------------|--|
| Parameter: | $q_{SA,i,y}$ |
| Data unit; | t/rai |
| Description; | Rate of application of soil amendment agent type i in year y |
| Source of data: | Land management records maintained by project participants |
| Measurement | - |

| | |
|-----------------------|--|
| procedures: | |
| Monitoring frequency: | Annual |
| QA/QC procedures: | Cross-check records of applied quantities with purchase receipts and inventory |
| Any comment; | - |

| | |
|-------------------------|---|
| Parameter: | $A_{SA,i,y}$ |
| Data unit; | rai |
| Description; | Area of land in which soil amendment agent type i is applied in year y |
| Source of data: | Measurement by project participants |
| Measurement procedures: | Standard land area measurement methods applicable in the host party |
| Monitoring frequency: | Annual |
| QA/QC procedures: | Check that standard land area measurement methods applicable in the host party are used |
| Any comment; | - |

| | |
|-------------------------|---|
| Parameter: | $A_{FR,i,y}$ |
| Data unit; | rai |
| Description; | Area of stratum i of land subjected to fire in year y |
| Source of data: | Measurement by project participants |
| Measurement procedures: | Standard land area measurement methods applicable in the host party |
| Monitoring frequency: | Annual |
| QA/QC procedures: | Check that standard land area measurement methods applicable in the host party are used |
| Any comment; | - |

| | |
|-------------------------|---|
| Parameter: | b_i |
| Data unit; | t dry matter/rai |
| Description; | Fuel biomass consumption per hectare in stratum i of land subjected to fire |
| Source of data: | Measurement by project participants. Alternatively, the default 'average above-ground biomass content in forest' values from Table 3A.1.4 of the Good Practice Guidance for Land Use, Land-Use Change and Forestry (IPCC-GPG-LULUCF 2003) |
| Measurement procedures: | Measurement may be carried out through sample plots |
| Monitoring frequency: | Annual |
| QA/QC procedures: | If sample plots are used, the estimated mean value should not have an uncertainty of greater than 10 per cent at 90 per cent confidence level |
| Any comment; | - |

| | |
|-------------------------|---|
| Parameter: | R_i |
| Data unit; | Dimensionless |
| Description; | Root-shoot ratio (i.e. ratio of below-ground biomass to above-ground biomass) for stratum i of land subjected to clearance or fire |
| Source of data: | Measurement by project participants. Alternatively, the default values from Table 4.4 of the 2019 Refinement to the 2006 IPCC Guidelines for National GHG Inventories may be used |
| Measurement procedures: | Measurement may be carried out through sample plots |
| Monitoring frequency: | Annual |
| QA/QC procedures: | If sample plots are used, the estimated mean value should not have an uncertainty of greater than 10% at 90% confidence level |
| Any comment; | - |

| | |
|-------------------------|---|
| Parameter: | Land use |
| Data unit; | variable |
| Description; | Service level of the project land use |
| Source of data: | - |
| Measurement procedures: | - |
| Monitoring frequency: | Annually |
| QA/QC procedures: | - |
| Any comment; | The service level of the project land use shall at least provide the pre- project service level, otherwise leakage shall be accounted for |

For biomass residuals, the table of data and the parameters for the project activity are not available, the table of parameters is applied.

| | |
|-------------------------|--|
| Parameter: | $BRP_{j,n,y}$ |
| Data unit; | tonnes on dry-basis |
| Description; | Quantity of biomass residues of category n used in facilities which are located at the project site and included in the project boundary in year y |
| Source of data: | On-site measurements |
| Measurement procedures: | Use weight meters. Adjust by the moisture content in order to determine the quantity of dry biomass |
| Monitoring frequency: | Data monitored continuously and aggregated as appropriate, to calculate emissions reductions |

| | |
|-------------------|--|
| QA/QC procedures: | Cross-check the measurements with an annual energy balance that is based on purchased quantities and stock changes |
| Any comment; | <p>The biomass residue quantities used should be monitored separately for (a) each type of biomass residue (e.g.) and each source (e.g. produced on-site, obtained from biomass residues suppliers, obtained from a biomass residues market, obtained from an identified biomass residues producer, etc.).</p> <p>In case of missing data of up to 30 consecutive days within six consecutive months one of the following options may be used to estimate the quantity of biomass:</p> <ol style="list-style-type: none"> 1. an annual mass balance that is based on purchased or collected quantities and stock changes; 2. calculated based on the carrying capacity of each truck delivering biomass (moisture content and density shall be known); 3. The highest value of the parameter for the same calendar period of the previous years. <p>These options are applicable for project activities or PoAs, where end users of the subsystems or measures are households/communities/small and medium enterprises (SMEs)</p> |

| | |
|-------------------------|--|
| Parameter: | NCV _{n,y} |
| Data unit; | GJ/tonnes on dry-basis |
| Description; | Net calorific value of biomass residues of category <i>n</i> in year <i>y</i> |
| Source of data: | On-site measurements |
| Measurement procedures: | Measurements shall be carried out at reputed laboratories and according to relevant international standards. Measure the NCV on dry-basis |
| Monitoring frequency: | At least every six months, taking at least three samples for each measurement |
| QA/QC procedures: | <p>Check the consistency of the measurements by comparing the measurement results with measurements from previous years, relevant data sources (e.g. values in the literature, values used in the national GHG inventory) and default values by the IPCC.</p> <p>If the measurement results differ significantly from previous measurements or other relevant data sources, conduct additional measurements, and ensure that the NCV is determined on the basis of dry biomass</p> |
| Any comment; | <p>The proposed sampling plan shall ensure that samples are randomly selected and are representative of the population.</p> <p>In case of missing data, the following can be used for project activities or PoAs, where end users of the subsystems or measures are households/communities/small and medium enterprises (SMEs):</p> <ul style="list-style-type: none"> ● IPCC default values at the upper limit of the uncertainty at a 95 per cent |

| | |
|--|--|
| | confidence interval as provided in table 1.2 of Chapter1 of Vol. 2 (Energy) of the 2006 IPCC Guidelines on National GHG Inventories; or The highest value from the previous monitoring periods of the same biomass type |
|--|--|

| | |
|-------------------------|--|
| Parameter: | Moisture content of the biomass residues |
| Data unit; | Percentage of water content in mass basis in wet biomass residues |
| Description; | Moisture content of each biomass residues type <i>n</i> |
| Source of data: | On-site measurements |
| Measurement procedures: | - |
| Monitoring frequency: | The moisture content should be monitored for each batch of biomass of homogeneous quality. The weighted average should be calculated for each monitoring period and used in the calculations |
| QA/QC procedures: | - |
| Any comment; | - |

| | |
|-------------------------|--|
| Parameter: | $EF_{CO_2,LE}$ |
| Data unit; | tCO ₂ /GJ |
| Description; | CO ₂ emission factor of the most carbon intensive fuel used in the country |
| Source of data: | Identify the most carbon intensive fuel type from the national communication, other literature sources (e.g. IEA). Possibly consult with the national agency responsible for the national communication/GHG inventory. If available, use national default values for the CO ₂ emission factor. Otherwise, IPCC default values may be used |
| Measurement procedures: | - |
| Monitoring frequency: | Annually |
| QA/QC procedures: | - |
| Any comment; | - |

6.2.2 Data and parameters to be monitored from electricity consumption

| | |
|-----------------|--|
| Parameter: | $EC_{P,j,y}$ |
| Data unit; | MWh/year |
| Description; | Quantity of electricity consumed by the project electricity consumption source <i>j</i> in year <i>y</i> |
| Source of data: | Plant records |

| | |
|-------------------------|---|
| Measurement procedures: | Measured by kWh Meter and continuously measured throughout the follow-up period. (Amount of electricity deducted from electricity generation for own use before being supplied to the transmission line) |
| Monitoring frequency: | continuous monitoring and at least monthly recording |

| | |
|-------------------------|--|
| Parameter: | TDL |
| Data unit; | - |
| Description; | Average technical transmission and distribution losses for providing electricity to source j in year y |
| Source of data: | Option 1 Measurement Report In the case of information on the amount of electricity released from the producer and the amount of electricity received by the consumer Option 2 uses a Default Value of 0.03 (3%). |
| Measurement procedures: | 1) If using Option 1, the project developer will have to monitor the value every year throughout the monitoring of greenhouse gas emissions reductions. 2) If using Option 2, the project developer must use this value throughout the monitoring of greenhouse gas emissions reductions. |
| Monitoring frequency: | Defined once in the first year of the credit period. |
| QA/QC procedures: | If the measurement results differ from previous measurements or other sources that are significantly related make additional measurements. |
| Any comment; | - |

| | |
|-------------------------|---|
| Parameter: | $EF_{grid,y}$ |
| Data unit; | tCO ₂ /MWh |
| Description; | Combined margin CO ₂ emission factor for grid connected power generation in year y |
| Source of data: | Report on greenhouse gas emissions (Emission Factor) from electricity generation in the power grid and from heat generation for projects and greenhouse gas reduction activities announced by TGO. |
| Measurement procedures: | <p><u>For the preparation of project proposal documents</u></p> <p>use the latest $EF_{grid,y}$ announced by TGO</p> <p><u>For monitoring the results of reducing greenhouse gas emissions</u></p> <p>Use the $EF_{grid,y}$ values announced by TGO according to the year of the carbon credit certification period. However, in the case that the year of the Carbon Credit certification period does not have $EF_{grid,y}$ values announced by TGO, use the latest $EF_{grid,y}$ values announced by TGO in that year instead.</p> |

6.2.3 Data and parameters to be monitored from transportation

| | |
|-------------------------|--|
| Parameter: | $D_{f,m}$ |
| Data unit; | kilometre |
| Description; | Return trip distance between the origin and destination of freight transportation activity f in monitoring period m |
| Source of data: | Records of vehicle operator or records by project participants |
| Measurement procedures: | Determined once for each freight transportation activity f for a reference trip using the vehicle odometer or any other appropriate sources (e.g. on-line sources) |
| Monitoring frequency: | To be updated whenever the distance changes |
| QA/QC procedures: | - |
| Any comment; | Applicable to Option B |

| | |
|-------------------------|---|
| Parameter: | $FR_{f,m}$ |
| Data unit; | tonnes |
| Description; | Total mass of freight transported in freight transportation activity f in monitoring period m |
| Source of data: | Records by project participants or records by truck operators |
| Measurement procedures: | - |
| Monitoring frequency: | Continuously |
| QA/QC procedures: | - |
| Any comment; | Applicable to Option B |

6.2.4 Data and parameters to be monitored from composting

| | |
|-------------------------|--|
| Parameter: | Q_y |
| Data unit; | t/yr |
| Description; | Quantity of waste composted in year y (wet basis) |
| Measurement procedures: | Use a weighbridge or any other applicable and calibrated weighing device, e.g. belt-scales |
| Monitoring frequency: | Continuously |
| QA/QC procedures: | Weighbridge or any other applicable weighing device is subject to periodic calibration (in accordance with stipulation of the weighing device supplier) in case option 1 in the step |

| | |
|--------------|--|
| Any comment; | <p>In case the data from weighbridge or any other applicable and calibrated weighing device available on site are missing for up to 30 consecutive days within six consecutive months, one of the following options to estimate quantity of waste composted can be applied:</p> <ul style="list-style-type: none"> a) Option 2 from the step “Determination of the quantity of waste composted”; b) The highest value of the parameter for the same calendar period of the previous years <p>These options are applicable for project activities or PoAs, where end users of the subsystems or measures are households/communities/small and medium enterprises (SMEs)</p> |
|--------------|--|

| | |
|-------------------------|--|
| Parameter: | $CT_{t,y}$ |
| Data unit; | t |
| Description; | Carrying capacity of each truck delivering waste to the composting installation in year y |
| Measurement procedures: | The maximum carrying capacity as stated on the truck’s nameplate is registered by personnel at the entrance gate of the composting installation. |
| Monitoring frequency: | Register maximum carrying capacity of every truck delivery for the year y |
| QA/QC procedures: | - |
| Any comment; | Applicable to Option 2 in the step “Determination of the quantity of waste composted” |

| | |
|-------------------------|--|
| Parameter: | Q_c |
| Data unit; | t |
| Description; | Quantity of waste composted in composting cycle c (wet basis) |
| Measurement procedures: | Weighed using weighbridge or any other applicable and calibrated weighing device, e.g. belt-scales |
| Monitoring frequency: | Measure the weight of waste for every truck delivery and aggregate for the same composting cycle for which $ECC_{CH_4,c}$ or $ECC_{N_2O,c}$ is being estimated |
| QA/QC procedures: | Weighbridge or any other applicable weighing device is subject to periodic calibration (in accordance with stipulation of the weighing device supplier). |
| Any comment; | <p>This is the specific amount of waste treated for the composting cycle c that emission measurements are made for ($ECC_{CH_4,c}$, $ECC_{N_2O,c}$)</p> <p>Applicable to Option 1 in the step “Determination of methane and nitrous oxide emissions from the composting process”</p> |

| | |
|-------------------------|--|
| Parameter: | $ECC_{CH_4,c}$, $ECC_{N_2O,c}$ |
| Data unit; | tCH ₄ , tN ₂ O |
| Description; | Methane and nitrous oxide emissions from the composting installation during the composting cycle c |
| Measurement procedures: | <p>Measurement procedures are specified for closed composting installations and non-closed composting installations:</p> <p>Closed composting installation. Choose between the following two options to measure emissions from a closed-composting system for composting cycle c:</p> <ul style="list-style-type: none"> Option 1: Measure methane and/or nitrous oxide concentrations, gas velocity, temperature and pressure in the exhaust pipe using appropriate analytical equipment (e.g. FID, IR, FTIR). Gas flow can be calculated from gas velocity and exhaust pipe diameter and has to be corrected for pressure and temperature. Methane and nitrous oxide emissions are obtained by integrating the product of gas flow and methane and nitrous oxide concentrations in the gas over the entire duration of the measurement (one composting cycle) Option 2: Use the TVER-TOOL-02-05 “Tool to calculate the mass flow of a greenhouse gas in a gaseous stream” latest edition with the following conditions <ul style="list-style-type: none"> The gaseous stream the tool shall be applied to is the exhaust gas from the closed composting installation CH₄ and/or N₂O are the greenhouse gases for which the mass flow should be determined; The flow of the gaseous stream should be measured on an hourly basis or a smaller time interval; and The simplification offered for calculating the molecular mass of the gaseous stream is valid (equations 3 or 17 in the tool) <p>Non-closed composting installation (windrows). Measure emissions using a flux box. In a flux box measurement, the concentration increase of CH₄ and/or N₂O in the box is measured over time and the emission flux from the surface covered by the box is calculated (kilogram CH₄ or N₂O per square meter per hour). From the measurements made during the cycle, an overall emission flux value can be determined. Emissions during the composting cycle can then be calculated over the time of the composting cycle and the total surface area of the windrow (kg per windrow per hour)</p> <p>The measurements shall be conducted as follows:</p> <p>Select measurement sites (at least 10 measurement sites per windrow)</p> <ul style="list-style-type: none"> Identify at least two measurement cross sections (across the width), which are spaced equally along the length of the windrow; |

| | |
|-----------------------|---|
| | <ul style="list-style-type: none"> In each cross-section, identify five measurement locations spaced equally apart; two on each side of the windrow, and one on the top. <p>Measurement frequency</p> <ul style="list-style-type: none"> Perform at least five measurement events in each measurement site of the windrow during a composting cycle (resulting in at least 50 individual measurements). Measurement events must be at regular time intervals during the composting cycle. <p>Identify and repeat invalid measurements</p> <ul style="list-style-type: none"> Make measurements at each measurement site over at least a continuous one-minute period, with consecutive concentration readings stored at a frequency of at least one per second; Identify if concentration increase is constant in time. If it is constant, then the measurement is valid. If the rate of increase is not constant, then this indicates a build-up of pressure in the flux box and the measurement is invalid and must be repeated <p>Identify the overall flux rate for the composting cycle</p> <ul style="list-style-type: none"> Identify the 80% confidence interval for all measurement made during a composting cycle (this is at least 50 measurements); Identify an overall flux rate as the upper value in the 80% confidence interval <p>Note: When measuring emissions using a flux box, the use of SF6 is strictly banned</p> |
| Monitoring frequency: | Measure at least one composting cycle per climatic season, and at least two cycles in one climatic season. This means there are at least three measurements of $ECC_{CH_4,cc}/ECC_{N_2O,cc}$ in each year in the case of two seasons |
| QA/QC procedures: | <p>Closed composting installation:</p> <p>According to the TVER-TOOL-02-05 "Tool to calculate the mass flow of a greenhouse gas in a gaseous stream" latest edition,</p> <p>Flux box measurement:</p> <p>Flux box equipment accuracies (as specified by the supplier of the flux box equipment) shall be 1 ppm or better for CH₄ and 100 ppb or better for N₂O</p> |
| Any comment; | Applicable to Option 1 in the step "Determination of methane and nitrous oxide emissions from the composting process" |

| | |
|--------------|--|
| Parameter: | $COD_{RO, y}$, $COD_{wastewater, y}$ |
| Data unit; | tCOD/m ³ |
| Description; | <p>Average COD of the run-off wastewater from the co-composting installation valid for year y</p> <p>Average COD of the wastewater co-composted valid for year y</p> |

| | |
|-------------------------|--|
| Measurement procedures: | <ul style="list-style-type: none"> Measure the COD according to national or international standards in liquid samples that are taken in accordance with the 'Standard: Sampling and surveys for CDM project activities and programme of activities' from unfiltered run-off wastewater. <p>The location for taking the sample depends on the collection system:</p> <ul style="list-style-type: none"> If there is a dedicated drainage system for collecting only the run-off wastewater from the composting installation, then the sample should be taken from this system; If there is no dedicated drainage system, then the sample should be taken from run-off wastewater exiting the installation and before entering a drainage system that collects run-off from other sites as well as the composting installation (if applicable). |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | <p>Document which national or international standard is applied for COD measurement in the monitoring report.</p> <p>Monitoring instruments shall be subject to regular maintenance and testing to ensure accuracy.</p> |
| Any comment; | <p>An example of an international standard is ISO 6060:1989 Water quality - Determination of the chemical oxygen demand.</p> <p>Applicable to Option 1 of the step "Determination of emissions from run-off wastewater ($PE_{RO,y}$)"</p> |

| | |
|--------------|--|
| Parameter: | $Q_{RO,y}$ |
| Data unit; | m^3/yr |
| Description; | Volume of run-off wastewater from the co-composting installation in year y |

| | |
|-------------------------|--|
| Measurement procedures: | <p>Measurement procedures are distinguished based on whether the composting installation is roofed and whether it has a dedicated drainage system (meaning a system that only collects run-off wastewater from the composting installation and not from other areas or sites as well)</p> <ul style="list-style-type: none"> • If run-off wastewater is collected in a dedicated drainage system, then measure the accumulative volume flow over time using a flow meter. If the site is unroofed, then also measure the rainfall precipitation on the surface of the composting installation. In the situation that the flow meter fails at an unroofed site (such as during a severe storm event), then for the period of time that the flow meter failed, substitute this missing data from the flow meter with the volume of precipitation on the surface of the composting installation. This is estimated as the amount of rainfall multiplied by the surface area of the site; • If there is no dedicated drainage system and a roof covering the composting installation then $Q_{RO,y}$ is the annual volume of wastewater applied ($Q_{wastewater,y}$) subtracted by the amount absorbed by the compost. The amount of wastewater absorbed is assumed to be the weight of the compost ($Q_{comp,y}$) multiplied by a default factor of 0.15 t/m^3; • If there is no dedicated drainage system and no roof covering the composting installation, then the annual volume of rainfall precipitation on the surface of the composting installation must be added to the amount of wastewater applied in excess of the amount absorbed by the compost, as calculated in the bullet points above. |
| Monitoring frequency: | Continuously |
| QA/QC procedures: | <p>Flow meters shall undergo maintenance and calibration in accordance with manufacturer specifications.</p> <p>Rainfall shall be measured using an on-site rain gauge. The gauge shall be calibrated according to manufacturer specifications</p> |
| Any comment; | Applicable to the step "Determination of emissions from run-off wastewater ($PE_{RO,y}$)" |

| | |
|-------------------------|---|
| Parameter: | $Q_{wastewater,y}$ |
| Data unit; | m^3/yr |
| Description; | Amount of wastewater co-composted in year y |
| Measurement procedures: | Flow meter |
| Monitoring frequency: | Monthly aggregated annually |
| QA/QC procedures: | Flow meters shall undergo maintenance and calibration in accordance with manufacturer |

| | |
|-------------------------|---|
| Any comment; | Applicable to Option 2 in the step "Determination of emissions from run-off wastewater ($PE_{RO,y}$)" and shall be used to estimate QRO,y for the situation there is no dedicated drainage system |
| Parameter: | $COD_{wastewater,y}$ |
| Data unit; | tCOD/m ³ |
| Description; | Average COD of wastewater co-composted valid for year y |
| Measurement procedures: | Measure the COD according to national or international standards in liquid samples that are taken in a representative way from unfiltered wastewater. $COD_{wastewater,y}$ is the average of the COD measurements of the 12 samples taken in year y |
| Monitoring frequency: | Monthly |
| QA/QC procedures: | The monitoring instruments shall be subject to regular maintenance and testing to ensure accuracy |
| Any comment; | Applicable to Option 2 in the step "Determination of emissions from run-off wastewater ($PE_{RO,y}$)" |

6.2.5 Data and parameters to be monitored from anaerobic digesters

| | |
|-------------------------|--|
| Parameter: | $Q_{biogas,y}$ |
| Data unit; | Nm ³ biogas |
| Description; | Amount of biogas collected at the digester outlet in year y |
| Measurement procedures: | The volumetric flow measurement should always refer to the actual pressure and temperature. Instruments with recordable electronic signal (analogical or digital) are required |
| Monitoring frequency: | Continuously measurement by the flow meter. Data to be aggregated monthly and yearly |
| QA/QC procedures: | - |
| Any comment; | - |

| | |
|-----------------------|--|
| Parameter: | $P_{COD,y}$ |
| Data unit; | t COD / m ³ |
| Description; | Average chemical oxygen demand (COD) of the liquid digestate in year y |
| Measurement | Manual collection of samples and laboratory analysis |
| Monitoring frequency: | Monthly and averaged annually |

| | |
|-------------------|---|
| QA/QC procedures: | Samples should be collected based on the “2005 Standard Methods for the Examination of Water and Wastewater, 21 st . American Public Health Association, Water Environment Federation and American Water Works Association” or any other equivalent national or international standard |
| Any comment; | - |

| | |
|-----------------------|--|
| Parameter: | $Q_{\text{stored},y}$ |
| Data unit; | m^3 |
| Description; | Amount of liquid digestate stored anaerobically in year y |
| Measurement | Using flow meters |
| Monitoring frequency: | Continuously and aggregated annually |
| QA/QC procedures: | |
| Any comment; | Applicable to Option 1 in the section “Determining $LE_{\text{storage},y}$ for liquid digestate” |

6.2.6 Data and parameters to be monitored from methane emission from biomass digestion under anaerobic condition for biomass and biomass residual processing

| | |
|-------------------------|--|
| Parameter: | $V_{\text{BP},\text{ww},y} / V_{\text{BRP},\text{ww},y}$ |
| Data unit; | m^3 |
| Description; | $V_{\text{BP},\text{ww},y}$: Quantity of wastewater generated from the processing of biomass in year y $V_{\text{BRP},\text{ww},y}$: Quantity of wastewater generated from the processing of biomass residues in year y |
| Source of data: | On-site measurements |
| Measurement procedures: | - |
| Monitoring frequency: | Data monitored continuously and aggregated as appropriate, to calculate emissions reductions |
| QA/QC procedures: | - |
| Any comment; | - |

| | |
|--------------|---|
| Parameter: | $\text{COD}_{\text{BP},\text{ww},y} / \text{COD}_{\text{BRP},\text{ww},y}$ |
| Data unit; | $\text{t}_{\text{COD}}/\text{m}^3$ |
| Description; | $\text{COD}_{\text{BP},\text{ww},y}$: Average chemical oxygen demand of the wastewater generated from the processing of biomass in year y $\text{COD}_{\text{BRP},\text{ww},y}$: Average chemical oxygen demand of the wastewater generated from the |

| | |
|-------------------------|---|
| | processing of biomass residues in year y |
| Source of data: | On-site measurements |
| Measurement procedures: | - |
| Monitoring frequency: | At least every six months, taking at least three samples for each measurement |
| QA/QC procedures: | - |
| Any comment; | - |

| | |
|-------------------------|---|
| Parameter: | $MCF_{BP,ww,y} / MCF_{BRP,ww,y}$ |
| Data unit; | - |
| Description; | <p>$MCF_{BP,ww,y}$: Methane conversion factor for the treatment of wastewater generated from the processing of biomass in year y</p> <p>$MCF_{BRP,ww,y}$: Methane conversion factor for the treatment of wastewater generated from the processing of biomass residues in year y</p> |
| Source of data: | Table 6.8 from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories |
| Measurement procedures: | No measurement procedures. The default IPCC values for B0 from the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories shall be properly justified. |
| Monitoring frequency: | - |
| QA/QC procedures: | |
| Any comment; | |

| | |
|-------------------------|--|
| Parameter: | GWP_{CH_4} |
| Data unit; | tCO ₂ e/t CH ₄ |
| Description; | The global warming potential of methane |
| Source of data: | It uses data from the IPCC Assessment Report produced by the Intergovernmental Commission on Climate Change. (Intergovernmental Panel on Climate Change or IPCC announced by TGO. |
| Measurement procedures: | <p><u>For the preparation of project proposal documents</u></p> <ul style="list-style-type: none"> - Use the latest GWP_{CH_4} value as announced by TGO. <p><u>For monitoring the results of reducing emissions</u></p> <ul style="list-style-type: none"> - Use the value of GWP_{CH_4} as announced by TGO. for estimating the amount of greenhouse gases according to the crediting period that has been certified for the amount of greenhouse gases. |
| Monitoring frequency: | - |
| QA/QC procedures: | - |
| Any comment; | - |

| | |
|-------------------------|--|
| Parameter: | GWP _{N₂O} |
| Data unit; | tCO ₂ e/t N ₂ O |
| Description; | The global warming potential of nitrous oxide |
| Source of data: | It uses data from the IPCC Assessment Report produced by the Intergovernmental Commission on Climate Change. (Intergovernmental Panel on Climate Change or IPCC announced by TGO. |
| Measurement procedures: | <p><u>For the preparation of project proposal documents</u></p> <ul style="list-style-type: none"> - Use the latest GWP_{N₂O} value as announced by TGO. <p><u>For monitoring the results of reducing emissions</u></p> <ul style="list-style-type: none"> - Use the value of GWP_{N₂O} as announced by TGO. for estimating the amount of greenhouse gases according to the crediting period that has been certified for the amount of greenhouse gases. |
| Monitoring frequency: | - |
| QA/QC procedures: | - |
| Any comment; | - |

7. Reference

CDM Methodological tools

- 1) Project and leakage emissions from biomass, Version 05
- 2) TOOL01: Tool for the demonstration and assessment of additionality, Version 07
- 3) TOOL03: Tool to calculate project or leakage CO₂ emissions from fossil fuel combustion, Version 03
- 4) TOOL04: Emissions from solid waste disposal sites, Version 08
- 5) TOOL05: Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation, Version 03
- 6) TOOL12: Project and leakage emissions from transportation of freight, Version 01.1.0
- 7) TOOL13: Project and leakage emissions from composting, Version 02
- 8) TOOL14: Project and leakage emissions from anaerobic digesters, Version 02

Appendix 1 Default values for biomass cultivation

Table 1 Default reference SOC stocks (SOC_{REF}) for mineral soils (tC/hectare in 0–30 cm depth)¹

| Climate region | HAC soils ² | LAC soils ³ | Sandy soils ⁴ | Spodic soils ⁵ | Volcanic soils ⁶ | Wetland soils ⁷ |
|-----------------------|------------------------|------------------------|--------------------------|---------------------------|-----------------------------|----------------------------|
| Polar Moist/Dry | 59 | NA | 27 | NA | NA | NA |
| Boreal Moist/Dry | 63 | NA | 10 | 117 | 20 | 116 |
| Cold temperate, dry | 43 | 33 | 13 | NA | 20 | 87 |
| Cold temperate, moist | 81 | 76 | 51 | 128 | 136 | 128 |
| Warm temperate, dry | 24 | 19 | 10 | NA | 84 | 135 |
| Warm temperate, moist | 64 | 55 | 36 | 143 | 138 | 135 |
| Tropical, dry | 21 | 19 | 9 | NA | 50 | 22 |
| Tropical, moist | 40 | 38 | 27 | NA | 70 | 68 |
| Tropical, wet | 60 | 52 | 46 | NA | 77 | 49 |
| Tropical montane | 51 | 44 | 52 | NA | 96 | 82 |

¹ 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 2.3 (updated).

² Soils with high activity clay (HAC) minerals are lightly to moderately weathered soils, which are dominated by 2:1 silicate clay minerals (in the World Reference Base for Soil Resources (WRB) classification these include Leptosols, Vertisols, Kastanozems, Chernozems, Phaeozems, Luvisols, Alisols, Albeluvisols, Solonetz, Calcisols, Gypsisols, Umbrisols, Cambisols, Regosols; in USDA classification includes Mollisols, Vertisols, high-base status Alfisols, Aridisols, Inceptisols).

³ Soils with low activity clay (LAC) minerals are highly weathered soils, dominated by 1:1 clay minerals and amorphous iron and aluminium oxides (in WRB classification includes Acrisols, Lixisols, Nitisols, Ferralsols, Durisols; in USDA classification includes Ultisols, Oxisols, acidic Alfisols).

⁴ Includes all soils (regardless of taxonomic classification) having >70 per cent sand and <8 per cent clay, based on standard textural analyses (in WRB classification includes Arenosols; in USDA classification includes Psamments).

⁵ Soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols).

⁶ Soils derived from volcanic ash with allophanic mineralogy (in WRB classification Andosols; in USDA classification Andisols).

⁷ Soils with restricted drainage leading to periodic flooding and anaerobic conditions (in WRB classification Gleysols; in USDA classification Aquic suborders).

Table 2 Relative stock change factors for different management activities on cropland

| Factor type | Level | Temperature regime | Moisture regime | Factor value | Description and criteria |
|-------------------------|----------------------|--------------------------------------|----------------------|--------------|---|
| Land use (f_{LU}) | Long-term cultivated | Cool temperate/ Boreal | Dry | 0.77 | Area has been continuously managed for crops for more than 20 years |
| | | | Moist | 0.70 | |
| | | Warm temperate | Dry | 0.76 | |
| | | | Moist | 0.69 | |
| | | Tropical | Dry | 0.92 | |
| | | | Moist/Wet | 0.83 | |
| Land use (f_{LU}) | Set aside (< 20 yrs) | Temperate/ Boreal and Tropical | Dry | 0.93 | Represents temporary set aside of annually cropland (e.g., conservation reserves) or other idle cropland that has been revegetated with perennial grasses. |
| | | | Moist/Wet | 0.82 | |
| | | Tropical montane | n/a | 0.88 | |
| Management (f_{MG}) | Full tillage | All | Dry and Moist/Wet | 1.00 | Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g. <30%) of the surface is covered by residues |
| Management (f_{MG}) | Reduced tillage | Cool Temperate/ Boreal | Dry | 0.98 | Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally, leaves surface with >30% coverage by residues at planting |
| | | | Moist | 1.04 | |
| | | Tropical | Dry | 0.99 | |
| | | | Moist/Wet | 1.04 | |
| | | Warm Temperate | Dry | 0.99 | |
| | | | Moist/Wet | 1.04 | |
| Management (f_{MG}) | No-tillage | Cool Temperate/ Boreal | Dry | 1.03 | Direct seeding without primary tillage, with only minimal soil disturbance in the seeding zone. Herbicides are typically used for weed control |
| | | | Moist | 1.09 | |
| | | Tropical | Dry | 1.04 | |
| | | | Moist/Wet | 1.10 | |
| | | Warm temperate | Dry | 1.04 | |
| | | | Moist/Wet | 1.10 | |

Note; Adapted from 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Table 5.5 (updated).

Table 3 Relative stock change factors for different levels of nutrient input on cropland

| Factor type | Level | Temperature regime | Moisture regime | Factor value | Description and criteria |
|--------------------|---------------------------|--------------------------|----------------------|--------------|---|
| Input (f_{IN}) | Low | Temperate/ Boreal | Dry | 0.95 | There is removal of residues (via collection or burning), or frequent bare-fallowing, or production of crops yielding low residues (e.g. vegetables, tobacco, cotton), or no mineral fertilization or N-fixing crops |
| | | | Moist | 0.92 | |
| | | Tropical | Dry | 0.95 | |
| | | | Moist/Wet | 0.92 | |
| | | Tropical montane | n/a | 0.94 | |
| Input (f_{IN}) | Medium | All | Dry and Moist/Wet | 1.00 | All crop residues are returned to the field. If residues are removed, then supplemental organic matter (e.g. manure) is added. In addition, mineral fertilization or N-fixing crop rotation is practised |
| Input (f_{IN}) | High without manure | Temperate/ Boreal and | Dry | 1.04 | Represents significantly greater crop residue inputs over medium C input cropping systems due to additional practices, such as production of high residue yielding crops, use of green manures, cover crops, improved vegetated fallows, irrigation, frequent use of perennial grasses in annual crop rotations, but without manure applied |
| | | | Moist/Wet | 1.11 | |
| | | Tropical Montane | n/a | 1.08 | |
| Input (f_{IN}) | High with manure | Temperate/ Boreal and | Dry | 1.37 | Represents significantly higher C input over medium C input cropping systems due to an additional practice of regular addition of animal manure |
| | | - | Moist/ Wet | 1.44 | |
| | | Tropical Montane | n/a | 1.41 | |

Table 4 Relative stock change factors (f_{LU} , f_{MG} , and f_{IN}) for grassland management

| Factor type | Level | Climate regime | Factor value | Description |
|--|------------------------|----------------------|--------------|--|
| Land use (f_{LU}) | All | All | 1.00 | All permanent grassland is assigned a land-use factor of 1 |
| Management (f_{MG}) | Non-degraded grassland | All | 1.00 | Non-degraded and sustainably managed grassland, but without significant management improvements |
| Management (f_{MG}) | High intensity grazing | All | 0.90 | High intensity grazing systems (or cutting and removal of vegetation) with shifts in vegetation composition and possibly productivity but is not severely degraded |
| Management (f_{MG}) | Severely degraded | All | 0.70 | Implies major long-term loss of productivity and vegetation cover, due to severe mechanical damage to the vegetation and/or severe soil erosion |
| Management (f_{MG}) | Improved grasslands | Temperate/ Boreal | 1.14 | Represents grassland which is sustainably managed with moderate grazing pressure and that receive at least one improvement (e.g. fertilization, species improvement, irrigation) |
| | | Tropical | 1.17 | |
| | | Tropical Montane | 1.16 | |
| Input (f_{IN}) (Applied only to improved grassland) | Medium | All | 1.00 | Improved grassland where no additional management inputs have been used. |
| | High | All | 1.11 | Improved grassland where one or more additional management inputs/improvements have been used (beyond that required to be classified as improved grassland) |

Note: Adapted from 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Table 6.2 (updated).

Appendix 2 Example identification of alternative uses

1. Consider a project activity which includes the installation of a new biomass-only power plant, and the retrofit of an existing co-fired biomass-fossil-fuel power plant, which has historically used rice husks, produced on-site. Suppose that the project activity will use two types of biomass residues, rice husks (historical use plus an additional amount) and diverse agricultural residues (as additional biomass residues compared to the historical situation). Further consider that the rice husks used in the project would come from two different sources, on-site production, and off-site supply from an identified rice mill. Presumably, the rice husks produced on-site would have been partly used on-site for electricity generation and partly be dumped in the determined alternative scenario. The rice husks procured off-site would have been dumped in the determined alternative scenario. The diverse agricultural residues are purchased from a biomass retailer. For this example, four categories of biomass residues should be considered in the subsequent analysis, as illustrated in Table 1.

2. The last column of Table 1 corresponds to the quantity of each category of biomass residues (tonnes). For the determination of the alternative scenario, at the validation stage, an ex ante estimation of these quantities should be provided. These quantities should be updated every year of the crediting period as part of the monitoring plan, so as to reflect the actual use of biomass residues in the project scenario. These updated values should be used for emissions reductions calculations. Along the crediting period, new categories of biomass residues (i.e. new types, new sources, with different fate) can be used in the project activity. In this case, a new line should be added to the table.

Table 1 Table for biomass residues categories

| Biomass residues category (k) | Biomass residues type | Biomass residues source | Biomass residues fate in the absence of the project activity | Biomass residues use in project scenario | Biomass residues quantity (tonnes) |
|-------------------------------|-----------------------|---|--|---|------------------------------------|
| 1 | Rice husks | On-site production | Electricity generation on-site (B4) | Electricity generation on-site (biomass- only boiler) | See comments above |
| 2 | Rice husks | On-site production | Dumped (B1) | Electricity generation on-site (biomass- only boiler) | See comments above |
| 3 | Rice husks | Off-site from an identified rice mill | Dumped (B1) | Electricity generation on-site (biomass- only boiler) | See comments above |
| 4 | Agricultural residues | Off-site from a biomass residues retailer | Unidentified (B4) | Electricity generation on-site (co-fired boiler) | See comments above |

Appendix 3 Explanation of factors used

1. In equation (2), the factor to account for soil N₂O emissions associated with loss of soil organic carbon is calculated following volume 4 chapters 3 and 11 of the 2019 IPCC Refinement to the 2006 Guidelines for National Greenhouse Gas Inventories. Loss of SOC leads to associated mineralisation of N in the soil, leading to N₂O emissions:
 - (a) The mineralised N can be calculated using equation (11.1) and (11.10), with $EF_1 = 0.01$, $EF_5 = 0.011$ and $Frac_{LEACH} = 0.24$, results in total $0.01264 \text{ tN-N}_2\text{O/tN}^1$;
 - (b) Using equation (11.8) of the IPCC guidelines, in which R is set to 8 tSOC/tN, results in $0.00158 \text{ tN-N}_2\text{O/tSOC}$;
 - (c) Converting to $\text{t CO}_2\text{e/tSOC}$ by multiplying with 265 (GWP_{N_2O}) and dividing by 28/44 (Weight of N in N₂O) results in $0.658 \text{ t CO}_2\text{e/tSOC}$;
 - (d) Dividing by 44/12 (mass ratio of CO₂ and C) to convert to $\text{tCO}_2\text{e/tCO}_2$ (dimensionless factor) results in 0.179 tCO₂e released in N₂O for each tCO₂ released from SOC.

2. In equation (3), the factor to account for the IPCC default factor was derived from evaluating worse-case scenario, i.e. worse uncertainties, in the used factors:
 - (a) Reviewing the IPCC data, SOC_{REF} has error estimate of 90% (2019 IPCC refinement, table 2.3, table note), whereas the various f factors have error estimate of up to 50 percent (IPCC tables 5.4 and 6.2). These are two sigma estimates, equivalent to 95 percent confidence interval;
 - (b) Converting them to 90 percent confidence interval (equivalent to 1.282 sigma), which is deemed appropriate for the tool, by multiplying with 1.282/2, results in SOC_{REF} uncertainty of 58 percent, and the various f factors in uncertainties of 32 percent;
 - (c) Adding the root-mean-square of these error estimates result in total 70 percent error (Note the f uncertainties have each half the weight of the SOC_{REF} error estimate, due to the addition in the equation);
 - (d) As SOC_{REF} always has error estimate of 58 percent, total error estimate has range of 58–70 percent;
 - (e) The error estimates being in the uncertainty band of 50-100 percent, result in a corrective factor of 1.21 according to FCCC/SBSTA/2003/10/Add.2/6

¹ $(EF_5 \times Frac_{LEACH}) + EF_1$

3. In equation (5), the default value of the aggregate emission factor for N₂O and CO₂ emissions resulting from production and application of nitrogen, is calculated following volume 4 chapters 3 and 11 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories, as well as based on Wood and Cowie (2004) and Swaminathan (2004). The calculation is for ammonium nitrate, which is considered conservative:
- Direct and indirect N₂O emissions (emissions associated to the fertiliser application on the soil) calculated, using IPCC equations (11.1), (11.9) and (11.10), with EF₁ = 0.01, EF₄ = 0.01, EF₅ = 0.011, Frac_{GASF} = 0.11, and Frac_{LEACH} = 0.24, results in total 0.01374 tN-N₂O/tN. This is converted, by multiplying with 265 (GWP_{N₂O}) dividing by 28/44 (Weight of N in N₂O), to 4.19 t CO₂e/tN²;
 - Emissions from synthetic fertilizer production, including fuel, feedstocks, and emissions during production, calculated based on Wood and Cowie (2004) and Swaminathan (2004), taken for ammonium nitrate, a conservative fertilizer, is 7.1 t CO₂e/tN;
 - Adding the above emissions results in 11.29 t CO₂e/tN.
4. In equation (8) from the tool, the factor to account for non-CO₂ emissions from biomass clearance or burning was calculated using the values in table 2.5, volume 4 chapter 2 of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories:
- Taking the values for savannah and grassland, which are most conservative;
 - $$\left[1,613 \text{ gCO}_2 + 2.3 \text{ gCH}_4 \times 21 (\text{GWP}_{\text{CH}_4}) + 0.21 \text{ gN}_2\text{O} \times 265 (\text{GWP}_{\text{N}_2\text{O}}) \right] / 1,613 \text{ gCO}_2 = 1.06$$

$$^2[(\text{EF}_4 \times \text{Frac}_{\text{GASF}}) + (\text{EF}_5 \times \text{Frac}_{\text{LEACH}}) + \text{EF}_1] \times \text{GWP}_{\text{N}_2\text{O}} / (28/44)$$

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