TOOL16

Methodological tool

Project and leakage emissions from biomass

Version 02.0

United Nations
Framework Convention on
Climate Change

TABLE OF CONTENTS **Page**

1. Introduction

1. This tool provides procedures to calculate project and leakage emissions relevant for project activities which utilise biomass. The biomass may be used as either fuel or feedstock in the project activity. The biomass may be biomass residues or cultivated in a dedicated plantation.

Table 1. Parameters determined

Parameter	Unit	Description
$PE_{BC,y}$	t CO_2e	Project emissions resulting from cultivation of biomass in a dedicated plantation, in year *y* (Section 5)
$PE_{BR,y}$	t CO_2e	Project emissions resulting from utilization of biomass residues, in year *y* (Section 6)
$LE_{BC,y}$	t CO_2e	Leakage emissions due to shift of pre-project activities resulting from cultivation of biomass in a dedicated plantation, in year *y* (Section 7)
$LE_{BR,y}$	t CO_2e	Leakage emissions due to diversion of biomass residues from other applications, in year *y* (Section 8)

2. Scope, applicability, and entry into force

2.1. Scope

2. This tool can be used for estimation of project and leakage emissions resulting from cultivation of biomass in a dedicated plantation of a CDM project activity that uses biomass.

3. This tool also includes approaches for identifying and estimating project and leakage emissions from project activities that utilise biomass residues.

4. Unless the methodology’s procedures allow it, only positive leakage, i.e. increased emissions outside the project boundary are allowed by this tool. If the biomass production or utilization results in any reduction of greenhouse gas (GHG) emissions outside the project boundary, they will not be accounted for.

5. The project does not calculate methane emissions from anaerobic decomposition of biomass, for example in stockpiles or wastewater.

2.2. Applicability

6. For project activities which include biomass cultivation:

   (a) The land in which biomass is cultivated:

      (i) Does not contain wetlands;

      (ii) Does not contain organic soils;

(iii) Does not contain forests nor contained forest since 31 December 1989;

(iv) Is not subjected to flood irrigation.

(b) Desalination is not a substantial source of water in the host country.

7. The tool is also applicable if biomass residues are consumed in a CDM project activity. 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.

2.3. Entry into force

8. The date of entry into force is the date of the publication of the EB 83 meeting report on 16 April 2015.

3. Normative references

9. This tool refers to the following documents:

(a) “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion”;

(b) “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”;

(c) “Project and leakage emissions from transportation of freight”.

4. Definitions

10. The definitions contained in the Glossary of CDM terms shall apply.

11. For the purpose of this tool, the following definitions apply:

(a) **Abandoned land** - land on which no land management (including crops, forestry, agroforestry and grazing) has been practiced for the longer period of:

(i) Three years;

(ii) The length of one crop rotation of the most recent crop grown on the plot.

(b) **Forest**[1] - in the absence of national definition of forests, the following shall apply: Forest is a minimum area of land of 0.05–1.0 hectares with tree crown cover (or equivalent stocking level) of more than 10–30 per cent with trees with the potential to reach a minimum height of 2–5 metres at maturity in situ. A forest may consist either of closed forest formations where trees of various storeys and undergrowth cover a high portion of the ground or open forest. Young natural stands and all plantations which have yet to reach a crown density of 10–30 per cent or tree height of 2–5 metres are included under forest, as are areas normally

[1] As defined by the minimum values of tree crown cover, land area, and tree height selected by the host party for the purposes of the CDM (see paragraph 8, annex to decision 5/CMP.1).

forming part of the forest area which are temporarily unstocked as a result of human intervention such as harvesting or natural causes but which are expected to revert to forest;

(c) **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;

(d) **Organic soil**[2] - soils are organic if they satisfy the requirements 1 and 2, or 1 and 3 below:

(i) Thickness of 10 cm or more. A horizon less than 20 cm thick must have 12 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 a few 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;

(e) **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;

(f) **Project region –** area within a radius of 250km around the project activity;

(g) **Stratum** - area of land with uniform properties;

(h) **Wetland**[3] - 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;

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

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

5. Project emissions from cultivation of biomass

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

$$PE_{BC,y} = PE_{SM,y} + PE_{EC,y} + PE_{BB,y} + PE_{TR,y}$$ Equation (1)

Where:

$PE_{BC,y}$	=	Emissions resulting from cultivation of biomass in a dedicated plantation, in year *y* (t CO_2e)
$PE_{SM,y}$	=	Emissions resulting from soil management, in year *y* (t CO_2e)
$PE_{EC,y}$	=	Emissions resulting from energy consumption, in year *y* (t CO_2e)
PE_{BBy}	=	Emissions resulting from burning of biomass, in year *y* (t CO_2e)
$PE_{TR,y}$	=	Emissions resulting from transport of biomass, in year *y* (t CO_2e)

13. Biomass originating from land areas included in registered A/R project activities may be considered to have no project emissions, provided that the emission reductions from the A/R project activity have been verified and issued for the time period in which the biomass was harvested.

5.1. Emissions resulting from soil management

14. Emissions resulting from soil management are estimated as follows:

$$PE_{SM,y} = PE_{SOC,y} + PE_{SF,y} + PE_{SA,y}$$ Equation (2)

Where:

$PE_{SM,y}$	=	Emissions resulting from soil management, in year *y* (t CO_2e)
$PE_{SOC,y}$	=	Emissions resulting from loss of soil organic carbon, in year *y* (t CO_2e)
$PE_{SF,y}$	=	Emissions resulting from of soil fertilization and management, in year *y* (t CO_2e)
$PE_{SA,y}$	=	Emissions resulting from soil amendment (liming), in year *y* (t CO_2e)

5.1.1. Emissions resulting from loss of soil organic carbon

15. 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 in appendix 1;

(b) Land-use and land management activities on croplands given in Tables 2 and 3 in appendix 1; and

(c) Land-use and land management activities on grasslands given in Table 4 in appendix 1. These apply also to abandoned land.

16. Emissions resulting from loss of soil organic carbon are estimated as follows:

$$PE_{SOC,y} = \max\left(\frac{44}{12} \times \frac{1.156}{T} \times \sum_{i} \Delta SOC_i \, , 0\right)$$ Equation (3)

Where:

$PE_{SOC,y}$	=	Emissions resulting from loss of soil organic carbon, in year *y* (t CO_2e)
T	=	Length of the first crediting period of the project in years (7 or 10)
ΔSOC_i	=	Loss of soil organic carbon in land stratum *i*, (t C)
$\frac{44}{12}$	=	Factor for converting units from t C to t CO_2e; dimensionless
1.156	=	Factor to account for soil N_2O emissions associated with loss of soil organic carbon,[4] dimensionless
i	=	Strata of areas of land

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

$$\Delta SOC_i = 1.21 \times A_{SOC,i} \times SOC_{REF,i} \times (f_{LUB,i} \times f_{MGB,i} \times f_{INB,i} - f_{LUP,i} \times f_{MGP,i} \times f_{INP,i})$$ Equation (4)

Where:

ΔSOC_i	=	Loss of soil organic carbon in land stratum *i*, (t C)
$A_{SOC,i}$	=	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 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

[4] Based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories. For details, see appendix 3.

1.21	=	Conservativeness factor accounting for the uncertainties in the values in Tables 2-4 in appendix 1[5]

18. The values of relative stock change factors shall be determined according to Tables 2-4 in appendix 1 of this tool.[6]

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

5.1.2. Emissions resulting from soil fertilization and management

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

$$PE_{SF,y} = q_{N,y} \times A_{FTM,y} \times EF_{FT}$$

Equation (5)

Where:

$PE_{SF,y}$	=	Emissions resulting from soil fertilization and management, in year *y* (t CO_2e)
$q_{N,y}$	=	Rate of nitrogen applied, in year *y* (t N/ha)
$A_{FTM,y}$	=	Area of land subjected to soil fertilization and management, in year *y* (ha)
EF_{FT}	=	Aggregate emission factor for N_2O and CO_2 emissions resulting from production and application of nitrogen (t CO_2e/(t N)). A default value of 13.3 t CO_2e/(t N)[7] shall be used

5.1.3. Emissions resulting from soil amendment

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

$$PE_{SA,y} = q_{LM,y} \times A_{LM,y} \times EF_{LM} + q_{DL,y} \times A_{DL,y} \times EF_{DL}$$

Equation (6)

Where:

$PE_{SA,y}$	=	Emissions resulting from soil amendment by liming, in year *y* (t CO_2e)
$q_{LM,y}$	=	Rate of application of limestone, in year *y* (t/ha)
$A_{LM,y}$	=	Area of land in which limestone is applied, in year *y* (ha)
EF_{LM}	=	Emission factor for CO_2 emissions from limestone application (t CO_2e/(t limestone)). A default value of 0.12 t CO_2e/(t limestone)[8] shall be used

[5] According to FCCC/SBSTA/2003/10/Add.2/6. For details, see appendix 3.

[6] Project proponents are encouraged to suggest revisions for this tool with alternative procedures (e.g. monitoring) to determine the relative stock change.

[7] Based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories. For details, see appendix 3.

[8] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 4, Ch 11, Eq 11.12.

$q_{DL,y}$	=	Rate of application of dolomite, in year *y* (t/ha)
$A_{DL,y}$	=	Area of land in which dolomite is applied, in year *y* (ha)
EF_{DL}	=	Emission factor for CO_2 emissions from dolomite application (t CO_2e (t dolomite). A default value of 0.13 t CO_2e /(t dolomite)[9] shall be used

5.2. Emissions resulting from energy consumption

22. Emissions resulting from energy consumption are estimated, unless otherwise required in the relevant methodology, by following the provisions in the “Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion” and the “Tool to calculate baseline, project and/or leakage emissions from electricity consumption”. These emissions include emissions due to:

    (a) Biomass cultivation practices; and

    (b) Thermal and mechanical processing of the biomass.

23. Small scale project activities may, unless otherwise required by the methodology, neglect emissions from energy consumption associated with cultivation of biomass.

5.3. Emissions resulting from clearance or burning of biomass

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

$$PE_{BB,y} = \frac{44}{12} \times 0.47 \times \sum_i A_{FR,i,z} \times b_i \times (1.07 + R_i) \quad \text{Equation (7)}$$

Where:

$PE_{BB,y}$	=	Emissions resulting from burning of biomass, in year *y* (t CO_2e)
$\frac{44}{12}$	=	Factor for converting units from t C to t CO_2e; dimensionless
0.47	=	Default value of carbon fraction of biomass burnt;[10] dimensionless
1.07	=	Factor to account for non-CO_2 emissions from biomass burning;[11] dimensionless. If biomass is cleared without using open fire, then this factor is set equal to 1 (one)
$A_{FR,i,y}$	=	Area of stratum *i* of land subjected to fire in year *y* (ha)
b_i	=	Fuel biomass consumption per hectare in stratum *i* of land subjected to fire (t dry matter/ha)

[9] Ibid.

[10] 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol 4, Ch 4 Table 4.3.

[11] Based on 2006 IPCC Guidelines for National Greenhouse Gas Inventories. For details, see appendix 3.

R_i	=	Root-shoot ratio (i.e. ratio of below-ground biomass to above-ground biomass) for stratum *i* of land subjected to fire; dimensionless
i	=	Strata of areas of land

5.4. Emissions resulting from transport

25. Emissions resulting from transport of biomass to the processing/utilisation facility are estimated, unless otherwise required in the relevant methodology, by following the provisions in the methodological tool "Project and leakage emissions from transportation of freight".

26. Small scale project activities may, unless otherwise required by the methodology, neglect this source of emissions if the transportation distance is less than 200 km.

6. Project emissions from utilization of biomass residues

27. Project emissions resulting from utilization of biomass residues are estimated as follows:

$$PE_{BC,y} = PE_{EC,y} + PE_{TR,y}$$

Equation (8)

Where:

$PE_{BC,y}$	=	Emissions resulting from utilization of biomass residues, in year *y* (t CO_2e)
$PE_{EC,y}$	=	Emissions resulting from energy consumption, in year *y* (t CO_2e)
$PE_{TR,y}$	=	Emissions resulting from transport of biomass, in year *y* (t CO_2e)

6.1. Emissions resulting from energy consumption

28. Emissions resulting from energy consumption are estimated, unless otherwise required in the relevant methodology, by following the provisions in the "Tool to calculate project or leakage CO_2 emissions from fossil fuel combustion" and the "Tool to calculate baseline, project and/or leakage emissions from electricity consumption". These emissions include emissions due to thermal and mechanical processing of the biomass residue.

29. Small scale project activities may, unless otherwise required by the methodology, neglect emissions from energy consumption associated with processing of biomass residue.

6.2. Emissions resulting from transport

30. Emissions resulting from transport of biomass residue to the processing/utilisation facility are estimated, unless otherwise required in the relevant methodology, by following the provisions in the methodological tool "Project and leakage emissions from transportation of freight".

31. Small scale project activities may, unless otherwise required by the methodology, neglect this source of emissions if the transportation distance is less than 200 km.

7. Leakage due to shift of pre-project activities

32. 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.

33. No leakage due to shift of pre-project activities occurs if one of the following two conditions apply:

    (a) The plantation area was 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.

34. 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.

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

36. 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 these 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.

8. Leakage due to diversion of biomass residues from other applications

37. 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.

8.1. Determination of the alternative scenario of the biomass residues in absence of the project activity

38. The alternative scenario for the “use”, in absence of the project activity, of biomass residues that will be used in the underlying CDM project activity shall include:

(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) B2: 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 in the absence of the project activity cannot be clearly identified.[12]

39. 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. This combinations shall be documented transparently in the CDM-PDD and remain consistent throughout the crediting period.

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

[12] 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.

(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 the two paragraphs 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 B above);

(d) Explain and document transparently in the CDM-PDD, using a table similar to Table 1 in 0, 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, project participants shall demonstrate that this is a realistic and credible alternative scenario. Towards this end one of 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 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,[13] 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 abundance of biomass in the project region cannot be demonstrated, the alternative use of the biomass shall be considered unknown (B4) and result in leakage emissions.

41. 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.

[13] 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.

8.2. Calculation of Leakage due to diversion of biomass residues

42. 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.

43. 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.

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

$$LE_{BR,y} = EF_{CO2,LE} \times \sum_{n} BR_{PJ,n,y} \times NCV_{n,y}$$

Equation (9)

Where:

$LE_{BR,y}$	=	Leakage emissions in year *y* (t CO_2e)
$EF_{CO2,LE}$	=	CO_2 emission factor of the most carbon intensive fossil fuel used in the country (t CO_2/GJ)
$BR_{PJ,n,y}$	=	Quantity of biomass residues used in 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

45. 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.

9. Monitoring methodology

9.1. Data and parameters not monitored

46. Data and parameters not monitored have been provided along with the relevant equation in the preceding section of the tool. Furthermore, for projects including biomass cultivation, the following parameter shall be known.

Data / Parameter table 1.

Data / Parameter:	**Pre-project land use**
Data unit:	variable
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 (if any):	-
Any comment:	-

47. For projects including biomass residues, the following parameter shall be known.

Data / Parameter table 2.

Data / 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:	Explain and document transparently in the CDM-PDD, using a table similar to table 1 in 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. The last column of table 1 in 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 so as to reflect 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
Measurement procedures (if any):	-
Any comment:	-

9.2. Data and parameters monitored

48. Data and parameters relevant to projects including biomass cultivation are monitored as described in the following parameter tables.

Data / Parameter table 3.

Data / Parameter:	$\mathbf{A_{SOC,i}}$
Data unit:	ha
Description:	Area of land stratum *i*
Source of data:	Measurement by project participants

Measurement procedures (if any):	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:	-

Data / Parameter table 4.

Data / Parameter:	$\mathbf{q_{N,y}}$
Data unit:	t N/ha
Description:	Rate of nitrogen applied, in year *y*
Source of data:	Land management records maintained by project participants and fertiliser composition information from supplier, study or independent laboratory. Alternatively, the default conservative value of 0.20 t N/ha per year may be used
Measurement procedures (if any):	-
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

Data / Parameter table 5.

Data / Parameter:	$\mathbf{A_{FTM,y}}$
Data unit:	ha
Description:	Area of land subjected to soil fertilization and management, in year *y*
Source of data:	Measurement by project participants
Measurement procedures (if any):	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:	Areas receiving one or more of the following inputs shall be added up to arrive at this value: (i) synthetic fertilisers; (ii) organic manure; (iii) return of the residues or cover crops

Data / Parameter table 6.

Data / Parameter:	$\mathbf{q_{LM,y}}$
Data unit:	t/ha
Description:	Rate of application of limestone, in year *y*
Source of data:	Land management records maintained by project participants

Measurement procedures (if any):	-
Monitoring frequency:	Annual
QA/QC procedures:	Cross-check records of applied quantities with purchase receipts and inventory
Any comment:	-

Data / Parameter table 7.

Data / Parameter:	$\mathbf{A_{LM,y}}$
Data unit:	ha
Description:	Area of land in which limestone is applied, in year *y*
Source of data:	Measurement by project participants
Measurement procedures (if any):	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:	-

Data / Parameter table 8.

Data / Parameter:	$\mathbf{q_{DL,y}}$
Data unit:	t/ha
Description:	Rate of application of dolomite, in year *y*
Source of data:	Land management records maintained by project participants
Measurement procedures (if any):	-
Monitoring frequency:	Annual
QA/QC procedures:	Cross-check records of applied quantities with purchase receipts and inventory
Any comment:	-

Data / Parameter table 9.

Data / Parameter:	$\mathbf{A_{DL,y}}$
Data unit:	ha
Description:	Area of land in which dolomite is applied, in year *y*
Source of data:	Measurement by project participants
Measurement procedures (if any):	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:	-

Data / Parameter table 10.

Data / Parameter:	$\mathbf{A}_{FR,i,y}$
Data unit:	ha
Description:	Area of stratum *i* of land subjected to fire in year *y*
Source of data:	Measurement by project participants
Measurement procedures (if any):	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:	-

Data / Parameter table 11.

Data / Parameter:	$\mathbf{b}_i$
Data unit:	t dry matter/ha
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 (if any):	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:	-

Data / Parameter table 12.

Data / Parameter:	$\mathbf{R}_\mathbf{i}$
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 fire
Source of data:	Measurement by project participants. Alternatively, the default values from Table 4.4 of the 2006 IPCC Guidelines for National GHG Inventories may be used
Measurement procedures (if any):	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:	-

Data / Parameter table 13.

Data / Parameter:	**Land use**
Data unit:	variable
Description:	Service level of the project land use
Source of data:	-
Measurement procedures (if any):	-
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

49. For projects utilising biomass residues, in the absence of relevant data/parameter tables in the methodology, the following parameter tables shall be used.

Data / Parameter table 14.

Data / Parameter:	$\mathbf{BR_{PJ,n,y}}$
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 (if any):	Use weight meters. Adjust for 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:	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.)

Data / Parameter table 15.

Data / Parameter:	$\mathbf{NCV_{n,y}}$
Data unit:	GJ/tonnes on dry-basis
Description:	Net calorific value of biomass residues of category *n* in year *y*
Source of data:	On-site measurements
Measurement procedures (if any):	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:	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. If the measurement results differ significantly from previous measurements or other relevant data sources, conduct additional measurements. Ensure that the NCV is determined on the basis of dry biomass
Any comment:	-

Data / Parameter table 16.

Data / Parameter:	**$EF_{CO2,LE}$**
Data unit:	t CO_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 (if any):	-
Monitoring frequency:	Annually
QA/QC procedures:	-
Any comment:	-

Appendix 1. Default values for biomass cultivation

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

Climate region	HAC soils[1]	LAC soils[2]	Sandy soils[3]	Spodic soils[4]	Volcanic soils[5]
Boreal	68	NA	10	117	20
Cold temperate, dry	50	33	34	NA	20
Cold temperate, moist	95	85	71	115	130
Warm temperate, dry	38	24	19	NA	70
Warm temperate, moist	88	63	34	NA	80
Tropical, dry	38	35	31	NA	50
Tropical, moist	65	47	39	NA	70
Tropical, wet	44	60	66	NA	130
Tropical montane	88	63	34	NA	80

[1] 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).

[2] 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).

[3] 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).

[4] Soils exhibiting strong podzolization (in WRB classification includes Podzols; in USDA classification Spodosols).

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

Table 2. Relative stock change factors for different management activities on cropland[6]

<table>
<tr><th>Factor type</th><th>Level</th><th>Temperature regime</th><th>Moisture regime</th><th>Factor value</th><th>Description and criteria</th></tr>
<tr><td rowspan="5">Land use (f_{LU})</td><td rowspan="5">Long-term cultivated</td><td rowspan="2">Temperate/ Boreal</td><td>Dry</td><td>0.80</td><td rowspan="5">Area has been continuously managed for crops for more than 20 years</td></tr>
<tr><td>Moist</td><td>0.69</td></tr>
<tr><td rowspan="2">Tropical</td><td>Dry</td><td>0.58</td></tr>
<tr><td>Moist/Wet</td><td>0.48</td></tr>
<tr><td>Tropical montane</td><td>n/a</td><td>0.64</td></tr>
<tr><td rowspan="3">Land use (f_{LU})</td><td rowspan="3">Short-term cultivated (<20 years) or set aside (<5 years)</td><td rowspan="2">Temperate/ Boreal and Tropical</td><td>Dry</td><td>0.93</td><td rowspan="3">Area has been managed for crops for less than 20 years and/or the area is cropland that has been in a fallow state for less than five years at any point during the last 20 years</td></tr>
<tr><td>Moist/Wet</td><td>0.82</td></tr>
<tr><td>Tropical montane</td><td>n/a</td><td>0.88</td></tr>
<tr><td>Management (f_{MG})</td><td>Full tillage</td><td>All</td><td>Dry and Moist/Wet</td><td>1.00</td><td>Substantial soil disturbance with full inversion and/or frequent (within year) tillage operations. At planting time, little (e.g. <30 per cent) of the surface is covered by residues</td></tr>
<tr><td rowspan="5">Management (f_{MG})</td><td rowspan="5">Reduced tillage</td><td rowspan="2">Temperate/ Boreal</td><td>Dry</td><td>1.02</td><td rowspan="5">Primary and/or secondary tillage but with reduced soil disturbance (usually shallow and without full soil inversion). Normally leaves surface with >30 per cent coverage by residues at planting</td></tr>
<tr><td>Moist</td><td>1.08</td></tr>
<tr><td rowspan="2">Tropical</td><td>Dry</td><td>1.09</td></tr>
<tr><td>Moist/Wet</td><td>1.15</td></tr>
<tr><td>Tropical montane</td><td>n/a</td><td>1.09</td></tr>
<tr><td rowspan="5">Management (f_{MG})</td><td rowspan="5">No-tillage</td><td rowspan="2">Temperate/ Boreal</td><td>Dry</td><td>1.10</td><td rowspan="5">Direct seeding without primary tillage, with only minimal soil disturbance in the seeding zone. Herbicides are typically used for weed control</td></tr>
<tr><td>Moist</td><td>1.15</td></tr>
<tr><td rowspan="2">Tropical</td><td>Dry</td><td>1.17</td></tr>
<tr><td>Moist/Wet</td><td>1.22</td></tr>
<tr><td>Tropical montane</td><td>n/a</td><td>1.16</td></tr>
</table>

[6] Adapted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Table 5.5.

Table 3. Relative stock change factors for different levels of nutrient input on cropland[7]

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. Additionally, mineral fertilization or N-fixing crop rotation is practised
Input (f_{IN})	High without manure	Temperate/ Boreal and Tropical	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 Tropical	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	

[7] Ibid.

Table 4. Relative stock change factors (f_{LU}, f_{MG}, and f_{IN}) for grassland management[8]

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})	Moderately degraded grassland	Temperate/ Boreal	0.95	Overgrazed or moderately degraded grassland, with somewhat reduced productivity (relative to the native or nominally managed grassland) and receiving no management inputs
		Tropical	0.97	
		Tropical Montane	0.96	
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	All grassland without input of fertilizers is assigned an input factor of 1
	High	All	1.11	Grasslands with direct application of fertilizers (organic or inorganic) beyond what is required to be classified as improved grassland

8 Adapted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4, Table 6.2.

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 (3), the factor to account for soil N_2O emissions associated with loss of soil organic carbon is calculated following volume 4 chapters 3 and 11 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Loss of SOC leads to associated mineralisation of N in the soil, leading to N_2O emissions:

   (a) The mineralised *N* can be calculated using equation (11.1) and (11.10), with EF_1*=0.01,* EF_5 *= 0.0075 and* $Frac_{LEACH}$ = 0.3, results in total 0.01225 tN-N_2O/tN;

   (b) Using equation (11.8) of the IPCC guidelines, in which *R* is set to 10 tSOC/tN, results in 0.001225 tN-N_2O/tSOC;

   (c) Converting to t CO_2e/tSOC by multiplying with 298 (GWP_{N2O}) and dividing by 28/44 (Weight of *N* in N_2O) results in 0.574 t CO_2e/tSOC;

   (d) Dividing by 44/12 (mass ratio of CO_2 and C) to convert to t CO_2e/t CO_2 (dimensionless factor) results in 0.156 t CO_2e released in N_2O for each t CO_2 released from SOC.

2. In equation (4), 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 per cent (IPCC table 2.3, table note), whereas the various *f* factors have error estimate of up to 50 per cent (IPCC tables 5.4 and 6.2). These are two sigma estimates, equivalent to 95 per cent confidence interval;

   (b) Converting them to 90 per cent 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 per cent, and the various *f* factors in uncertainties of 32 per cent;

   (c) Adding the root-mean-square of these error estimates result in total 70 per cent 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 per cent, total error estimate has range of 58–70 per cent;

   (e) The error estimates being in the uncertainty band of 50-100 per cent, result in a corrective factor of 1.21 according to FCCC/SBSTA/2003/10/Add.2/6.

3. In equation (5), the default value of the aggregate emission factor for N_2O and CO_2 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:[1]

   (a) Direct and indirect N_2O emissions (emissions associated to the fertiliser application on the soil) calculated, using IPCC equations (11.1), (11.9) and (11.10), with $EF_1 = 0.01, EF_4 = 0.01$ $EF_5 = 0.0075, Frac_{GASF} = 0.1$ and $Frac_{LEACH} =$ 0.3, results in total 0.01325 tN-N_2O/tN. This is converted, by multiplying with 298 (GWP_{N2O}) dividing by 28/44 (Weight of *N* in N_2O), to 6.20 t CO_2e/tN;

   (b) Emissions from synthetic fertiliser production, including fuel, feedstocks and emissions during production, calculated based on Wood and Cowie (2004) and Swaminathan (2004), taken for ammonium nitrate, a conservative fertiliser, is 7.1 t CO_2e/tN;

   (c) Adding the above emissions results in 13.3 t CO_2e/tN.

4. In equation (7), the factor to account for non-CO_2 emissions from biomass burning was calculated using the values in table 2.5, volume 4 chapter 2 of 2006 IPCC Guidelines for National Greenhouse Gas Inventories:

   (a) Taking the values for savannah and grassland, which are most conservative;

   (b) (1613 g CO_2 + 2.3 g CH_4 x 25 (GWP_{CH4}) + 0.21 g N_2O x 298 (GWP_{N2O}))/1613 g CO_2 = 1.07.

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[1] As a comparison, the calculation is repeated for organic fertiliser:

(a) Direct and indirect N_2O emissions calculated similarly to ammonium nitrate, but with $Frac_{GASM}$=0.2 resulting in 6.67 t CO_2e/tN;

(b) No emissions from fertiliser production are considered, resulting in total 6.67 t CO_2e/tN.

As an additional comparison, the calculation is also repeated for synthetic urea:

(a) Direct and indirect N_2O identical to ammonium nitrate equals 6.20 t CO_2e/tN;

(b) Emissions from urea production, from the same source as ammonium nitrate, is 1.70 t CO_2e/tN;

(c) Emissions from urea applications (carbon released from the urea decomposition) calculated as 0.429 tC/tN, which is the C/N mass ratio in urea. This is converted, by dividing by 12/44 (Weight of *C* in CO_2), to 1.57 t CO_2e/tN;

(d) Adding the above emissions results in 9.5 t CO_2e/tN.

Document information

Version	*Date*	*Description*
02.0	16 April 2015	EB 83, Annex 8 Revision to: • Simplify and streamline the requirements for accounting for leakage emissions from use of biomass residues or biomass from cultivation; • Introduce leakage calculation due to use of biomass residues; • Expand simplified approaches to include both small-scale and large-scale methodologies; • Includes project emissions due to biomass processing and biomass transport; • Change the title from “Project emissions from cultivation of biomass” to “Project and leakage emissions from biomass”.
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