July 2009

General Methodology for Quantifying the Greenhouse Gas Emission Reductions from the Production and Incorporation into Soil of Biochar in Agricultural and Forest Management Systems

1 List of Documents and Methodologies upon which the Proposed Methodology is Based or with which it is Consistent:

- VCS 2007.1 'Specification for the project-level quantification, monitoring and reporting as well as validation and verification of greenhouse as emissions reductions and removals'
- VCS Guidance for Agriculture, Forestry and Other Land Use Projects
- VCS Tool for AFOLU Methodological Issues
- VCS Tool for AFOLU Non-Permanence Risk Analysis and Buffer Determination
- Simplified modalities and procedures for small-scale clean development mechanism project activities
- CDM small-scale methodology AMS-III.L: Avoidance of methane production from biomass decay through controlled pyrolysis
- CDM small-scale methodology AMS III.E: Avoidance of methane production from decay of biomass through controlled combustion, **gasification or mechanical/thermal treatment**
- CDM baseline and monitoring methodology AM0025: Avoided emissions from organic waste through alternative waste treatment processes.
- CDM tool for the demonstration and assessment of additionality
- CDM Tool for estimation of Carbon Stocks, Removals and Emissions for the Dead Organic Matter Pools due to Implementation of a CDM A/R Project Activity.
  http://cdm.unfccc.int/methodologies/ARmethodologies/Tools/methAR_tool12_v01.pdf

2 Applicability: VCS Recognised Project Type the Methodology Relates to:

The methodology is applicable under the following conditions:

- The project type is an agricultural land management (ALM) or improved forest management (IFM) project
- The project reduces net GHG emissions from cropland and managed forests by increasing carbon stocks in soils. It is covered by VCS category 'Improved cropland management, including the adoption of practices that demonstrably reduce net GHG emissions from a defined land area by increasing soil carbon stocks'.

3 Technology/measure

3.1 This project category comprises measures that increase the carbon stocks in soils by treating crop residues or other biomass produced as part of agricultural activities or forest management through controlled pyrolysis[1]. The resulting carbon rich residue is applied to soils. Due to the project activity, net GHG emissions from cropland, grassland or managed forest land will be reduced by increasing carbon stocks in soils.[2]

3.2 This category is applicable to project activities that sequester carbon through pyrolysis of biomass that would otherwise have been left to decay or been burned in an uncontrolled manner. It applies where this biomass would not have been collected and put to any other use, e.g. as a fuel. Rather, in the absence of the project activity, the organic matter would have been burned or left to decay in aerobic conditions, with CO_2 emitted to the atmosphere and some carbon sequestered in the soil as organic soil content[3]. Alternatively, where biomass is expected to decay in non-aerobic conditions, the fraction of biomass that would have been converted to methane may be covered by the CDM small-scale methodology AMS-III.L: Avoidance of methane production from biomass decay through controlled pyrolysis. Categories of biomass that may be covered by this methodology are as follows:

- Crop residues, such as straw, husks, shells and pips
- Material from pruning or thinning of woody vegetation in agricultural systems with shade trees
- Off-cuts, sawdust and other material produced as a by-product of forest management or harvesting operations
- Diseased trees or deadwood felled in the course of plantation or woodland management

3.3 The project category applies where it is possible to ensure (for example through optimising the temperature at which materials are pyrolysed) that the pyrolysed residues are no longer prone to combustion or decomposition. The pyrolysed residues will only be considered biologically inert if the volatile-carbon/fixed-carbon ratio is equal to or lower than 50%.

3.4 Measures shall include recovery and combustion of non-CO_2 greenhouse gases produced during pyrolysis in order to ensure that no significant changes in greenhouse gas emissions occur as a consequence of the project activity: all the syngas produced will be combusted and not released unburned to the atmosphere. Measures to avoid physical leakage of the syngas shall also be adopted. Project proponents shall provide evidence that no GHG emissions, other than biogenic CO_2, occur due to chemical reactions during the pyrolysis process. Where some GHG emissions from the pyrolysis of non-biogenic materials are unavoidable, project proponents shall state the nature and extent of these emissions and account for these in calculations of the project's emissions.

---

1 Pyrolysis is defined as the thermo-chemical decomposition of organic materials into a carbon rich residue, non-condensable combustible gases, and condensable vapors, by heating in the absence or lack of oxygen, without any other reagents, except possibly steam.

2 A number of additional positive benefits are associated with the application of biochar to soil. These are not considered here.

3 If the biomass is left to decay in anaerobic conditions, for example in landfill, then this methodology shall not apply, but instead CDM small-scale methodology AMS-III.L *Avoidance of methane production from biomass decay through controlled pyrolysis* should be used.

3.5 If the pyrolysis facility is used for heat and electricity generation, that component of the project activity shall use a corresponding methodology relating to renewable energy generation.

3.6 Measures are limited to those that result in emission reductions of less than or equal to 60kt CO_2 equivalent annually.

3.7 Local regulations do not constrain the establishment of pyrolysis/thermal treatment plants nor the use of biochar as a soil additive.

3.8 During the pyrolysis process to produce biochar, no chemical or other additives shall be used.

3.9 The production of biochar shall be undertaken in such a way that does not act to the detriment of sustainable management principles.

4 Boundary

4.1 The project boundary is the physical, geographical sites:

(a) Where the crop residues or other biomass are produced;
(b) Where the crop residues or other biomass would have been disposed of in the absence of the project activities;
(c) Where the treatment of the crop residues or other biomass through controlled pyrolysis takes place;
(d) The storage site(s) of the pyrolysed residues;
(e) The areas where the pyrolysed residues are applied;
(f) And in the itineraries between them, where the transportation of crop residues or other biomass and pyrolysis residues occurs.

4.2 The temporal boundary of the project is 10 years.

4.3 The greenhouse gas emissions to be accounted for in the calculations of project emissions and emission removals are CO_2, CH_4 and N_2O as shown in table 1, below.

Table 1: Summary of gases and sources included in the project boundary, and explanation where gases are not included

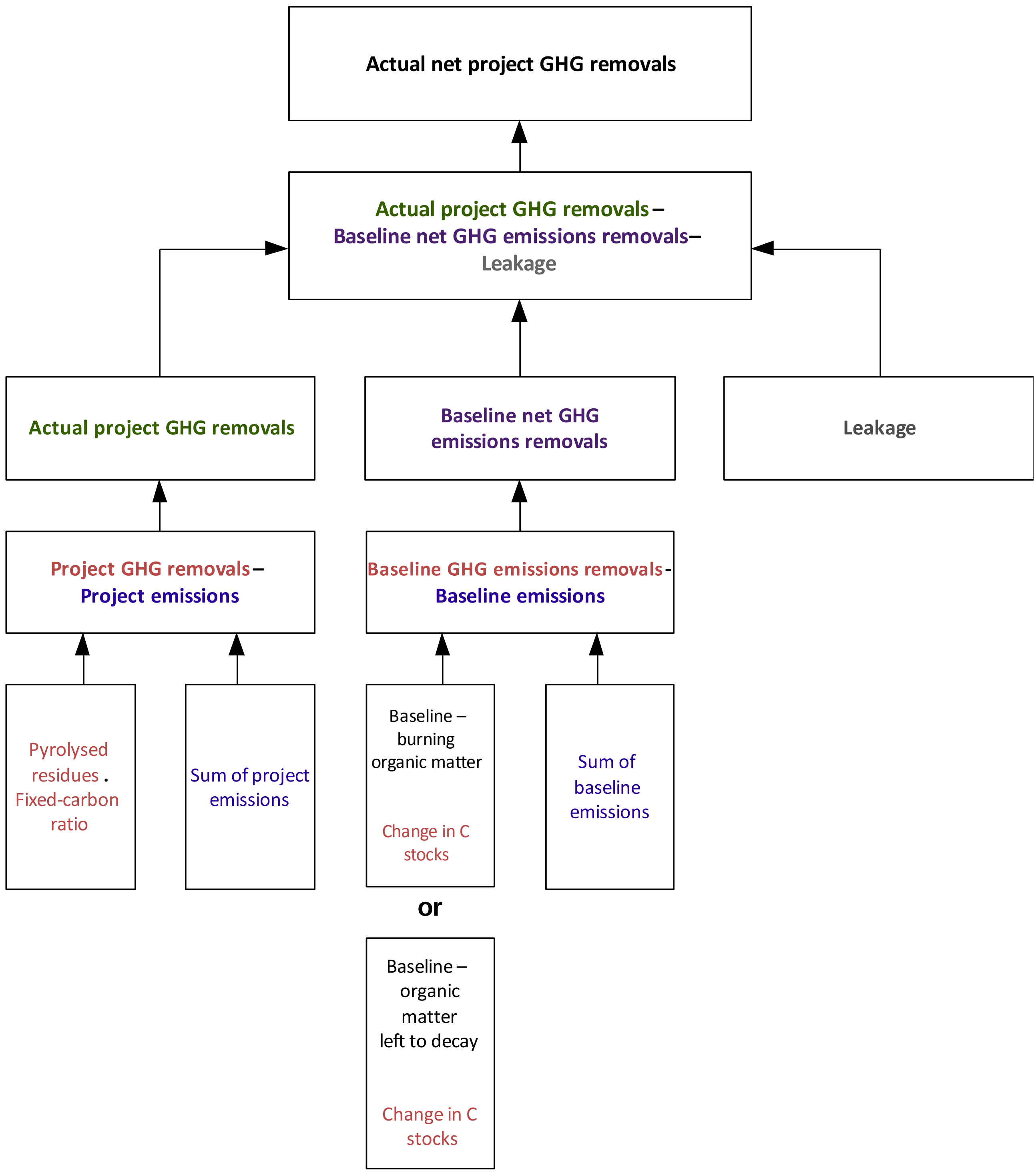
	Source	Gas		Explanation
Baseline	Emissions from the decomposition of agricultural residues or other biomass	CO_2	Excluded	These are not quantified as the methodology quantifies carbon sequestration directly based on quantities of organic matter (and does not require quantification of carbon fluxes from and to the atmosphere)
		CH_4	Excluded	CH_4 emissions are small compared to CO_2. Exclusion of this gas is conservative.
		N_2O	Excluded	N_2O emissions are small compared to CO_2. Exclusion of this gas is conservative.
	Emissions from the combustion of agricultural residues or other biomass	CO_2	Excluded	These are not quantified as the methodology quantifies carbon sequestration directly based on quantities of organic matter (and does not require quantification of carbon fluxes from and to the atmosphere)
		CH_4	Excluded	CH_4 emissions are small compared to CO_2. Exclusion of this gas is conservative.
		N_2O	Excluded	N_2O emissions are small compared to CO_2. Exclusion of this gas is conservative.
	Emissions removals from the fixed carbon content of residues (organic matter)	CO_2	Included	The major source of emissions removals.
		CH_4	Excluded	CH_4 sequestration is assumed to be zero.
		N_2O	Excluded	N_2O sequestration is assumed to be zero.
	Emissions from other sources related to the baseline practices	CO_2	Included	There are unlikely to be any other significant emissions from the displaced baseline activities. If no values are included this will constitute a conservative assumption.
		CH_4	Included	There are unlikely to be any other significant emissions from the displaced baseline activities. If no values are included this will constitute a conservative assumption.
		N_2O	Included	There are unlikely to be any other significant emissions from the displaced baseline activities. If no values are included this will constitute a conservative assumption.
Project Activity	Emissions removals from the fixed carbon content of biochar	CO_2	Included	The major source of emissions removals.
		CH_4	Excluded	CH_4 sequestration is assumed to be zero.
		N_2O	Excluded	N_2O sequestration is assumed to be zero.
	Emissions from the pyrolysis process	CO_2	Included	Non-biogenic CO_2 emissions have a GWP of 1.
		CH_4	Excluded	These emissions are assumed to be negligible.

		N_2O	Excluded	These emissions are assumed to be negligible.
	Emissions from the transportation and application of biochar	CO_2	Included	CO_2 is a significant source of transport emissions.
		CH_4	Excluded	These emissions are assumed to be negligible.
		N_2O	Excluded	These emissions are assumed to be negligible.
	Emissions from the fossil fuels and / or electricity consumed by project activities	CO_2	Included	CO_2 is the major source of emissions from fossil fuel and electricity consumption.
		CH_4	Excluded	These emissions are assumed to be negligible.
		N_2O	Excluded	These emissions are assumed to be negligible.

5 Summary of Process for Quantifying Net Emissions Reductions

5.1 Figure 1 below shows how overall project GHG emissions removals are calculated.

Figure 1: Actual net project GHG emissions removals per year



6 Total Net Project GHG Removals

6.1 The net anthropogenic GHG removals achieved by the project are quantified by calculating the difference between “with” and “without” project emissions. The difference between the two is the reduction achieved by the project. The net anthropogenic GHG removals achieved by the project activity for year *y* can be calculated as:

$PR_{,y} = C_{net,y} – C_{bsl,y} - Ly$

Where:

$PR_{,y}$ = Is the total net anthropogenic GHG removals achieved by the project in year *y* (tCO_2e).
$C_{net,y}$ = Is the net GHG removals as a result of the project activity in year *y* (tCO_2e/year). See section 7.
$C_{bsl,y}$ = Is the baseline GHG removals (tCO_2e/year). See section 11.
L_y = Is the leakage attributable to the project activity at time *y* (tCO_2e/year). See section 14.

7 Net Project Activity GHG Removals

7.1 Net project GHG removals are quantified by calculating project GHG removals and subtracting any emissions associated with the project's activities. Net GHG removals as a result of the project activity in year *y* are equal to:

$C_{net,y} = C_{sequest,y} - PE_y$

Where:

$C_{net,y}$ = Is the net GHG removals as a result of the project activity in year *y* (tCO_2e/year).
$C_{sequest,y}$ = Is the GHG removals in year *y* (tCO_2e/year). See section 8.
PE_y = Is the project emissions in year *y* (tCO_2e). See section 9.

8 Project Activity GHG Removals

8.1 The project activity will result in GHG removals through sequestration of carbon in soils. The project activity GHG removals by sequestration can be calculated by:

$C_{sequest,y} = Q_{residue,y} * CC_{residue,y} * SC_{carbon-}CO_2$

Where:

$C_{sequest,y}$ = Is the GHG removals in year *y* (tonnes of CO_2 equivalent).
$Q_{residue,y}$ = Is the quantity of pyrolysed residue in year *y* (tonnes).
$CC_{residue,y}$ = Is the average fixed carbon content of pyrolysed residue in year *y* (%).
$SC_{carbon-}CO_2$= Is the stoichiometric conversion from carbon to CO_2 (44/12).

8.2 The quantity of pyrolysed residue in year *y* should be obtained by weighing the mass of pyrolysed residue in year *y.*

8.3 Fixed carbon content ratio, $CC_{residue,y}$, can be calculated according to the procedures outlined in Standard Test Method for Chemical Analysis of Wood Charcoal ASTM D1762-84 (2007). The average fixed-carbon to volatile-carbon ratio of pyrolysed residues must be over 50% in order to be considered biologically inert.

9 Project Activity Emissions

9.1 Project activity emissions consist of:

(a) CO_2 emissions from non-biogenic organic material pyrolysed with crop residues or other biomass;

(b) CO_2 emissions from the consumption of auxiliary fossil fuels by the pyrolysis facility;

(c) CO_2 emissions from the collection and transportation of crop residues or other biomass to the pyrolysis facility, and transportation of the pyrolysed residues to sites where they are stored or sites where they are applied to soils.

(d) CO_2 emissions from machinery used in the application of the pyrolysed residues to soils.

(e) CO_2 emissions related to the fossil fuel and/or electricity consumed by the project activity facilities, including the equipment for air pollution control required by regulations. In case the project activity consumes grid electricity, the grid emission factor shall be calculated using the method outlined below[4].

9.2 The project emissions in year *y* are:

$$PE_y = PE_{pyrol,y} + PE_{fuel,y} + PE_{tran,y} + PE_{mach,y} + PE_{other,y}$$

Where:
PE_y = Is the project emissions during the year y (tCO_2e)
$PE_{pyrol,y}$ = Is the emissions from the pyrolysis process in year y excluding emissions from biogenic organic material (tCO_2e). See section 9.3.
$PE_{fuel,y}$ = Is the emissions from auxiliary fossil fuel combustion by the pyrolysis facility in year y (tCO_2e). See section 9.4.
$PE_{tran,y}$ = Is the emissions due to collection and transportation in year y (tCO_2e). See section 9.5.
$PE_{mach,y}$ = Is the emissions from the use of machinery to apply the pyrolysis residues in year y (tCO_2e). See section 9.6.
$PE_{other,y}$ = Is the emissions from other fuel or electricity consumption by the project activity facilities in year y (tCO_2e). See section 9.7.

9.3 *Emissions from pyrolysis*

Where the project activity involves pyrolysis, CO_2 emissions from non-biogenic materials which are pyrolysed with crop residues and other biomass are calculated as follows (non-biogenic materials

4 This method is consistent with CDM simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories: *I.D Grid connected renewable energy generation* available at http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_PHPV5WESACMBTJ2YY54GAJYSIEI3HD

may include plastic baling materials, containers etc):

Step 1:

$PE_{pyrol,y} = Q1_{emissions,y} + Q2_{emissions,y} .... + Qn_{emissions,y}$

Where:
$Q1_{emissions,y}$ = Is the emissions from a 1st type of non-biogenic material treated in the pyrolysis process in year *y* (tCO_2e)
$Q2_{emissions,y}$ = Is the emissions from a 2nd type of non-biogenic material treated in the pyrolysis process in year *y* (tCO_2e)
$Qn_{emissions,y}$ = Is the emissions from an nth type of non-biogenic material treated in the pyrolysis process in year *y* (tCO_2e)

Step 2:

$Q_{emissions,y} = Q_{material,y} * NCV_{materlal} * EF_{n\text{-}bmaterial}$

Where:

$Q_{material,y}$ = Is the quantity of material in year *y* (l or kg)
$NCV_{materlal}$ = Is the net caloric value of the material (MJ/l or MJ/kg)
$EF_{n\text{-}bmaterial}$ = Is the CO_2 emissions factor of the material (tCO_2/MJ)

Alternatively,

$$PE_{pyrol,y} = \frac{Q_{n\text{-}bmaterial,y}}{Q_{total,y}} * QCO_{2,,pyro,y}$$

Where:
$Q_{n\text{-}bmaterial,y}$ = Is the quantity of non-biogenic material pyrolysed in the year *y* (tonnes)
$Q_{total,y}$ = Is the total quantity of material pyrolised in the year *y* (tonnes)
$QCO_{2,,pyro,y}$ = Is the CO_2 emitted by the pyrolysis process in the year y (tCO2e)

If no non-biogenic materials are pyrolysed the value for $PE_{pyrol,y}$ will be zero.

Anticipated annual quantity of materials for pyrolysis by the project activity during the crediting period shall be reported in the project design document, including the quantities of biogenic and non-biogenic materials.

9.4 *Emissions from Auxiliary Fossil Fuel Combustion*

$PE_{fuel,y} = Q_{fuel,y} * NCV_{fuel} * EF_{fuel}$

Where:

$Q_{fuel,y}$ = Is the quantity of fossil fuel combusted in year *y* (l or kg)
NCV_{fuel} = Is the net caloric value of the fossil fuel (MJ/l or MJ/kg)
EF_{fuel} = Is the CO_2 emissions factor of the fossil fuel (tCO_2/MJ)

Anticipated annual auxiliary fuel consumption for the pyrolysis process shall be provided in the project design document.

9.5 *Emissions from Transportation*

$PE_{tran,y} = Q_{transfuel,y} * NCV_{transfuel} * EF_{transfuel}$

Where:

$Q_{transfuel,y}$ = Is the quantity of transport fuel combusted in year *y* (l or kg)
$NCV_{transfuel}$ = Is the net caloric value of the transport fuel (MJ/l or MJ/kg)
$EF_{transfuel}$ = Is the CO_2 emissions factor of the transport fuel (tCO_2/MJ)

9.6 *Emissions from Machinery*

$PE_{mach,y} = Q_{machfuel,y} * NCV_{machfuel} * EF_{machfuel}$

Where:

$Q_{machfuel,y}$= Is the quantity of fuel combusted by machinery in year *y* (l or kg)
$NCV_{machfuel}$ = Is the net caloric value of the fuel (MJ/l or MJ/kg)
$EF_{machfuel}$ = Is the CO_2 emissions factor of the fuel (tCO_2/MJ)

9.7 *Emissions from Other Sources*

$PE_{other,y} = Q_{otherfuel,y} * EF_{otherfuel}$

Where:

$Q_{otherfuel,y}$ = Is the quantity of fuel combusted by machinery in year *y* (l or kg)
$EF_{otherfuel}$ = Is the CO_2 emissions factor of the fuel (tCO2/MJ)

Alternatively,

$PE_{other,y} = Q_{elec,y} * EF_{elec}$

Where:

$Q_{elec,y}$ = Is the grid electricity consumed in year *y* (kWh)
EF_{elec} = Is the weighted average emissions factor for grid electricity of the current generation mix for the year in which the electricity is consumed ($kgCO_2e$/kWh)5

In cases where non-grid electricity is consumed, the emissions factor for electricity should be calculated according to the method set out in CDM document *I.D Grid connected renewable energy*

5 This data should be obtained from an official source (e.g. the national or state government).

generation6

In cases where both other fuels and electricity are consumed, $PE_{other,y}$ will be the sum of emissions from other fuels and electricity.

10 Baseline GHG Removals

10.1 The baseline scenario is the situation where, in the absence of the project activity, biogenic and other organic matter would have been burned or left to decay in aerobic conditions and CO_2 would be emitted to the atmosphere and some carbon would be sequestered in the dead organic matter (DOM) pool or in the soil as soil organic matter (SOM).

Project proponents should provide evidence in the project design document to demonstrate that the prevailing practices prior to the project involved either the burning or decay in aerobic conditions of crop residues or other organic matter. The appropriate evidence may include:

(a) Satellite images/remote sensing data
(b) Local, regional or national agricultural inventories, official reports, or peer reviewed studies.

11 Net Baseline GHG Removals

11.1 Net GHG removals in the baseline scenario are quantified by calculating total GHG removals and subtracting any emissions associated with baseline activities. Net baseline removals in year *y* are equal to:

$$BC_{net,y} = BC_{sequest,y} - BE_y$$

Where:

$BC_{net,y}$ = Is the net GHG removals in the baseline scenario in year *y* (tCO_2e).

$BC_{sequest,y}$ = Is the GHG removals in the baseline scenario in year *y* (tCO_2e).

BE_y = Is the baseline emissions in year *y* (tCO_2e). See section 10.6.

12 Baseline GHG Removals

12.1 The baseline scenario will result in GHG removals through the sequestration of carbon in dead organic matter and soils. If the baseline scenario involves burning agricultural residues or other organic matter a proportion of the biomass will not be combusted, and a proportion of the carbon

6 CDM simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories available at http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_PHPV5WESACMBTJ2YY54GAJYSIEI3HD

in the non-combusted biomass will be sequestered in the soil. If the baseline scenario involves leaving biomass to decay in aerobic conditions, a proportion of the carbon in the biomass will be sequestered in dead organic matter and in the soil.

12.2 This methodology does not quantify the total annual change in the dead organic matter (DOM) carbon pool or soil organic matter (SOM) carbon pool, but aims to quantify the additional carbon in DOM and SOM in the baseline scenario due to absence of the project scenario activities (i.e. the removal of biomass for pyrolysis). These additional baseline GHG removals at any year *y* during the crediting period are calculated based on the quantity of biomass which is removed in the project scenario and a calculation of the proportion of the carbon in the biomass which would have been sequestered in DOM or SOM in the baseline scenario. Different methods are required for calculating the baseline GHG removals depending on whether the baseline involves burning or decay of the agricultural residues or other organic matter.

12.3 ***Method for baseline involving the burning of agricultural residues or other organic matter.***

If the baseline scenario involves the burning of agricultural residues or other organic matter the following method should be used to estimate GHG removals.

$$BC_{sequest,y} = Q_{DOM,residue,y} * CC_{DOM,residue,y} * SC_{carbon\text{-}}CO_2$$

Where:

$BC_{sequest,y}$ = Is the GHG removals in year *y* (tonnes of CO_2 equivalent)
$Q_{DOM,residue,y}$ = Is the quantity of DOM residue after burning in year *y* (tonnes)
$CC,_{DOM,residue,y}$ = Is the average carbon content of DOM residue in year *y* (%)
$SC_{carbon\text{-}}CO_2$= Is the stoichiometric conversion from carbon to CO_2 (44/12)

The quantity of DOM residue after burning is determined by the quantity of DOM collected for pyrolysis and the fraction of DOM which is not combusted after burning. The quantity of DOM residue after burning in year y is equal to:

$$Q_{DOM,residue,y} = Q_{DOM,\ y} * f_{BL,\ DOM}$$

where:

$Q_{DOM,\ y}$ = Quantity of DOM collected for pyrolysis in year *y* (tonnes)

$f_{BL,\ DOM}$ = Average fraction of DOM left to decay after burning of DOM stocks, default value 0.4[7]

A value for $Q_{DOM,\ y}$ should be obtained from ex post monitoring of the quantity of biomass pyrolysed in year *y*.

There will be some DOM which is not collected for pyrolysis which will not be accounted for under this method, however this DOM will be left to decay in the project scenario and either left to decay

[7] The value given is that for live tree wood, derived from data in IPCC publications (for details, see *Annex 1, Section A.I.4*, of the methodological tool: *Estimation of emissions from clearing, burning and decay of existing vegetation due to implementation of a CDM A/R project activity*; (available at <http://cdm.unfccc.int/ Reference/tools>).

or be burnt in the baseline scenario. If the DOM is left to decay in the baseline scenario there will not be a difference in emissions or removals associated with this DOM between the two scenarios. If the DOM is burnt in the baseline scenario this is likely to result in greater emissions and less removals associated with this DOM compared to the project scenario, and would therefore result in a conservative estimate of emissions reductions.

A value for $f_{BL, DOM}$ may be obtained from:

(a) Preferably— official reports or peer reviewed studies on plantations of the same species or the same agricultural system, in the same broad climate zone as the project. If data for the same species do not exist, preferably use data from the same *genus*, or otherwise from the same *family*;
(b) Or alternatively—if no better data are available, a default value of 0.4 may be used.

A value for the average carbon content of the DOM residue left after burning, may be obtained from:

(a) Sampling plots where burning practices are used, and testing for the carbon content of DOM residues left after burning using an elemental analyser;

(b) Official reports or peer reviewed studies

A proportion of the DOM which is left after burning may decay and a proportion may be sequestered. In order to simplify the method a further conservative assumption is made; that the carbon in the DOM which is left after burning is sequestered and is counted as a removal.

12.4 *Method for baseline in which agricultural residues and other organic matter are left to decay in aerobic conditions*

In the absence of burning of DOM, an estimate must be made of the carbon removals in the baseline attributable to the biomass that would be harvested for biochar under the project scenario. These removals will occur in the dead organic matter and soil organic matter (SOM) pools.

The carbon removals in the DOM and SOM pools in year *y*, are given by:

$$BC_{sequest,y} = \Delta C_{DOM,y} + \Delta C_{SOM,y}$$

where:

$BC_{sequest,y}$ = Is the baseline GHG removals in year y (tonnes of CO_2 equivalent)

$\Delta C_{DOM,y}$ = Average annual change in carbon stocks in the baseline DOM pool attributable to biomass that would be harvested for biochar under the project scenario, allocated to year y; tCO_2e

$\Delta C_{SOM,y}$ = Average annual change in carbon stocks in the baseline SOM pool attributable to biomass that would be harvested for biochar under the project scenario, allocated to year y; tCO_2e

The average annual change in baseline DOM pool carbon stocks attributable to biomass that would be harvested for biochar under the project scenario should be estimated by the use of a model, in accordance with IPCC Guidance Tier 3 methods. Estimates of changes to DOM carbon stocks should be made for a scenario where biomass that would be pyrolysed under the project scenario – i.e. prunings – is left in situ and for a scenario where these prunings are removed. The average annual change in carbon stocks in the baseline DOM pool is calculated as follows:

$\Delta C_{DOM,y} = \Delta C_{ALLDOM,y} - \Delta C_{DOMNoPr,y}$

where:

$\Delta C_{DOM,y}$ = Average annual change in carbon stocks in the baseline DOM pool, allocated to year y; tCO_2e

$\Delta C_{ALLDOM,y}$ = Average annual change in carbon stocks in the scenario where prunings are left in situ, allocated to year y; tCO_2e

$\Delta C_{DOMNoPr,y}$ = Average annual change in carbon stocks in the scenario where prunings are removed, allocated to year y; tCO_2e

Estimates of the average annual change in baseline SOM pool carbon stocks ($\Delta C_{SOM,y}$) attributable to biomass that would be harvested for biochar under the project scenario, can be made using either the Century or SCUAF soil organic matter model 8. Estimates of changes to SOM carbon stocks should be made for the baseline scenario where agricultural residues or other biomass (prunings) is left in situ and for a scenario where this biomass is removed. The average annual change in carbon stocks in the baseline SOM pool is calculated as follows:

$\Delta C_{SOM,y} = \Delta C_{ALLSOM,y} - \Delta C_{SOMNoPr,y}$

where:

$\Delta C_{SOM,y}$ = Average annual change in carbon stocks in the baseline SOM pool, allocated to year y; tCO_2e

$\Delta C_{ALLSOM,y}$ = Average annual change in carbon stocks in the scenario where prunings are left in situ, allocated to year y; tCO_2e

$\Delta C_{SOMNoPr,y}$ = Average annual change in carbon stocks in the scenario where prunings are removed, allocated to year y; tCO_2e

13 Baseline emissions

$BE_y = BE1_{emissions,y} + BE2_{emissions,y} .... + BEn_{emissions,y}$

Where:

$BE1_{emissions,y}$ = Is the emissions from a 1st emissions source in year *y* (tCO_2e)

8 See Colorado State University's Century Soil Organic Matter Model, http://nrel.colostate.edu/projects/century5/ and the Australian Centre for International Agricultural Research's Model to Estimate Soil Changes Under Agriculture, Agroforestry and Forestry, available at http://www.une.edu.au/carbon/scuaf.php. Both models require field experiments to provide data inputs to the model; the latter recommending several years' worth of experiments.

$BE2_{emissions,y}$ = Is the emissions from a 2nd emissions source in year *y* (tCO_2e)
$BEn_{emissions,y}$ = Is the emissions from an nth emissions source in year *y* (tCO_2e)

If there are no significant emissions sources in the baseline scenario then emissions can be conservatively assumed to be zero.

14 Leakage

14.1 Leakage refers to any changes in emissions (positive or negative) that occur outside the project boundary – i.e. outside the control of the project proponents – as a result of the project activity. The type of ALM or IFM project activity covered by this methodology is not anticipated to result in any leakage. There is no land use change involved and no people, crops or livestock will be displaced. As this project type is only applicable where the crop residues or other biomass that will be used to produce biochar under the project scenario are not used for any particular purpose (e.g. as fuel) under the baseline scenario, no leakage is anticipated from increased biomass collection outside the project boundary.

14.2 However, if the pyrolysis technology is equipment transferred from another activity or if any existing charcoal equipment is transferred to another activity, leakage effects are to be considered.

15 Additionality Methodology

15.1 The additionality of the project activity shall be demonstrated and assessed using the latest version of the "Tool for the demonstration and assessment of additionality" agreed by the CDM Executive Board, or approved VCS additionality tool.

16 Monitoring

16.1 The quantity of pyrolysis residue (biochar) ($Q_{residue,y}$) produced each year shall be measured and recorded.

16.2 The percentage composition of volatile-carbon, fixed-carbon, ashes and moisture in the biochar shall be determined in a representative number of samples. The size and frequency of sampling shall be statistically significant with a maximum uncertainty range of 20% at a 95% confidence level. At a minimum, sampling should be undertaken four times a year. Determinations shall be made according to the "Standard Test Method for Chemical Analysis of Wood Charcoal" - ASTM D1762-84 (2001). The pyrolysed residues will only be considered biologically inert if the volatile-carbon/fixed-carbon ratio is equal to or lower than 50%.

16.3 The amount of crop residues or other biomass pyrolysed each year ($Q_{material,y}$) shall be measured and recorded. The weight fraction of any non-biogenic material shall be determined through representative sampling and recorded to enable estimation of emissions from the pyrolysis process in the year, excluding emissions from biogenic organic material ($PE_{pyrol,y}$). The size and frequency of sampling shall be statistically significant with a maximum uncertainty range of 20% at a 95%

confidence level. At a minimum, sampling should be undertaken four times a year.

16.4 The quantity of auxiliary fuel used ($Q_{fuel,y}$) and fuel type(s) shall be measured and recorded unless it is demonstrated that the fuel used is renewable biomass, to enable the calculation of project activity emissions from auxiliary fuel use.

16.5 The quantity of fuel used for transportation ($Q_{transfuel,y}$) and fuel type(s) shall be measured and recorded to enable the calculation of project activity emissions attributable to transportation.

16.6 The quantity of fuel used by machinery ($Q_{machfuel,y}$) and fuel type(s) shall be measured and recorded to enable the calculation of project activity emissions from machinery use.

16.7 The quantity of other fuels used ($Q_{otherfuel,y}$) as well as the type(s) of fuel and the power consumption of the project activity facilities ($Q_{elec,y}$) and/or power generation by the project activity shall be monitored and recorded.

16.8 The project participants shall demonstrate annually, through the assessment of common practices at proximate and equivalent sites, that the amount of crop residues or other biomass pyrolysed by the project activity facilities would have been-burned or left to decay aerobically in the absence of the project activity.

16.9 Where the project activity uses pyrolysis technology transferred from another activity and leakage effects are being considered, all identified potential leakage effects shall be monitored. Monitoring shall occur on a six-monthly basis.