METHODOLOGICAL DOCUMENT

AFOLU & Waste handling and disposal

BCR0011

Sustainable biochar production, carbon removal and long-term storage

BioCarbon Cert™

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Acronyms and abbreviations

AD	Anaerobic digestion
AFOLU	Agriculture, forestry, and other Land Use
BCR	Biochar Carbon Removal
BECCS	Bioenergy with carbon dioxide capture and storage
CDM	Clean Development Mechanism
CDR	Carbon Dioxide Removal
CH_4	Methane
CEC	Cation exchange capacity
CCS	Carbon Dioxide Capture and Storage
CDR	Carbon Dioxide Removal
CO_2	Carbon Dioxide
DM	Dry matter
DOC	Degradable organic carbon
EBC	European Biochar Certificate
FAO	Food and Agriculture Organization of the United Nations
FC	Fixed carbon
GHG	Greenhouse gases
LCA	Life Cycle Assessment
HTC	Hydrothermal Carbonization
IBI	International Biochar Initiative
IPCC	Intergovernmental Panel on Climate Change
N_2O	Nitrous oxide
SCS	Soil carbon sequestration
SDG	Sustainable Development Goals
SA	Surface area
SOC	Soil organic carbon
SWDS	Solid waste disposal sites

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1 Introduction

The increase in global energy demand has led to a surge in greenhouse gas (GHG) emissions from fossil fuels, prompting the urgent need for a transition towards achieving net-zero emissions by 2050. To address this challenge, a circular bioeconomy strategy in alignment with the United Nations Sustainable Development Goals (SDGs) aims to optimize resource usage and establish renewable economic systems.

As part of efforts to combat climate change, a significant reduction in greenhouse gas emissions is critical. Biochar, particularly derived from biomass, stands out as a significant contributor. This carbon-rich row material holds properties that not only enrich soil fertility and augment crop yields but also contribute to the reduction of GHG emissions. Historically, biochar has played a vital role dating back thousands of years, notably as a soil amendment that has exhibited prolonged stability and enhanced fertility in agricultural settings.

Recent research endeavors combining biochar with other soil amendments have showcased promising reductions in emissions and enhanced nutrient utilization in plant growth (Hossain et al., 2020). Nevertheless, understanding the long-term consequences of these combined applications on GHG emissions and soil properties remains limited, hindering the development of sustainable agricultural practices.

Biochar, generated from biomass pyrolysis, has garnered attention as a potential solution to curtail GHG emissions. Studies utilizing life cycle assessment (LCA) have thoroughly examined its impact as a soil amendment, revealing its versatility as a carbon sequestration material or catalyst precursor. This versatile material not only enhances soil quality but also plays a role in mitigating GHG emissions. Its effectiveness in reducing GHG emissions arises from its unique physicochemical properties, which interact with soil and microorganisms. These interactions result in improved soil characteristics, such as increased carbon content and pore richness, leading to a reduction in overall warming potential. Additionally, biochar regulates soil gas emissions by influencing microbial activity, thus impacting methane and nitrous oxide levels (Bai et al. 2025).

In line with global climate change mitigation goals, BioCarbon Cert is committed to providing valuable insights and scientific evidence to support the development and implementation of sustainable practices. This includes the positive impact of biochar on GHG reduction throughout its lifecycle, counteracting emissions associated with biomass collection and transport by using waste and non-waste materials for biochar production.

The methodology also includes quantification of emission reductions associated with permanent storage through non-soil applications incorporated into building materials (concrete, asphalt, and any other application where long-term storage is possible), recognizing that implementation of sustainable mitigation projects will require decisions about methods, scale, and timing of deployment, and how to address sustainability and feasibility challenges.

This methodology aligns with ISO 14064 standards for carbon accounting and ensures credibility, transparency, and eligibility for carbon credit certification, providing a structured and compressive method for assessing the short and long-term impacts of biochar application on greenhouse gas emissions and soil health parameters.

2 Sources

This methodology is based on:

CLEAN DEVELOPMENT MECHANISM. AMS-III.BG. Small-scale Methodology Emission reduction through sustainable charcoal production and consumption Version 04.0 (United Nations, 2023a).

CLEAN DEVELOPMENT MECHANISM. AMS-III.K.: Avoidance of methane release from charcoal production. Version 05.0 (United Nations, 2025b).

CDM – Executive Board. EB33 Report. AMS-III.L. Indicative simplified baseline and monitoring methodologies for selected small-scale CDM project activity categories. Avoidance of methane production from biomass decay through controlled pyrolysis, version 2.0 (United Nations, 2025a).

CLEAN DEVELOPMENT MECHANISM. AMS-III.E Small-scale Methodology. Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment Version 17.0 (United Nations, 2015).

CLEAN DEVELOPMENT MECHANISM. TOOL16. Methodological tool Project and leakage emissions from biomass Version 05.0 (United Nations, 2020c).

CLEAN DEVELOPMENT MECHANISM. TOOL03. Methodological tool. Tool to calculate project or leakage CO2 emissions from fossil fuel combustion. Version 03.0 (United Nations, 2017d).

CLEAN DEVELOPMENT MECHANISM. TOOL04. Emissions from solid waste disposal site. Version 08.1 (United Nations, 2023b).

CLEAN DEVELOPMENT MECHANISM. TOOL05. Methodological tool Baseline, project and/or leakage emissions from electricity consumption and monitoring of electricity generation Version 03.0 (United Nations, 2017a).

CLEAN DEVELOPMENT MECHANISM. TOOL08. Determining the baseline efficiency of thermal or electric energy generation systems. Version 03.0 (United Nations, 2020b).

CLEAN DEVELOPMENT MECHANISM. TOOL12. Methodological tool Project and leakage emissions from transportation of freight Version 01.1.0 (United Nations, 2012).

CLEAN DEVELOPMENT MECHANISM. TOOL13. Project and leakage emissions from composting. Version 02.0 (United Nations, 2017c).

CLEAN DEVELOPMENT MECHANISM. TOOL14. Project and leakage emissions from anaerobic digesters. Version 03.0 (United Nations, 2024).

CLEAN DEVELOPMENT MECHANISM. Executive Board. EB23 Report, Annex 18. Definition of Renewable Biomass (United Nations, n.d.).

CLEAN DEVELOPMENT MECHANISM TOOL21. Methodological tool Demonstration of additionality of small-scale project activities Version 13.1 (United Nations 2020a).

3 Purpose of the methodology

This methodology establishes the requirements for the production, utilization, and carbon storage of biochar. It aims to quantify, monitor and verify greenhouse gas (GHG) reductions from biochar use in soil and non-soil applications, ensuring adherence to sustainable practices.

In this context, the purpose of this methodology is to:

(a) provide specification of the production technologies requirements for use under this methodology;

(b) provide information about the eligibility of different types and combinations of biochar in agricultural soil amendments, including their effects on mitigating greenhouse gas emissions and enhancing soil fertility;

(c) bring guidance on the effects of different types of biochar, concentrations and combinations with other agricultural materials on greenhouse gas emissions and soil quality;

(d) set out the requirements for the economic viability and environmental sustainability of the use of biochar as a soil amendment for the reduction of greenhouse gas emissions in agricultural practices;

(e) stablish guidelines for the complete life cycle to determine the overall environmental impact of biochar production, transportation, application, and the resulting impact on GHG emission reductions;

(f) bring the specifications about the types of biomasses eligible under this methodology;

(g) set out the requirements for end-use applications of biochar;

(h) determine the methodological requirements necessary for the identification of the baseline for the biochar production and application;

(i) furnish the methodological requirements to demonstrate additionality of BioChar projects;

(j) describe the requirements for the monitoring and follow-up of BioChar projects;

(k) establish requirements related to permanence and leakages;

(l) to define the requirements for quantifying the GHG emission reductions from the project activity;

(m) facilitate the articulation of the project accounting with national accounting, if applicable.

4 Version and validity

This document constitutes the document for public consultation. August 1, 2025.

This version may be updated from time to time and intended users should ensure that they use the most recent version of the document.

5 Scope

This methodology corresponds to a methodology for establishing baseline, quantifying greenhouse gas (GHG) emission reductions/removals, and monitoring GHG projects. It encompasses aspects such as leakage management, monitoring and mitigation results.

The quantification of emissions reductions focuses on various biochar types, employing a life cycle assessment (LCA) approach to understand their short-term and long-term effects. The scope includes assessing biochar's role in mitigating greenhouse gas emissions, while the limitations encompass potential challenges in data consistency, complexity of interactions, and resource constraints. Overall, this methodology intends to provide insights into biochar's effectiveness in reducing emissions and improving soil quality, yet it acknowledges the potential limitations in generalizing findings and the dynamic nature of evolving technologies in this field.

The scope of this methodology includes the biochar production and the biochar application, including soil and non-soil. The combination of such activities may produce quantifiable mitigation results. It is important to remark that the biochar application shall be into a stable matrix where the carbon will remain durably stored.

This methodology is applicable to projects utilizing through approved thermochemical processes/conversion technologies to produce biochar for soil and non-soil applications. It ensures adherence to sustainability, additionality, and permanence principles.

6 Applicability conditions

This Methodology is applicable under the following conditions:

(a) a new or retrofitted biochar facility production should be involved in the project activities;

(b) the project activities include the following production processes: pyrolysis, gasification and/or biomass boilers (See Appendix 1);

(c) the processes used to produce biochar are not the following: torrefaction, hydrothermal carbonization (HTC), combustion (e.g., charcoal making);

(d) the end-use application requires that the biochar be used for long-term carbon storage. It is not possible to use biochar for energy production;

(e) the use of biochar shall include the assessment of short-term, medium-term and long-term effects of biochar and its combinations with other agricultural materials. Only biochar used in permanent applications (≥100 years) is eligible for carbon crediting;

(f) the biochar production and use include a thorough evaluation of the full life cycle of biochar, encompassing production and application, as well as the subsequent environmental implications;

(g) the project activities include the assessment of the potential of biochar in reducing greenhouse gas emissions, contributing to a comprehensive understanding of its impact on climate change;

(h) the production of biochar is exclusively permitted when utilizing biomass and excluding fossil carbon;

(i) the production of biochar[1]: include the following feedstock: agricultural biomass, forestry and wood processing, landscape and urban biomass, food and industrial biomass, water and marine biomass, and anaerobic digestion residues. (See Appendix 2);

(j) the project activities do not include the following processes[2]: torrefaction, hydrothermal carbonization (HTC), combustion (e.g., Charcoal Production);

(k) the biomass used for biochar production is classified as renewable biomass (See Appendix 3);

(l) the land in which biomass is produced does not contain wetlands, and is not subjected to flood irrigation;

(m) feedstock is produced locally or regionally if they are also an environmentally sustainable option. And are not imported across international borders to avoid leakage;

(n) biochar production systems shall be sustainable, healthy and efficient, and shall meet the environmental standards and regulatory requirements of the country in which they operate;

(o) the biochar production does not cause deforestation or biodiversity loss.

7 Normative references

The following normative references are essential for the application of this methodology. The user shall consult the latest available versions of each document:

(a) BioCarbon Standard, including all relevant program rules, eligibility conditions, and applicable procedures for GHG crediting activities;

[1] Biochar is a porous, carbon-rich material made by heating biomass in a low-oxygen environment at temperatures between 350°C and 1000°C. It is used to lock carbon in the ground for long periods or to replace fossil carbon in products; it is not meant to be burned for energy (EBC, 2024).

[2] These processes are excluded because they do not yield a product with the properties required for stable, long-term carbon sequestration.

(b) IPCC Guidelines for National Greenhouse Gas Inventories (2006 and 2019), Volume 4 – Agriculture, Forestry and Other Land Use (AFOLU);

(c) National legal frameworks relevant to land use, land tenure, forest classification, deforestation permits, and concession systems in the host country.

7.1 Applicable tools

This methodology shall be applied in conjunction with the BIOCARBON PROGRAM and all applicable official tools issued by BioCarbon. The following tools are mandatory and shall be applied in full, as per the project's scope and characteristics:

(a) Baseline and Additionality Tool;

(b) Uncertainty Management Tool;

(c) Permanence and Risk Management Tool;

(d) Monitoring, Reporting and Verification (MRV) Tool;

(e) Avoiding Double Counting (ADC) Tool;

(f) Sustainable Development Safeguards (SDSs) Tool;

(g) Sustainable Development Goals (SDGs) Tool;

These tools form part of the normative framework of the BIOCARBON STANDARD. Selective application or modification is not allowed. Project documentation shall demonstrate the complete and consistent application of each tool, as per the most recent version at the time of validation or verification. Failure to comply with these instruments shall result in ineligibility for registration, verification, or credit issuance.

BioCarbon reserves the right to develop, approve, and publish additional tools, templates, or guidance documents that supplement the BCR STANDARD and its methodologies. Any such instruments, once officially issued and published by the Program, shall be considered binding and shall be applied by all project holders from their effective date onward, unless stated otherwise in transitional provisions.

8 Terms and definitions

Additionality

Is the effect of the GHG Project activity to reduce anthropogenic GHG emissions below the level that would have occurred in the absence of the GHG Project activity.

In the AFOLU sector, other than REDD+ projects, additionality is the effect of the project activity to increase actual net GHG removals by sinks above the sum of the changes in carbon stocks in the carbon pools within the project boundary that would have occurred in the absence of project activity.

Source: Adapted from Glossary CDM terms. Version 11.0 (United Nations, 2022).

Agriculture, Forestry and other land use (AFOLU)

The sector comprises either greenhouse gas emissions or removals attributable to project activities in agriculture, forestry, and other land uses.

Anaerobic decomposition (Anaerobic digestion)

Degradation and stabilization of organic materials by the action of anaerobic bacteria that result in production of methane and carbon dioxide. Typical organic materials that undergo anaerobic digestion are municipal solid waste (MSW), animal manure, wastewater, organic industrial effluent and biosolids from aerobic wastewater treatment plants (United Nations, 2017b).

Atmosphere

The gaseous envelope surrounding the earth, divided into five layers — the troposphere which contains half of the earth's atmosphere, the stratosphere, the mesosphere, the thermosphere, and the exosphere, which is the outer limit of the atmosphere. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93 % volume mixing ratio), helium and radiatively active greenhouse gases (GHGs) such as carbon dioxide (CO_2) (0.04% volume mixing ratio) and ozone (O_3). In addition, the atmosphere contains the GHG water vapor (H_2O), whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and **aerosols**[3]**.**

Baseline emissions

The GHG emissions that would occur in the baseline scenario (United Nations, 2022).

Baseline scenario

The baseline scenario is the scenario that reasonably represents the sum of the variations in carbon stocks, included in the project boundaries, that would occur in the absence of the project's activities.

For a project activity (in sectors other than AFOLU), the scenario for the GHG mitigation project that reasonably represents the anthropogenic emissions by sources of GHGs that would occur in the absence of the GHG mitigation project activity.

For an AFOLU project, the scenario for the GHG Project that reasonably represents the sum of the changes in carbon stocks in the carbon pools within the project boundary that would occur in the absence of the GHG Project.

Source: Adapted from Glossary CDM terms. Version 11.0 (United Nations, 2022).

Biochar

Biochar is defined as a solid material produced by heating biomass to temperatures above 350°C under controlled conditions with limited oxygen to prevent combustion (IPCC, 2019b).

Stable, carbon-rich material produced by heating biomass in an oxygen-limited environment. Biochar may be added to soils to improve soil functions and to reduce greenhouse gas emissions from biomass and soils, and for carbon sequestration. This definition builds from IBI (IPCC, 2018).

[3] A suspension of airborne solid or liquid particles, with a typical size between a few nanometers and 10 μm, that reside in the atmosphere for at least several hours. Aerosols may be of natural or anthropogenic origin and can influence climate by scattering or absorbing radiation and interacting with clouds. They originate from primary emissions or as secondary formations from gaseous precursors (IPCC, 2018).

Bioenergy with carbon dioxide capture and storage (BECCS)

Carbon Dioxide Capture and storage (CCS) technology applied to a bioenergy facility. Note that depending on the total emissions of the BECCS supply chain, carbon dioxide can be removed from the atmosphere.

Biogenic

Refers to carbon or greenhouse gas (GHG) emissions that originate from biological sources or processes. In the context of carbon accounting, "biogenic" typically applies to emissions resulting from the decomposition, combustion, or transformation of biomass materials such as wood, crop residues, animal waste, or other organic matter of recent biological origin. Biogenic CO_2 is considered part of the natural carbon cycle and is treated differently from fossil-derived CO_2, which introduces carbon previously stored underground into the active carbon cycle.

Biogenic emissions include CO_2 from the combustion of biomass, CH_4 and N_2O from manure management, composting, and anaerobic decay, CO_2 from the respiration of plants and animals (not typically accounted in GHG inventories).

They are commonly distinguished from fossil emissions, which arise from coal, oil, or natural gas, and are considered net additions to atmospheric CO_2. (IPCC, 2006)[4]

Biogenic carbon

Carbon derived from biogenic (plant or animal) sources excluding fossil carbon. Note that peat is treated as a fossil carbon in these guidelines as it takes so long to replace harvested peat (IPCC, 2019a).

Biomass

Living or recently dead organic material (IPCC 2018).

Non-fossilized and biodegradable organic material originating from plants, animals and micro-organisms including: (a) Biomass residue; (b) The non-fossilized and biodegradable organic fractions of industrial and municipal wastes; (c) The gases and

[4] The term “biogenic” is not defined as a glossary entry, but it is widely used throughout the document, especially in reference to “biogenic CO_2”.

liquids recovered from the decomposition of non-fossilized and biodegradable organic material (United Nations 2022).

Carbon dioxide

A naturally occurring gas, CO_2 is also a by-product of burning fossil fuels (such as oil, gas and coal), of burning biomass, of land-use changes (LUC) and of industrial processes (e.g., cement production). It is the principal anthropogenic greenhouse gas (GHG) that affects the Earth's radiative balance. It is the reference gas against which other GHGs are measured and therefore has a global warming potential (GWP) of 1. See also Greenhouse gas (GHG) (IPCC 2018).

Carbon dioxide removal (Carbon removal)

According to the (IPCC, n.d.) refers to technologies, practices, and approaches that remove and durably store carbon dioxide (CO_2) from the atmosphere. CDR is required to achieve global and national targets of net zero CO_2 and greenhouse gas (GHG) emissions. CDR cannot substitute for immediate and deep emissions reductions, but it is part of all modelled scenarios that limit global warming to 2°or lower by 2100.

Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products. It includes existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage but excludes natural CO_2 uptake not directly caused by human activities (IPCC, 2018).

End-use applications

Refer to the various ways biochar is utilized across different industries and sectors to harness its beneficial properties. Biochar has a wide range of applications due to its ability to improve soil health, sequester carbon, purify water, and support industrial processes.

The end-use applications of biochar include agriculture and soil amendment, energy and fuel production, environmental remediation, water filtration and treatment, livestock farming, construction and industrial applications, etc.

Feedstock

The materials that are processed thermochemically to produce biochar. Feedstocks shall be biogenic and meet the eligibility requirements.

Feedstock supply

Feedstock supply refers to the sourcing and availability of raw materials used in production processes across various industries, such as biofuels, chemicals, manufacturing, and food processing.

Sustainable biochar is made from biomass residue materials like rice husks, corn stover, or non-commercial forestry residues. Biomass waste materials appropriate for biochar production include crop residues, as well as yard, food and forestry wastes, and animal manures. Large amounts of agricultural, municipal, and forestry biomass are currently burned or left to decompose, releasing carbon and methane back into the atmosphere. These residue materials can also pollute local ground and surface waters — a large issue for livestock wastes (International Biochar Initiative, 2025).

Freight

Goods and materials (including waste materials) that are transported.

Freight transportation activity

Trips undertaken under the project activity that shall be grouped together as using the same vehicle class and transporting freight between the same origin and destination;

Gasification

Gasification can be defined as a thermochemical process which transfer heating value from carbonaceous materials into syngas (i.e., a mixture of H_2 and CO), tars and biochar at high temperature (>500 °C) and oxygen-deficient conditions. The gasification process generally involves four consecutive steps, i.e., drying, pyrolysis (i.e., thermally induced fragmentation via bond dissociation and dehydrogenation), partial oxidation and reduction (Loha et al., 2015).

GHG Project (Greenhouse gas project)

Activity or activities that alter the conditions of a GHG baseline and cause GHG emissions reductions or GHG removals.

[SOURCE: ISO 14064-3:2019(en), 3.4.1.]

GHG Project holder (greenhouse gas project proponent)

Individual or organization that has overall control and responsibility for a GHG project. Note 1 to entry: The term "project proponent" is also used synonymously in the text.

[SOURCE: ISO 14064-2:2019(en), 3.3.2]

Greenhouse gas reservoir (GHG reservoir)

Component, other than the atmosphere, that has the capability to accumulate GHGs, and to store and release them.

Note 1 to entry: The total mass of carbon contained in a GHG reservoir at a specified point in time could be referred to as the carbon stock of the reservoir.

Note 2 to entry: A GHG reservoir can transfer GHGs to another GHG reservoir.

Note 3 to entry: The collection of a GHG from a GHG source before it enters the atmosphere and storage of the collected GHG in a GHG reservoir could be referred to as GHG capture and GHG storage.

Leakages

The net change of anthropogenic emissions by sources of GHGs which occur outside the project boundary, and which is measurable and attributable to the project activity.

Lifecycle assessment (LCA)

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product or service throughout its life cycle. This definition builds from ISO (IPCC, 2018).

Manure

According to Eurostat (2008), "manure (also known as livestock manure) is organic matter, mostly derived from animal faeces and urine, but normally also containing plant material (often straw), which has been used as bedding for animals and has absorbed the faeces and urine. In the Nitrates Directive (Council Directive 91/676/EEC), it is defined as "waste products excreted by livestock or a mixture of litter and waste products excreted by livestock, even in processed form". Dairy, beef and swine manure may be either solid or slurry. Horse and poultry manures are solid.”.

Methane (CH_4)

One of the six greenhouse gases (GHGs) to be mitigated under the Kyoto Protocol and is the major component of natural gas and associated with all hydrocarbon fuels. Significant emissions occur as a result of animal husbandry and agriculture, and their management represents a major mitigation option (IPCC, 2018).

Mineral soils

Any soil that does not meet the definition of organic soil (see Annex 3A.5, Chapter 3, Volume 4 of the 2006 IPCC Guidelines) (IPCC, 2006a).

Mitigation

An anthropogenic intervention to reduce the sources or enhance the sinks of greenhouse gases.

Nitrous oxide (N_2O)

One of the six greenhouse gases (GHGs) to be mitigated under the Kyoto Protocol. The main anthropogenic source of N_2O is agriculture (soil and animal manure management), but important contributions also come from sewage treatment, fossil fuel combustion, and chemical industrial processes. N_2O is also produced naturally from a wide variety of biological sources in soil and water, particularly microbial action in wet tropical forests (IPCC, 2018).

Organic carbon (C_{org})

Organic carbon content in the biochar produced. It is expressed in dry weight of organic carbon over dry weight of biochar.

For the application of this methodology, the C_{org} content shall be superior to 50% on a dry weight basis.

Organic soils

According to FAO (definition adopted by (Hiraishi et al., 2014)), they are soils with organic carbon content equal to or greater than 12%. Organic soils (e.g., peat and manure) have at least 12 to 20 percent organic matter by mass and thrive under poorly drained wetlands conditions.

Organic soils are identified based on criteria 1 and 2, or 1 and 3 listed below:

1. Organic horizon thickness is greater than or equal to 10 cm. A horizon of less than 20 cm has 12 percent or more organic carbon when mixed to a depth of 20 cm.

2. Soils that are never saturated with water for more than a few days shall contain more than 20 percent organic carbon by weight (i.e., about 35 percent organic matter).

3. Soils are subject to water saturation episodes and have either:

   (a) At least 12 percent organic carbon by weight (i.e., about 20 percent organic matter) if the soils have no clay.

   (b) At least 18 percent organic carbon by weight (i.e., about 30 percent organic matter) if the soils have 60% or more clay; or

   (c) An intermediate proportional amount of organic carbon for intermediate amounts of clay.

Permanence

The ability of stored carbon to remain sequestered over the long term (typically ≥100 years).

Pyrolysis process

The conversion of feedstock into char involves thermochemical processes such as pyrolysis, gasification, and baking. In most existing studies, the primary method for biochar preparation is pyrolysis. This preference stems from the definition of biochar as a carbon-rich material produced through the pyrolysis of biomass under anoxic or oxygen-limited conditions.

Renewable biomass

The Biomass is "renewable" if one of the five conditions included in Appendix 2, applies.

Residual waste

A solid waste type with largely homogenous properties. This includes, inter alia, material that remains after the waste is treated, e.g. anaerobic digestate and compost, and biomass residues (by-product, residue or waste stream from agriculture, forestry and related industries);

Sewage sludge

Sewage sludge stands as the primary biological waste produced by municipal wastewater treatment plants, accompanied by high treatment costs. Conventional disposal methods like landfills and incineration give rise to environmental issues, including soil contamination and greenhouse gas (GHG) emissions.

Soil carbon

Organic carbon contained in mineral and organic soils (including peat) to a given depth chosen by the country and applied consistently throughout the time series. Live fine roots of less than 2 mm (or another diameter chosen by the country for underground biomass) are included with soil organic matter when they cannot be distinguished from the latter empirically.

Soil carbon sequestration (SCS)

Land management changes which increase the soil organic carbon content, resulting in a net removal of CO_2 from the atmosphere (IPCC, 2018).

Soil organic matter

Soil organic matter comprises all organic materials of plant or animal origin, decomposed, partially decomposed and undecomposed. It is generally synonymous with humus, although the latter is more commonly used to refer to well-decomposed organic matter, referred to as humic substances. Soil organic matter is a primary indicator of soil quality.

Solid waste

Material that is unwanted and insoluble (including gases or liquids in cans or containers). Hazardous waste is not included in the definition of solid waste. Solid waste may include residual wastes.

Solid waste disposal site (SWDS)

Designated areas intended as the final storage place for solid waste. Stockpiles are considered a SWDS if: (a) their volume to surface area ratio is 1.5 or larger; and if (b) a visual inspection by the DOE confirms that the material is exposed to anaerobic conditions (i.e. it has a low porosity and is moist).

Stockpile

A pile of solid waste (not buried below ground). Anaerobic conditions are not assured in a stockpile with low volume to surface area ratios (less than 1.5) because the waste may be exposed to higher aeration.

Sustainable biochar

A biochar produced through a process that aligns with environmental, social and economic sustainability principles. It is produced enhancing soil health, while ensuring responsible feedstock sourcing, efficient production, and equitable socio-economic benefits.

Wetland

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 (IPCC, 2003).

9 Biochar properties and impact on Greenhouse Gas (GHG) Emissions

Biochar plays a crucial role in reducing GHG emissions and mitigating climate change. This methodology includes the accounting of the effects of biochar on greenhouse gas (GHG) emissions reduction, affirming its importance as a method for reduction and a positive force in climate change mitigation.

Its impact on GHG emissions occurs through three stages: *feedstock supply, production process, and application process***.** The supply of raw materials influences GHG emissions by preventing the burning or accumulation of residual biomass. In contrast, the production and application processes have a direct impact, contributing to emissions arising from biochar production and its subsequent application.

Biochar's high porosity and surface area improve soil structure, reducing soil organic carbon decomposition and influencing microbial activity to mitigate methane (CH_4) emissions. Furthermore, the nutrients present in biochar can be harnessed to stimulate photosynthesis in green plants, actively contributing to the atmospheric CO_2 cycle.

These attributes collectively contribute to biochar's capacity to enhance soil conditions, making it a vital player in sustainable soil management practices. The intricate interplay of its physical and chemical characteristics underscores the nuanced and multifaceted nature of biochar's impact on the soil environment.

9.1 Physical properties

The physical properties of biochar, such as specific surface area (SA), porosity, total porosity, structure, and particle size, exert a direct or indirect influence within the soil system. At the same time, chemical properties, including volatiles, ash, fixed carbon (FC), pH, cation exchange capacity (CEC), electrical conductivity, and elemental composition, intricately determine both the carbon stability and carbon sequestration capacity of biochar (Suliman et al., 2017).

The diversity in biochar properties is intricately connected to the type of feedstock used and the temperature of the pyrolysis process. Biochar derived from animal manure and solid waste displayed lower specific surface area, carbon content, and volatile fraction but exhibited a higher cation exchange capacity (CEC) at elevated pyrolysis temperatures, especially when contrasted with biochar obtained from crop straw and woody biomass. The augmentation of pyrolysis temperature consistently led to an increase in pH, specific surface area, porosity, adsorption properties, ash content, and carbon content, while CEC and volatile fraction experienced a reduction.

Understanding these variations in biochar properties is essential for optimizing biochar production based on the application and environmental conditions of the intended use. The complexity of biochar properties, coupled with feedstock and production conditions, emphasizes the importance of a careful approach to optimize the effectiveness of biochar application.

Increases in temperature have been reported to correlate with increases in pH, surface area (SA), and carbon content. There is considerable variability in carbon content and

SA among different feedstocks. Waste wood biochar has the highest carbon content, up to 90.5%. Using waste wood as a biochar feedstock has benefits. The temperature-dependent trends emphasize that temperature control during pyrolysis is crucial to adjust biochar properties and consider environmental impact.

Moreover, the organic fraction of biochar, distinguished by its highly stable aromatic carbon and distinctive carbon skeleton structure, serves to fortify the stability of soil organic matter. This dual mechanism involving stable organic carbon and the unique structural attributes of the organic fraction underscores biochar's role not only as a carbon sink but also as a catalyst for enhancing the resilience and durability of soil organic matter. The nuanced interplay between these physicochemical features elucidates the multifaceted contribution of biochar to soil carbon sequestration and the overall improvement of soil health.

9.2 Chemical properties

The chemical properties play a decisive role in influencing greenhouse gas (GHG) emissions resulting from biochar application, including its organic constituents, pH, and nutritional elements. Biochar has a stable aromatic carbon structure, making it an effective carbon sink.

Beyond its role in shaping greenhouse gas (GHG) emissions, biochar possesses inherent nutritional value, especially in manure-derived biochar, making a significant contribution to its efficacy as a fertilizer. Manure or waste biochar exhibits a heightened concentration of nutrients such as phosphorus (P) and potassium (K) in comparison to biochar derived from crop straw or woody sources. This nutrient-rich composition amplifies its potential as a valuable source of plant nutrients.

Functioning as a supplementary nutrient for plants, biochar not only delivers essential elements but also actively supports photosynthesis, facilitates carbon cycling, and contributes to carbon fixation in the soil. By serving as a reservoir of nutrients and promoting these crucial physiological processes, biochar transcends its role in GHG mitigation to become a multifaceted asset in enhancing soil fertility and fostering robust plant growth.

The incorporation of nutrient-rich biochar into agricultural practices thus emerges as a holistic approach, addressing both environmental concerns and the nutritional needs of crops for sustainable and productive agriculture.

9.3 Properties of biochar and its role to reduce GHG emissions

The biochar physical structure limits CO2 release by reducing soil organic carbon decomposition. The biochar influences N_2O and CH_4 emissions through microbial regulation and pH adjustments.

The biochar chemical properties help enhance soil carbon pools, improve soil quality, and promote plant photosynthesis, ultimately contributing to the atmospheric CO_2 cycle.

In summary, biochar is a promising strategy for reducing greenhouse gas emissions. Its effectiveness depends on careful consideration of production methods, feedstock selection, and application practices appropriate to specific environmental contexts.

10 Sustainable biochar production[5]

The project holder shall demonstrate a sustainable biochar production and end-use system. The process shall adhere to environmental, social and economic principles while effectively reducing greenhouse gas (GHG) emissions. The mainly criteria for demonstrate the sustainability in the biochar production and end-use are listed below.

10.1 Sustainable biochar production

To ensure sustainability, biochar production is required to follow specific criteria for feedstock sourcing, processing and use:

10.1.1 Feedstock selection and sourcing

(a) Renewable biomass: Biochar is produced primarily from agricultural, forestry, or industrial biomass to avoid deforestation and forest degradation (See Appendix 1);

(b) *Non-competition with food production*: Feedstock not come from food crops or land essential for food security;

[5] In the context of promoting soil health and fertility, as advocated by the International Biochar Initiative, cf. Principle 1 of the Environmental Outcomes in the Guiding Principles for a Sustainable Biochar Industry (International Biochar Initiative, 2023).

(c) *Sustainably managed resources*: Feedstocks is sourced sustainably, considering land use rights, protecting biodiversity, and water availability.

10.1.2 Biochar production process

(a) *GHG-Neutral or negative*: The production process has minimal or negative carbon emissions by utilizing energy-efficient pyrolysis or gasification.

(b) *Energy Efficiency and by product utilization*:

(i) Syngas, bio-oil, and process heat should be captured and used to offset fossil fuel energy use;

(ii) Energy recovery systems should improve efficiency and economic viability.

(c) *Pollution control*: Emissions from biochar production is controlled to meet air quality standards, minimizing particulate matter, volatile organic compounds (VOCs), and other pollutants.

(d) *Product quality standards*: Biochar properties shall be assessed for *carbon stability, nutrient content, and potential contaminants* to ensure long-term soil benefits.

10.1.3 Safe and responsible use

(a) *Land application and storage*:

(i) Biochar should be applied to soils in ways that enhance *carbon sequestration*, *soil fertility*, and *water retention*.

(ii) Storage of biochar before use shall prevent uncontrolled oxidation or combustion, which could release stored carbon back into the atmosphere.

(b) *Biodiversity Protection*: Production and application should avoid negative impacts on native ecosystems and biodiversity.

11 Life Cycle Assessment (LCA) of Greenhouse Gas Emissions Impact Associated with Biochar

The LCA (Life Cycle Assessment) evaluation process is challenging due to different assumptions in functional units, soil types, and study contexts. However, efforts can be made to harmonize methodologies, facilitating result comparisons. Although LCA processes have different objectives and scopes, common processes within the entire life cycle of biochar, spanning from production to application, can be standardized to evaluate their impacts on GHG emissions.

The project holder shall apply a Life Cycle Assessment (LCA) of biochar, providing a comprehensive evaluation of its greenhouse gas (GHG) emissions impact, considering its entire production and utilization cycle. The primary goal of this LCA is to quantify the GHG emissions associated with biochar production, distribution, application, and end-of-life management.

11.1 Scope of the LCA

Conducting a Life Cycle Assessment (LCA) for biochar applications, both soil and non-soil, involves a systematic evaluation of environmental impacts throughout the biochar's life cycle. This process encompasses several critical stages, each with specific requirements to ensure a comprehensive and accurate assessment. The scope of the LCA shall include:

(a) System boundaries: From biomass sourcing to final application (cradle-to-grave approach);

(b) Functional unit: Determine a reference unit for analysis, commonly per ton of biochar produced or per hectare of land amended.

(c) Impact categories: GHG emissions measured in CO_2-equivalent (CO_2-eq).

11.2 Objective definition

The project holder shall clearly define the purpose of the LCA, such as quantifying greenhouse gas (GHG) emissions reduction, assessing energy efficiency, or evaluating economic viability. The objective definition shall establish the processes to be included, from biomass sourcing to biochar production, application, and end-of-life scenarios.

11.3 Life cycle stages and GHG emissions

(a) Biomass sourcing and collection

(i) Emissions from land-use change, harvesting, and transportation.

(ii) Variability in emissions based on feedstock type (e.g., agricultural residues vs. forest biomass).

(b) Production process

(i) Energy consumption and fuel inputs for production process;

(ii) GHG emissions from process heat and bio-oil or syngas utilization;

(iii) Carbon sequestration potential of biochar.

(c) Transportation and distribution

(i) Emissions from transporting biochar to application sites;

(ii) Effect of transportation distance and mode on total emissions.

(d) Application and soil interactions

(i) Reduction in soil emissions due to improved carbon stability;

(ii) Potential avoidance of synthetic fertilizers and related emissions;

(iii) Soil microbial interactions that influence N_2O and CH_4 fluxes.

(e) Other applications

(i) Incorporating biochar into construction materials, and environmental footprints;

(ii) Biochar as a supplementary material, improving strength and durability while sequestering carbon within the built environment;

(iii) Biochar's non-soil applications contribute to environmental sustainability by enhancing material properties and promoting waste management.

11.4 End-of-Life issues

(a) Long-term carbon stability;

(b) Decomposition rates and potential emissions over time.

11.5 Comparative GHG impact assessment

(a) Comparison of biochar with alternative material uses and waste management strategies;

(b) Sensitivity analysis on key factors such as production efficiency and biomass type;

(c) Net GHG balance: whether biochar contributes to negative emissions.

11.6 Specific considerations

11.6.1 For soil applications

(a) Soil carbon sequestration: Assess the stability and longevity of carbon stored in soils amended with biochar.

(b) Soil health impacts: Evaluate changes in soil fertility, structure, and microbial activity.

(c) Agronomic benefits: Measure potential increases in crop yields and reductions in fertilizer requirements.

11.6.2 For non-soil applications

(a) Alternative uses: Explore applications such as biochar in construction materials, water treatment, or as a carbon-rich additive in industrial processes.

(b) Material properties: Analyze how biochar incorporation affects the performance and lifespan of products.

(c) End-of-Life scenarios: Consider the disposal, recycling, or repurposing of biochar-infused materials.

Finally, compliance with international standards, such as ISO 14040/44:2006 and ISO 14067:2018, ensures consistency and credibility in LCA studies. These standards provide guidelines for conducting LCA and quantifying carbon footprints, respectively.

12 Permanence

The mitigation outcome from biochar projects shall be considered permanent only when the carbon is stored in a form and application that prevents significant re-emission to the atmosphere for at least 100 years.

The project holder shall demonstrate that the biochar produced has the potential for long-term stability commonly associated with biochar, resulting from the highly stable molecular structure of biochar resulting from the production process. In the framework of this methodology, this is accepted by the characteristics listed below[6].

12.1 Biochar stability criteria

The production and application of biochar shall meet the following stability requirements (International Biochar Initiative., 2015):

(a) $H:C_{org}$[7] ratio ≤0.7 ensures long-term biochar stability (data and based on the sampling and laboratory analysis results), ensuring biochar is stable for long-term sequestration[8];

(b) Organic carbon (C_{org}) content ≥50% by dry weight[9];

The project holder shall provide scientific evidence supporting biochar stability for at least 100 years, based on:

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[6] In compliance with ISO 14064-2 permanence assessment (ISO 14064-2:2019).

[7] This abbreviation represents the molar ratio of hydrogen (H) to organic carbon (Corg), which is a key parameter used to assess the chemical composition and predict the stability of biochar.

[8] The requirement for this specific threshold (≤ 0.7) is derived from the standardized Biochar Carbon Stability Test Method. This method, established by an expert panel, employs the H:Corg ratio as the primary determinant for long-term carbon persistence, with stability evaluated against a 100-year horizon.

[9] The organic carbon (Corg) content shall be determined via laboratory analysis, based on a statistically representative sampling methodology. Furthermore, a specific condition applies when a diverse range of biomass types is utilized as feedstock: in such cases, it is mandatory to conduct separate laboratory analysis for each distinct type of biochar produced to ensure accurate characterization.

(a) Pyrolysis temperature and retention time;

(b) Chemical composition analysis;

(c) Long-term field trials and degradation studies.

Laboratory results shall be specific to the production facility and the feedstock used and shall be made available for each verification event.

12.2 Eligible end-use applications

The biochar shall be applied or embedded in systems thar ensure long-term carbon storage. The following are the end-use conditions:

(i) Soil application with incorporation at ≥10 cm depth or mixed with organic material to prevent oxidation;

(ii) Use in durable materials such as construction composites, asphalt, or concrete;

(iii) Encapsulation or immobilization in materials with lifespan ≥ 100 years.

Non-permanent uses such as combustion, use in activated carbon, animal feed, water filtration, or any application that results in decomposition within a short timeframe are ***not eligible for crediting*** under this methodology.

12.3 Other conditions

(i) Only biochar from high-tech facilities is eligible;

(ii) Biochar shall be applied within 12 months of production, to prevent degradation before use.

Under this methodology, the combustion for energy production purposes is not an eligible end use for biochar.

12.4 Evidence and verification

Project holders shall provide verifiable evidence for each batch of biochar used and for each application site, including:

(a) Laboratory analysis of H:Corg ratio;

(b) Documentation of end-use application (e.g., soil maps, usage logs, photographic evidence);

(c) Evidence that the application method prevents short-term degradation or re-emission.

The permanence of stored carbon shall be monitored and verified at each verification event. Any deviation from eligible uses shall result in discounting of emission reductions for the corresponding quantity of biochar.

12.5 Soil health safeguards for permanence

For projects applying biochar to soils, permanence of stored carbon shall also be contingent upon maintaining soil health and functionality. Project holders shall demonstrate, through monitoring and reporting (see Section 18), that biochar application does not cause significant long-term degradation of soil fertility, microbial activity, or physical structure.

Evidence from soil health monitoring shall be integrated into permanence assessments. If monitoring indicates adverse impacts attributable to biochar application, the project holder shall implement corrective measures and transparently document the response in the Project Document and subsequent verification reports.

12.6 Permanence risk assessment and reversal requirements

All project activities shall assess the permanence risk associated with biochar storage using the BioCarbon Standard's official Permanence and Reversal Risk Management Tool (Version 2.0 or latest).

12.6.1 Mandatory permanence assessment

The application of the tool is mandatory for all projects, unless the biochar is used in applications that meet the strict exemption criteria outlined in Section 12.6.6.

12.6.2 Risk rating and buffer allocation

The tool shall be used to assign a permanence risk class to each project, which determines the required percentage of verified carbon credits (VCCs) to be withheld in the program's permanence buffer. The risk class is based on:

(a) Type and stability of biochar;

(b) End-use matrix and reversibility;

(c) Environmental and management conditions;

(d) Monitoring and control mechanisms.

12.6.3 Reversal period and monitoring

All project activities shall commit to monitor the permanence of carbon stored through biochar application for at least 40 years, or longer if required by the BIOCARBON STANDARD or host country regulation. The Project Document shall include a monitoring plan to:

Detect potential carbon losses;

Evaluate exposure to natural, chemical, or anthropogenic degradation;

Report reversals to the program.

12.6.4 Response to reversal events

If a reversal of carbon storage occurs, the project holder shall:

(a) Report the event within 12 months;

(b) Quantify the magnitude of the reversal;

(c) Compensate the loss through retirement of buffer credits or issuance cancellation;

(d) Implement corrective actions to restore long-term storage integrity, when feasible.

Project holders may use advanced monitoring systems, including multi-source satellite-based early-warning tools, to detect potential fire events or other disturbances that could affect permanence. Such systems shall be technology-neutral, based on verifiable and traceable data, and may complement field-based monitoring. The integration of these tools, where available, is encouraged to strengthen permanence and risk management.

12.6.5 *Transparency and documentation*

The permanence risk assessment and all assumptions used in the classification shall be documented in the Project Document and subject to validation. Risk classification, monitoring results, and buffer deductions shall be published transparently.

12.6.6 *Exemption from Reversal Risk Rating Tool*

Project holders may be exempted from applying the BioCarbon Permanence and Reversal Risk Management Tool only if all of the following conditions are met:

(a) The biochar is applied exclusively in a physical and chemical storage matrix that is demonstrably stable for at least 100 years, without significant exposure to biological, thermal, mechanical, or chemical degradation;

(b) The application is not subject to soil incorporation, redistribution, or any form of land management that could expose the biochar to decay, erosion, or mobilization;

(c) The storage matrix (e.g., concrete, asphalt, or engineered composite) is part of a permanent, inert infrastructure not subject to excavation, demolition, or fragmentation over the course of at least 100 years;

(d) The project provides documented evidence demonstrating that the expected degradation or loss of biochar carbon under the proposed conditions is negligible over the full-time horizon;

(e) Scientific references, durability tests, or standardized assessments (e.g., under EBC[10] or IBI[11] protocols) are provided to support the claim of long-term physical and chemical permanence of the biochar in the intended application;

(f) The project includes procedures to ensure that the storage matrix will be maintained and protected from disturbance or removal for the full permanence period.

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[10] European Biochar Certificate
[11] International Biochar Initiative

If all conditions are met, the project holder may formally request an exemption from the risk assessment tool. The exemption request shall:

(a) Be submitted and justified as part of the Project Document;

(b) Be subject to review by the Conformity Assessment Body during validation;

(c) Require review and approval by the CAB prior to registration.

Where the exemption is not granted, or if significant uncertainty remains regarding the actual permanence of carbon storage, the application of the Permanence and Reversal Risk Rating Tool shall be mandatory, as specified in this section.

13 Project boundaries

The project holder shall define clearly the project boundaries to avoid double counting of emission reductions. The project boundaries are described below.

13.1 System boundary

The system boundary includes:

(a) Feedstock collection and processing;

(b) Biochar production and energy recovery;

(c) Biochar transport and application.

13.2 Spatial boundary

The geographical boundary includes:

(a) Feedstock sourcing locations;

(b) The biochar production facility;

(c) Transportation networks, and

(d) Biochar application sites.

13.3 Temporal boundary

The temporal boundary begins at the project start date and extends 40[12] years for carbon sequestration and storage verification.

13.4 Emission sources and reservoirs

The project boundary shall include all significant sources, sinks, and reservoirs associated with the production, processing, transportation, storage, application, and degradation of biochar, as well as any feedstock-related activities.

All emission sources and reservoirs listed below shall be considered. In accordance with the principles of environmental integrity and conservativeness, any source or reservoir that is excluded shall be explicitly justified in the Project Document.

The Table 1 presents the relevant sources and reservoirs included in or excluded for biochar projects.

Table 1. Emission sources and reservoirs included or excluded in the project boundary

Source/Reservoir	Included?	Justification/Explanation
Biomass production (if purpose-grown)	Yes*	Included when biomass is cultivated or harvested directly for the project.
Biomass collection (residues)	Yes	Applies to collection and handling of waste biomass.
Biomass transportation to facility	Yes	Emissions from vehicle fuel use are included.
Biochar production (pyrolysis unit)	Yes	Includes all combustion, off-gases, and auxiliary energy use.
Electricity or heat recovery	No	Only if recovered for use; otherwise excluded with no net benefit claimed.
Biochar storage	Yes	Includes possible oxidation losses during storage.
Biochar transportation to end-use site	Yes	Emissions from transport vehicles are included
Biochar application to soil	Yes	Includes all handling and incorporation activities.

[12] For the specific rules governing the project's temporal boundary, as stipulated in the BCR Standard for projects in the AFOLU and other sectors, cf. Section 11.5 regarding project duration and quantification periods (BioCarbon Standard, 2024).

Source/Reservoir	Included?	Justification/Explanation
Biochar degradation (oxidation in soil)	Yes	Carbon stability and decay over time are modeled via conservative factors.
Facility construction	No	Excluded due to immaterial contribution (<1%) and short duration.
Emissions from avoided decomposition	No	Not applicable as baseline emissions are conservatively assumed as zero.
*If only residual biomass is used and no land-use change occurs, this source of reservoir may be excluded with justification.		

The inclusion of each source or reservoir shall be confirmed and documented in the Project Document and validated by the CAB. Emissions or removals not listed above but considered material in the specific project context shall be added as applicable.

All emission sources and potential leakage effects associated with biomass sourcing, processing, and displacement shall be included within the system boundary. Where leakage is likely, project holders shall quantify or conservatively deduct it as per Appendix 3.

13.5 Emission sources and GHG

The greenhouse gases included in or excluded from the project boundary are shown in Table 2.

Table 2. GHG included or excluded in the project boundary

Baseline / Project scenario	Source	Gas	Included or Excluded	Justification/Explanation
Baseline	Biomass decay under anaerobic conditions (e.g., landfill, stockpiles)	CH_4	Included	Methane emissions from anaerobic decomposition in baseline; addressed via TOOL04.
	Biomass combustion during land clearing	CH_4, N_2O	Included	Incomplete combustion in the baseline releases CH_4 and N_2O; included via TOOL16.
	Biomass combustion during land clearing	CO_2	Excluded	CO_2 of biogenic origin is not counted under IPCC guidelines.
	Composting of biomass (uncontrolled)	CH_4, N_2O	Included	Emissions from open composting in the absence

Baseline / Project scenario	Source	Gas	Included or Excluded	Justification/Explanation
				of the project; TOOL13 applies.
	Anaerobic digestion of biomass residues	CH_4	Included	CH_4 from digestion without methane recovery; addressed via TOOL14.
Project scenario	Fossil fuel combustion in machinery and processing (e.g., pyrolysis, handling)	CO_2	Included	Direct emissions from fossil fuel use in processing systems; TOOL03.
	Fossil fuel combustion in machinery and processing	CH_4, N_2O	Included	Minor non-CO_2 gases from fossil combustion included for completeness.
	Electricity consumption in processing (e.g., grinders, dryers, reactors)	CO_2	Included	Grid emissions accounted via TOOL05.
	Transportation of biomass, biochar, additives or residues	CO_2	Included	Fossil fuel combustion for logistics; TOOL12.
	Transportation of biomass, biochar, additives or residues	CH_4, N_2O	Included	Minor but included under comprehensive transport accounting (TOOL12).
	Biochar application to soil or stable matrices (e.g., construction materials)	N/A	Excluded	No emissions assumed from stable storage applications.
	Biochar degradation or oxidation during use	CO_2	Excluded	Addressed via permanence mechanism, not included in ex-ante project emissions.
	Leakage due to displacement of prior uses of biomass (e.g., fuel, bedding, composting)	CO_2, CH_4	Included (if applicable)	Included where relevant, especially in case of market leakage or diversion (TOOL16).

14 Demonstration of Additionality

All project activities shall apply the official BioCarbon Standard Tool for the Identification of a Baseline Scenario and Demonstration of Additionality (Version 1.0 or the latest applicable version).

All project activities shall apply the official BioCarbon Standard Tool for the Identification of a Baseline Scenario and Demonstration of Additionality (Version 1.0 or the latest applicable version).

The demonstration of additionality shall be conducted by following the full step-wise procedure defined in the Tool, including:

Step 1: Identification of realistic and credible alternative scenarios;

Step 2: Barrier analysis; and/or

Step 3: Investment analysis;

Step 4: Common practice analysis (mandatory in all cases).

Project holders may choose to demonstrate additionality through either barrier analysis or investment analysis, or both, depending on the characteristics of the project. Regardless of the pathway selected, the project shall demonstrate that the proposed activity:

(a) Would not occur in the absence of carbon credit revenues or equivalent enabling incentives;

(b) Is not required by law or regulation (or if required, such regulation is not enforced in practice);

(c) Is not common practice in the relevant sector and geographic area.

All assumptions, justifications, calculations, and supporting evidence shall be included in the Project Document and be subject to third-party validation in accordance with the BIOCARBON STANDARD rules.

Note: The use of simplified additionality procedures is only allowed under the conditions established in Annex B of the BioCarbon Additionality Tool.

15 Quantification of GHG emissions, emission reductions and removals ($ERR_{p,y}$)

To quantify greenhouse gas (GHG) emission reductions and removals in a biochar project, a systematic approach is required. This approach shall consider all relevant GHG emissions and/or reductions

The methodology ensures accurate carbon crediting and environmental benefits in biochar projects. Applied parameters, and standardized estimations are used to maximize the credibility and impact of biochar as a climate solution.

Emission reductions/removals ($ER_{p,y}$) are calculated as follows:

$$ERR_{p,y} = \left(E_{bl,y} - PE_y\right) + PRA_y - Lk_y \qquad \text{Equation 1}$$

Where:

$ERR_{p,y}$	=	Emissions reductions/removals in the project scenario, in the year *y;* tCO_2e
$E_{bl,y}$	=	Emissions/removals in the baseline scenario, in year *y;* tCO_2e
PE_y	=	Emissions/removals in the project scenario, in year *y;* tCO_2e
PRA_y		Project emissions reductions, removals and avoidance, in year y; tCO2e
Lk_y	=	Indirect emissions caused by project activities, in year *y;* tCO_2e

15.1 Emissions in the baseline scenario

For the purpose of ensuring environmental integrity and aligning with conservative quantification principles, baseline emissions shall be assumed to be zero unless site-specific evidence is provided and validated.

In the context of biochar production from waste biomass, the baseline scenario shall assume no methane (CH_4) or other GHG emissions from biomass decomposition unless the project holder can demonstrate, through robust and verifiable data, that the baseline management practice leads to significant anaerobic decomposition under the local environmental and waste management conditions.

Acceptable evidence may include:

(a) Empirical measurements of CH_4 from similar waste piles in the region;

(b) Peer-reviewed studies specific to the biomass type and climatic conditions;

(c) Regulatory documentation showing mandatory anaerobic disposal.

In the absence of such evidence, the default baseline emissions value shall be zero.

15.1.1.1 Baseline emissions resulting from clearance or burning of biomass in year y ($BL_{BB,y}$)

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

$$BL_{BB,y} = \frac{44}{12} \times 0.47 \times \sum A_{FR,i,z} \times b_i \times (1.06 + R_i) \qquad \text{Equation 2}$$

Where:

$BL_{BB,y}$	=	Emissions resulting from clearance or burning of biomass; tCO2e
$\frac{44}{12}$	=	Factor for converting units from t C to t CO2e; dimensionless
0.47	=	Default value of carbon fraction of biomass burnt[13]; dimensionless
1.06	=	Factor to account for non-CO2 emissions from biomass clearance or burning (IPCC, 2019C). If biomass is cleared without using open fire, then this factor is set equal to 1 (one);

[13] This default value is based on the data presented in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Intergovernmental Panel on Climate Change [IPCC], 2006, Vol. 4, Ch. 4, Table 4.3).

$A_{FR,i,z}$	=	Area of stratum i of land subjected to clearance or fire in year y (ha);
b_i	=	Fuel biomass consumption per hectare in stratum i of land subjected to clearance or fire (t dry matter/ha);
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

15.1.2 Baseline emissions from waste disposal and management ($BL_{WDM,y}$)

If the project activities include the waste management and the production of biochar with biogenic waste, those avoiding emissions should be accounted based on the CDM Tool04 (United Nations, 2008).

However, if there are any organic waste matter that is left to decay within the project boundary and methane is emitted to the atmosphere, the baseline emissions shall be accounted.

According to the IPCC (2000) Methane (CH4) is emitted during the anaerobic decomposition of organic waste disposed of in solid waste disposal sites (SWDS). Organic waste decomposes at a diminishing rate and takes many years to decompose completely.

15.1.2.1 Landfilling (CH_4 emissions)

Landfills produce methane due to anaerobic decomposition of degradable organic carbon (DOC). DOC is the organic carbon that is accessible to biochemical decomposition and should be expressed as Gg C per Gg waste. It is based on the composition of waste and can be calculated from a weighted average of the carbon content of various components of the waste stream.

The CH4 emissions are calculate as follows:

$$BL_{landfilling,y} = \left(MSW_i \times DOC_i \times DOC_f \times MCF \times F \times (16/12)\right) - R \quad \text{Equation 3}$$

Where:

$BL_{landfilling,y}$	=	Baseline emissions from anaerobic decomposition of DOC in year y, tCO2e
MSW_i	=	Mass of organic waste disposed; tonnes
DOC_i	=	Degradable Organic Carbon content in waste; fraction
DOC_f	=	Fraction of DOC that decomposes
MCF	=	Methane Correction Factor (accounts for landfill type)
$16/12$	=	Conversion factor for CH_4 from C
R	=	Conversion factor for CH_4 from C

15.1.2.2 *Composting (CH_4 and N_2O baseline emissions)*

The emissions resulting from the composting activities are associated with the production of methane (CH_4) and nitrous oxide (N_2O). The composting process generates methane (CH_4) within the anaerobic digestors and nitrous oxide (N_2O) through the oxidation of nitrogen. The project emissions are calculated as follows:

$$CH_{4_{bl,emissions,y}} = MSW_{i,y} \times EF_{CH_4} \quad \text{Equation 4}$$

$$N_2O_{bl,emissions,y} = MSW_{i,y} \times EF_{N_2O} \quad \text{Equation 5}$$

Where:

$CH_{4_{bl,emissions,y}}$	=	CH4 emissions in year y, tCO2e
MSW_i	=	Mass of organic waste disposed in year y; tonnes
EF_{CH_4}	=	Emission factor for methane (IPCC default: 4g CH_4/kg waste)
$N_2O_{bl,emissions,y}$	=	N2O emissions in year y
EF_{N_2O}	=	Emission factor for nitrous oxide (IPCC default: 0.3g N_2O/kg waste)

15.1.2.3 Anaerobic Digestion (Biogas Recovery)

Anaerobic digestion (AD) is a biological process where organic waste decomposes in oxygen-free conditions, producing biogas (a mixture of methane (CH_4) and carbon dioxide (CO_2)). According to the IPCC 2006 Guidelines (Volume 5, Chapter 4) and the 2019 Refinement, AD can be a GHG mitigation strategy when methane is captured and used for energy, but it can also be a GHG source if biogas is not properly managed. Anaerobic digestion produces CH_4, which can be recovered or emitted.

The CH4 emissions are calculate as follows:

$$BL_{AD,y} = \left(MSW_i \times DOC_i \times DOC_f \times MCF \times F \times (16/12)\right) - R \qquad \text{Equation 6}$$

Where:

$BL_{AD,y}$	=	Baseline emissions from anaerobic decomposition of DOC in year y, tCO2e
MSW_i	=	Mass of organic waste disposed; tonnes
DOC_i	=	Degradable Organic Carbon content in waste; fraction
DOC_f	=	Fraction of DOC that decomposes
MCF	=	Methane Correction Factor (accounts for landfill type)
$16/12$	=	Conversion factor for CH_4 from C
R	=	Conversion factor for CH_4 from C

(Where R is the amount of methane recovered for energy use.)

If methane is fully captured, emissions are minimal and may be neglected.

15.1.2.4 Waste incineration

Incineration is a thermal waste treatment process where municipal solid waste (MSW) and other organic waste are combusted at high temperatures to reduce volume, destroy hazardous components, and recover energy. While incineration reduces landfill dependency and can generate electricity, it is also a source of greenhouse gas (GHG) emissions, particularly carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O).

According to the IPCC (2006b) Guidelines for National Greenhouse Gas Inventories (Volume 5, Chapter 5: Incineration and Open Burning of Waste) and the 2019 Refinement (IPCC, 2019C), emissions from incineration depend on:

(a) Waste composition (fossil vs. biogenic content);

(b) Combustion efficiency;

(c) Energy recovery practices;

(d) Pollution control measures.

The primary GHGs emitted during incineration are:

(a) Carbon Dioxide (CO2)

Fossil-derived CO_2 (from plastics, synthetic textiles, rubber, etc.) contributes to net GHG emissions.

(b) Biogenic CO_2

Biogenic CO_2 (from food waste, wood, paper, etc.) is considered carbon-neutral because it is part of the natural carbon cycle.

(c) Methane (CH_4)

CH_4 emissions occur due to incomplete combustion or poorly managed incineration processes.

CH_4 emissions are generally low in well-maintained incinerators.

(d) Nitrous Oxide (N_2O).

N_2O is produced during high-temperature combustion, particularly when waste contains high nitrogen content (e.g., sewage sludge, textiles). It has a high Global Warming Potential (GWP = 265), making it a significant contributor to climate change.

The baseline emissions from waste incineration are calculated with the following equations.

$$CO_{2\,bl,emissions,y} = MSW_i \times CF \times EFCO_2$$ Equation 7

$$CH_{4\,bl,emissions,y} = MSW_{i,y} \times EF_{CH_4}$$ Equation 8

$$N_2O_{bl,emissions,y} = MSW_{i,y} \times EF_{N_2O}$$ Equation 9

Where:

$CO_{2\,bl,emissions,y}$		CO2 emissions in year y; tCO2
MSW_i		Mass of organic waste disposed in year y; tonnes
CF		Carbon fraction of waste (kg C/kg waste)
$EFCO_2$		Emission factor (kg CO_2/kg C)
$CH_{4\,bl,emissions,y}$	=	CH4 emissions in year y, tCO2e
EF_{CH_4}	=	Emission factor for methane (IPCC default: 0.001 kg CH_4/tonne waste)
$N_2O_{bl,emissions,y}$	=	Emission factor for CH_4 (kg CH_4/tonne waste)
EF_{N_2O}	=	Emission factor for nitrous oxide (IPCC default: 0.01–0.06 kg N_2O/tonne waste[14])

Convert to CO_2-Equivalent Emissions, Using *Global Warming Potential (GWP)*:

CH_4 = 28 (100-year GWP)

N_2O = 265 (100-year GWP)

$$CO_{2e} = (CH_4 \times 28) + (N_2O \times 265)$$ Equation 10

[14] In the context of methodologies for national greenhouse gas inventories, the Intergovernmental Panel on Climate Change (IPCC) provides default emission factors for waste incineration that vary depending on waste composition and temperature; cf. the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2006b).

15.1.3 Baseline scenario identification and other quantification requirements

All baseline scenarios shall be consistent with the outcomes of the BioCarbon Additionality Tool (Section 14) and shall be quantified following the methodological procedures below.

(a) Selection of the baseline scenario

The baseline scenario shall be the most plausible and conservative alternative identified through Step 5 of the BioCarbon Additionality Tool. Project holders shall justify that the selected baseline represents:

(i) A technically feasible and legally permitted option under prevailing enforcement conditions;

(ii) An option that is not prevented by implementation barriers;

(iii) A scenario with higher net GHG emissions than the project activity;

(iv) A scenario that reflects realistic practices in the applicable region and sector.

(b) Quantification of baseline emissions

The quantification of baseline emissions shall be conducted using the approved CDM methodological tools applicable to the specific baseline scenario, including but not limited to (Table 3):

Table 3. Quantification of baseline emissions

Baseline scenario	**Applicable Tool**	**Description**
Waste disposal in landfills	TOOL04 v08.1	Emissions from Solid Waste Disposal Sites
Composting without methane recovery	TOOL13 v02.0	Project and leakage emissions from composting
Anaerobic digestion without methane recovery	TOOL14 v03.0	Project and leakage emissions from anaerobic digesters
Incineration without energy recovery	TOOL16 v05.0	Emissions from biomass combustion

(c) Application of first-order decay models and default parameters

For landfill scenarios, the quantification shall follow the FOD (First Order Decay) model as per TOOL04. All required parameters (e.g. DOCj, MCF, ϕy, Oxidation factor) shall be based on:

(i) Project-specific data where available and verifiable; or

(ii) IPCC default values or CDM-approved defaults when project-specific data are not available.

(d) Documentation and transparency

All baseline calculations shall be:

(i) Fully documented in an open and traceable spreadsheet;

(ii) Based on transparent assumptions and conservative values;

(iii) Supported by credible sources, literature, or default values cited in the applicable tool;

(iv) Submitted as part of the Project Document and verified during validation.

15.2 Project emissions ($PE_{,y}$)

This section applies only if the project activities include the cultivation of biomass. The GHG project emissions involve emissions resulting from:

(a) The cultivation of biomass, included the feedstocks eligible (see Appendix 2), if the project activities include the removals attributable to the biomass cultivation;

(b) Waste disposal and management;

(c) Processing of waste and non-waste biomass for biochar production;

(d) Transportation, including:

  (i) Transportation of biomass to the site for processing;

(ii) Transportation of biomass residues;

The GHG project emissions are calculated with the Equation 2.

$$PE_y = PE_{BC,y} + PE_{WDM,y} + PE_{BP,y} + PE_{T,y} \quad \text{Equation 11}$$

Where:

PE_y	=	Project emissions in the year y, tCO2e
$PE_{BC,y}$	=	Project emissions from cultivation of biomass, in the year y, tCO2e
$PE_{WDM,y}$	=	Project emissions from waste disposal and management, in year y; tCO2e
$PE_{BP,y}$	=	Project emissions from biochar production, in year y, tCO2e
$PE_{T,y}$	=	Project emissions from transportation, in year y; tCO2e

15.2.1 Project emissions from cultivation of biomass

If the removals attributable to the biomass cultivation activities are not included in the $ERR_{p,y}$, in a conservative manner, the project emissions resulting from cultivation of biomass may not be considered.

If the project activities include the cultivation of biomass with the purpose to produce biochar, the following emissions may be included in the project emissions.

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

If the project activities include the cultivation of biomass in a dedicated plantation, project emissions resulting from cultivation of biomass are estimated as follows:

$$PE_{BC,y} = PE_{SOC,y} + PE_{SM,y} + PE_{BSH,EC,y} + PE_{BB,y} \quad \text{Equation 12}$$

Where:

$PE_{SOC,y}$ = Project emissions resulting from loss of soil organic carbon, in year y; tCO_2e

$PE_{SM,y}$	=	Project emissions resulting from soil management in year y; tCO_2e
$PE_{SM,y}$	=	Project emissions resulting from energy consumption (electricity and fuel) for biomass seeding and harvesting in year y; tCO_2e
$PE_{BB,y}$	=	Project emissions resulting from clearance or burning of biomass, in year y; tCO_2e

15.2.1.2 Emissions resulting from loss of soil organic carbon in year y ($PE_{SOC_{i},y}$)

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 (contained in Tool16) ;

(b) Land-use and land management activities on croplands given in Tables 2 and 3 from Appendix 1 (contained in Tool16); and

(c) Land-use and land management activities on grasslands given in Table 4 from Appendix 1 (contained in Tool16). 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.

Subject to this provision, emissions resulting from loss of soil organic carbon are estimated as follows:

$$PE_{SOC_{i},y} = max\left(\frac{44}{12} \times \frac{1.179}{T} \times \sum \Delta SOC_{i}, 0\right) \quad \text{Equation 13}$$

Where:

$PE_{SOC_{i,y}}$	=	Emissions from loss of soil organic carbon; tCO_2e

T	=	Quantification 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 t C to t CO2e; dimensionless
1.179	=	Factor to account for soil N2O emissions associated with loss of soil organic carbon[15]; dimensionless
i	=	Strata of areas of land

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

$$\Delta_{SOC_I} = 1.21 \times A_{SOC,i} \times SOC_{REF,i} \times \left(f_{LUB,i} \times f_{MGB,i} \times f_{INB,i} - f_{LUP,i} \times f_{MGP,i} \times f_{INP,i}\right) \quad \text{Equation 14}$$

Where:

Δ_{SOC_I}	=	Loss of soil organic carbon in a stratum
$A_{SOC,i}$	=	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;

[15] In the context of accounting for indirect soil emissions, as per the methodologies detailed in the IPCC updates, cf. the factor for soil N_2O emissions in Appendix 3 (Tool 16) of the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC, 2019C).

$f_{INP,i}$ = 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;[16]

The values of relative stock change factors shall be determined according to Tables 2 to4 from Appendix 1 in the Tool16.[17]

After the first quantification period of the project, the value of PE_{SOC_i}shall be zero.

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

Emissions resulting from soil management are estimated as follows:

$$PE_{SM,y} = PE_{SF,y} + PE_{SA,y} \quad \text{Equation 15}$$

Where:

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

$PE_{SF,y}$ = Project emissions resulting from of soil fertilization and management in year y; t CO2e

$PE_{SA,y}$ = Project emissions resulting from soil amendment in year y; t CO2e

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

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

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[16] As established by the Subsidiary Body for Scientific and Technological Advice (SBSTA, 2003), cf. the provisions detailed in Appendix 1 of the Good practice guidance for land use, land-use change and forestry (FCCC/SBSTA/2003/10/Add.2).

[17] Project proponents are encouraged to suggest revisions for the 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.

$$PE_{SF,y} = q_{N,y} \times A_{FTM,y} \times EF_{FT} \quad \text{Equation 16}$$

Where:

$PE_{SF,y}$	=	Emission resulting from soil fertilization and management; tCO_2e
$q_{N,y}$	=	Rate of nitrogen applied in year y; tN/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 (tCO_2e/ (N)). A default value of 11.29 t CO_2e/ (t N)[18] shall be used

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

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

$$PE_{SA,y} = \sum_{i} q_{SA,i,y} \times A_{SA,i,y} \times EF_{SA,i,y} \quad \text{Equation 17}$$

Where:

$PE_{SA,y}$	=	Emissions resulting from soil amendment;
$q_{SA,i,y}$	=	Rate of application of soil amendment agent type i in year y (t/ha);
$A_{SA,i,y}$	=	Area of land in which soil amendment agent type i is applied in year y (ha);
$A_{SA,i,y}$	=	Emission factor for CO_2 emissions from application of soil amendment agent type i (tCO_2e/t). Default values for limestone

[18] In the context of methodologies for national greenhouse gas inventories, as provided by the Intergovernmental Panel on Climate Change (IPCC), cf. the guidance and tools detailed in the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, specifically Appendix 3 (Tool 16) (IPCC, 2019a).

(0.12 t CO2e/t)[19], dolomite (0.13 t CO2e/t)[20] and urea (0.20 t CO2e/t)[21] shall be used.

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

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:

$$PE_{BSH,EC,y} = PE_{BSH,electricity,y} + PE_{BSH,fuel,y} \quad \text{Equation 18}$$

Where:

$PE_{BSH,EC,y}$	=	Project emissions resulting from energy consumption (electricity and fuel) for biomass seeding and harvesting in year y; tCO2e
$PE_{BSH,electricity,y}$	=	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; tCO_2e

$PE_{BSH,electricity,y}$ and $PE_{BSH,fuel,y}$ are determined based on the provisions of the TOOL05 and TOOL03, respectively, where:

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[19] In the context of methodologies for national greenhouse gas inventories, as stipulated by the Intergovernmental Panel on Climate Change (IPCC), cf. the default emission factor for limestone detailed in Volume 4, Chapter 11, Equation 11.12 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

[20] Ibid., cf. the discussion of dolomite accompanying Equation 11.12.

[21] In the context of methodologies for national greenhouse gas inventories, as stipulated by the Intergovernmental Panel on Climate Change (IPCC), cf. the default emission factor for urea detailed in Volume 4, Chapter 11, Equation 11.13 of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

(a) The parameter $PE_{BSH,electricity,y}$ corresponds to the parameter $PE_{EC,y}$ from the TOOL05;

(b) The parameter $PE_{BSH,fuel,y}$ corresponds to the parameter $PE_{FC,J,y}$ from the TOOL03.

According to the Conference of the Parties (2002), GHG projects that "*not exceed total direct emissions of 15 kilotonnes (kt) of carbon dioxide (CO2) equivalent annually*", may, unless otherwise required by the methodology, neglect emissions from energy consumption associated with seeding and harvesting of biomass.

15.2.2 Emissions due to biochar production ($PE_{BP,y}$)

15.2.2.1 Project emissions resulting from processing of biomass in year y ($PE_{BP,y}$) and Project emissions resulting from processing of biomass residues in year y ($PE_{BRP,y}$)

Emissions resulting from processing of biomass and biomass residues are determined as based on the equations below:

$$PE_{BP,y} = PE_{BP,electricity,y} + PE_{BP,fuel,y} + PE_{BP,CH4,y} + PE_{BP,COMP,y} + PE_{BP,AD,y} + PE_{BE,ww,y} + PE_{BP,additives,y} \quad \text{Equation 19}$$

$$PE_{BRP,y} = PE_{BRP,electricity,y} + PE_{BRP,fuel,y} + PE_{BRP,CH4,y} + PE_{BRP,COMP,y} + PE_{BRP,AD,y} + PE_{BRP,ww,y} + PE_{BP,additives,y} \quad \text{Equation 20}$$

Where:

$PE_{BP,y}$	=	Project emissions resulting from processing of biomass in year y; tCO2e
$PE_{BP,electricity,y}$	=	Project emissions resulting from the consumption of electricity due to thermo-chemical, biological and mechanical processing of the biomass in year y*; tCO2e*
$PE_{BP,fuel,y}$	=	Project emissions resulting from the consumption of fossil fuels for thermo-chemical, biological and mechanical processing of the biomass in year y; tCO2e
$PE_{BP,CH4,y}$	=	Project methane emissions resulting from the decay of biomass under anaerobic conditions as a result of thermo-chemical, biological and

mechanical processing in year *y; tCO2e*

$PE_{BP,COMP,y}$	=	Project emissions resulting from composting due to thermo-chemical, biological and mechanical processing of the biomass in year *y; tCO2e*
$PE_{BP,AD,y}$	=	Project emissions resulting from the anaerobic digester due to thermo-chemical, biological and mechanical processing of the biomass in year *y; tCO2e*
$PE_{BE,ww,y}$	=	Project emissions resulting from wastewater treatment due to thermo-chemical, biological and mechanical processing of the biomass in year *y; tCO2e*
$PE_{BP,additives,y}$	=	Project emissions resulting from the use of additives to process the biomass in year *y; tCO2e*
$PE_{BRP,y}$		Project emissions resulting from processing of biomass residues in year y; tCO2e
$PE_{BRP,electricity,y}$	=	Project emissions resulting from the consumption of electricity due to thermo-chemical, biological and mechanical processing of the biomass residues in year y; tCO2e
$PE_{BRP,fuel,y}$	=	Project emissions resulting from the consumption of fossil fuels due to thermo-chemical, biological and mechanical processing of the biomass residues in year y; tCO2e
$PE_{BP,CH4,y}$	=	Project methane missions resulting from the decay of biomass residues under anaerobic conditions due to thermo-chemical, biological and mechanical processing in year *y; tCO2e*
$PE_{BRP,COMP,y}$	=	Project emissions associated resulting from composting due to thermo- chemical, biological and mechanical processing of the biomass residues in year *y; tCO2e*
$PE_{BRP,AD,y}$	=	Project emissions resulting from the anaerobic digester due to thermo-chemical, biological and mechanical processing of the biomass residues in year *y; tCO2e*

$PE_{BRP,ww,y}$	=	Project emissions resulting from wastewater treatment due to thermo-chemical, biological and mechanical processing of the biomass residues in year *y; tCO2e*
$PE_{BP,additives,y}$	=	Project emissions resulting from the use of additives to process the biomass residues in year *y; tCO2e*

15.2.2.2 Project emissions resulting from the electricity consumed due to thermo-chemical, biological and mechanical processing of biomass in year y ($PE_{BP,electricity,y}$) and Project emissions resulting from the electricity consumed due to thermo-chemical, biological and mechanical processing biomass residues in year y ($PE_{BRP,electricity,y}$)

Emissions resulting from the electricity consumed due to thermo-chemical, biological and mechanical processing of the biomass and biomass residues are determined based on the provisions of the TOOL05, where the parameters $PE_{BP,electricity,y}$ and $PE_{BRP,electricity,y}$ corresponds to $\square\square_{\square\square,\square}$ from the tool.

15.2.2.3 Project emissions resulting from the fuel consumed due to thermo-chemical, biological and mechanical processing of biomass in year y ($PE_{BP,fuel,y}$) and Project emissions resulting from the fuel consumed due to thermo-chemical, biological and mechanical processing of biomass residues in year y ($PE_{BRP,fuel,y}$)

Emissions resulting from the fuel consumed due to thermo-chemical, biological and mechanical processing of the biomass and biomass residues are determined based on the provisions of the TOOL03, where the parameters $PE_{BP,fuel,y}$ and $PE_{BRP,fuel,y}$ correspond to $\square\square_{\square\square,\square,\square}$ from the tool.

15.2.2.4 Project methane emissions resulting from the decay of biomass under anaerobic conditions as a result of thermo-chemical, biological and mechanical processing in year y ($PE_{BP,CH_4,y}$) and Project methane emissions resulting from the decay of biomass residues under anaerobic conditions as a result of thermo-chemical, biological and mechanical processing in year y ($PE_{BRP,CH_4,y}$)

Emissions of methane from the decay of biomass under anaerobic conditions as a result of thermo-chemical, biological and mechanical processing of the biomass and biomass residues are determined based on the provisions of the TOOL04, where the parameters $PE_{BP,CH_4,y}$ and $PE_{BRP,CH_4,y}$ correspond to $\square\square_{\square\square 4,\square\square\square\square,\square}$ from the tool.

15.2.2.5 Project emissions resulting from composting due to thermo-chemical, biological and mechanical processing of biomass in year y ($PE_{BP,COMP,y}$) and Project emissions resulting from composting due to thermo-chemical, biological and mechanical processing of biomass residues year y ($PE_{BRP,COMP,y}$)

Emissions of methane from the composting as a result of thermo-chemical, biological and mechanical processing of the biomass and biomass residues are determined based on the provisions of the TOOL13, where the parameters $PE_{BP,COMP,y}$ and $PE_{BRP,COMP,y}$ correspond to $PE_{COMP,y}$ from the tool.

15.2.2.6 Project emissions resulting from the anaerobic digester due to thermo-chemical, biological and mechanical processing of biomass in year y ($PE_{BP,AD,y}$) and Project emissions resulting from the anaerobic digester due to thermo-chemical, biological and mechanical processing of biomass residues in year y ($PE_{BRP,AD,y}$)

Emissions from the anaerobic digester due to thermo-chemical, biological and mechanical processing of the biomass and biomass residues are determined based on the provisions of the TOOL14, where the parameters $PE_{BP,AD,y}$ and $PE_{BRP,AD,y}$ correspond to $PE_{AD,y}$ from the tool.

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

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:

$$PE_{BP,ww,y} = GWP_{CH_4} \times V_{BP,ww,y} \times COD_{BP,WW,y} \times B_{o,WW} \times MCF_{BP,ww}$$ Equation 21

$$PE_{BRP,ww,y} = GWP_{CH_4} \times V_{BRP,WW,y} \times COD_{BRP,WW,y} \times B_{o,WW} \times MCF_{BRP,ww}$$ Equation 22

Where:

GWP_{CH_4}	=	Global warming potential for methane valid for the relevant commitment period; tCO_2/tCH_4
$V_{BP,ww,y}$	=	Quantity of wastewater generated from the processing of biomass in year *y;* m^3
$COD_{BP,WW,y}$	=	Average chemical oxygen demand of the wastewater generated from the processing of biomass in year *y;* $tCOD/m^3$
$B_{o,WW}$	=	Methane generation potential of the wastewater; $tCH_4/tCOD$
$MCF_{BP,ww}$	=	Methane correction factor for the treatment of wastewater generated from the processing of biomass in year *y;* ratio
GWP_{CH_4}	=	Global warming potential for methane valid for the relevant commitment period; tCO_2/tCH_4
$V_{BRP,WW,y}$	=	Quantity of wastewater generated from the processing of biomass residues in year *y;* m^3
$COD_{BRP,WW,y}$	=	Average chemical oxygen demand of the wastewater generated from the processing of biomass residues in year *y;* $tCOD/m^3$
$B_{o,WW}$	=	Methane generation potential of the wastewater; $tCH_4/tCOD$
$B_{o,WW}$	=	Methane conversion factor for the treatment of wastewater generated from the processing of biomass residues in year *y;* ratio

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

$$\mathrm{PE_{BP,additives,y}} = \mathrm{PE_{BP,additives,transport,y}} + \mathrm{PE_{BP,additives,electricity,y}} + \mathrm{PE_{BP,additives,FF,y}} \qquad \text{Equation 23}$$

$$\mathrm{PE_{BRP,additives,y}} = \mathrm{PE_{BRP,additives,transport,y}} + \mathrm{PE_{BRP,additives,electricity,y}} + \mathrm{PE_{BRP,additives,FF,y}} \qquad \text{Equation 24}$$

Where:

$\mathrm{PE_{BP,additives,transport,y}}$	=	Project emissions from the transportation of the additives from the production site to the biomass processing facility; tCO_2

$PE_{BP,additives,electricity,y}$	=	Project emissions from the consumption of electricity to produce the additives used by the biomass processing facility; tCO_2
$PE_{BP,additives,FF,y}$	=	Project emissions from the consumption of fossil fuels to produce the additives used by the biomass processing facility; tCO_2
$PE_{BRP,additives,transport,y}$	=	Project emissions from the transportation of the additives from the production site to the biomass residues processing facility; tCO_2
$PE_{BRP,additives,electricity,y}$	=	Project emissions from the consumption of electricity to produce the additives used by the biomass residues processing facility; tCO_2
$PE_{BRP,additives,FF,y}$	=	Project emissions from the consumption of fossil fuels to produce the additives used by the biomass residues processing facility; tCO_2

$PE_{BP,additives,transport,y}$ and $PE_{BRP,additives,transport,y}$ are determined following the provisions from the TOOL12. The simplifications contained in the section 15.2.3.1 (below).

Project emissions resulting from the electricity consumed to produce the additives are determined based on the provisions of the TOOL05, where the parameters $PE_{BP,additives,electriciy,y}$ and $PE_{BRP,additives,electricity,y}$ corresponds to $PE_{EC,y}$ from the tool.

Project emissions resulting from the fuel consumed due to produce the additives are determined are determined based on the provisions of the TOOL03, where the parameters $PE_{BP,additives,fuel,y}$ and $PE_{BRP,additives,fuel,y}$ corresponds to $PE_{FC,j,y}$ from the tool.

As an alternative to the monitoring of the parameters needed to calculate $PE_{BP,additives,y}$ and $PE_{BRP,additives,y}$ project holders 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 10%, emissions from both the consumption of electricity and fuel to produce the additives and to transport the additives shall be accounted. Project proponents may determine these emission sources based on literature such as peer reviewed studies.

15.2.3 Project emissions resulting from transportation in year y ($PE_{T,y}$)

The project emissions resulting from transportation is calculated as follows:

$$PE_{T,y} = PE_{BT,y} + PE_{BRT,y} + PE_{BCT,y}$$

Where:

$PE_{T,y}$	=	Project emissions resulting transportation in year y; tCO_2e
$PE_{BT,y}$	=	Project emissions resulting from transportation of biomass in year y; tCO_2e
$PE_{BRT,y}$	=	Project emissions resulting from transportation of biomass residues in year y; tCO_2e
$PE_{BCT,y}$	=	Project emissions resulting from transportation of biochar in year y; tCO_2e

15.2.3.1 Project emissions resulting from transportation of biomass in year y ($PEBT,y$), and project emissions resulting from transportation of biomass residues in year y ($PE_{BRT,y}$)

Unless otherwise required in the applied methodology, project emissions resulting from transport of biomass and biomass residues are determined separately by following the provisions from the TOOL12, considering the following transport routes:

(a) For biomass:

(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;

(b) For biomass residues:

   (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:

(a) For microscale and small-scale project activities, apply a default emission factor of 0.0142 tCO_2/ton of biomass[22];

(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.

The net to gross adjustment of 10%, 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:

[22] This default factor is calculated based on the assumption of transporting one tonne of biomass via heavy-duty vehicles over a 110 km round-trip distance. The vehicle-specific emission factor of 129 gCO_2/t-km is sourced from Table 1 of TOOL12 ("Project and leakage emissions from transportation of freight"), and the transport distance represents the observed average from a sample of registered Clean Development Mechanism (CDM) projects.).

(i) 110 km is observed in monitoring reports of registered GHG 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 gCO_2/tkm);

(a) 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 tCO_2/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 the TOOL08 (35%);

(iii) The grid emission factors in non-Annex I countries currently reported is typically above 0.69 tCO_2/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 gCO_2/tkm, or 129×10^{-6} tCO_2/tkm), which is equal to 0.0258 tCO_2/tbiomass.

The emission reductions from the electricity generated by 1 tonne of biomass are determined as the product between the energy released when burning one tonne of black liquor (5.9 TJ/Gg, or 1.64 MWh/tonne), the efficiency of the technology consuming biomass (35%) and the grid emission factor (0.5 tCO_2/MWh), resulting in 0.287 tCO_2/tbiomass. This is further discounted by the emissions due to transport 1 tonne of biomass determined above (0.0258 tCO_2/tbiomass) and the result is equal to 0.261 tCO_2/tbiomass.

The ratio is, therefore, equals to 0.0258 / 0.261, which is approximately 10%.

15.2.3.2 *Project emissions resulting from transportation of biochar in year y ($PE_{BCT,y}$)*

Project emissions from transportation of biochar from production to end-use application are calculated as follows:

$$PE_{BCT,y} = PE_{T,y}$$

Where: the transport of the biomass between the biomass production site and the biomass utilization facility.

Where:

$PE_{BCT,y}$	=	Project emissions resulting transportation of biochar in year y; tCO2e
$PE_{BT,y}$	=	Project emissions resulting from transportation of the biochar between the biochar production site and the biochar end-use application in year y; tCO2e

15.3 Net GHG emission reductions and removals

15.3.1 *Project emission reductions*

Project emission reductions are calculated as follows:

$$ER_{p,y} = \sum_{y=1}^{n} \left(BL_{emissions} - \left(PE_y + Lk_y\right)\right) \qquad \text{Equation 25}$$

Where:

$ER_{p,y}$	=	Project emission reductions in year y; tCO2e
$BL_{emissions}$	=	Emissions in the baseline scenario in the year y; tCO2e
PE_y	=	Project emissions in year y; tCO2e
Lk_y	=	Leakages in year t; tCO2e

15.3.2 *GHG avoidance methane through biochar production*

This section is based on the AMS-III.L.: Avoidance of methane production from biomass decay through controlled pyrolysis --- Version 2.0 (United Nations, 2025a).

This project activities comprises measures that avoid the production of methane from biogenic organic matter that would have otherwise been left to decay under clearly anaerobic conditions till the end of the quantification period in a solid waste disposal site without methane recovery. Due to the project activity, decay is prevented through controlled pyrolysis[23].

This methodology is applicable to project activities where it is possible to ensure the pyrolyzed residues are no longer prone to anaerobic decomposition. The pyrolyzed residues will only be considered biologically inert if the volatile-carbon/fixed-carbon ratio is equal to or lower than 50%.

The project activities shall include recovery and combustion of non-CO_2 greenhouse gases produced during pyrolysis in order to ensure that no relevant changes in greenhouse gas emissions (other than methane avoidance) occur as a consequence of the project activity and/or need to be accounted for, except for the possibilities of leakage. If the pyrolysis facility is used for heat and electricity generation, that component of the project activity shall use a corresponding methodology under type I project activities.

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

The project activity does not recover or combust methane from a landfill unlike AMS III.G. Nevertheless, the location and characteristics of the disposal site in the baseline condition shall be known, in such a way as to allow the estimation of its methane emissions.

If the waste would be submitted to landfill disposal in the absence of the project activity, a methodology under type II (energy efficiency) might be used to account for lesser fossil fuel usage in landfilling, due to waste mass and volume reductions achieved by the pyrolysis process.

[23] Pyrolysis refers to the thermo-chemical decomposition of organic material into a carbon-rich residue, non-condensable combustible gases, and condensable vapors. This process is induced by heating in an oxygen-limited environment and proceeds without other reagents, with the potential exception of steam.

15.3.3 GHG removals and storage

15.3.3.1 Project removals for cultivation of biomass ($PR_{BC,y}$)

If the project activities include the cultivation of biomass with the purpose to produce biochar, the project holder may account the removals attributable to the biomass cultivation activities.

15.3.3.2 Project storage for biochar application ($PS_{BC,y}$)

Biochar stores carbon in a long-term stable form, preventing CO_2 release. The project storage for biochar is accounted by the Stable Carbon Content (SCC) and the organic carbon content ($Corg$) in biochar.

The $Corg$ is expressed in dry weight of organic carbon over dry weight of biochar. It is determined by laboratory analyses of the biochar produced (Woolf et al., 2021).

The project storage for biochar is calculated as follows:

$$PS_{BC,y} = M_{BCR,y} \times C_{org} \times SSC_y \times \frac{44}{12} \quad \text{Equation 26}$$

Where:

$PS_{BC,y}$	=	Project storage for biochar in year y; tCO2e
M_{BCR}	=	Mass of biochar produced in year y; ton
C_{org}	=	Organic Carbon content in biochar produced in year y;
SSC	=	Carbon fraction in biochar that remains stable over a specific period (e.g. 100 years)[24].

[24] This value represents the Stable Soil Carbon (SSC) fraction. The SSC is a permanence factor that quantifies the portion of carbon remaining after accounting for losses from microbial degradation over a specified period. The Intergovernmental Panel on Climate Change (IPCC, 2019c) provides default data indicating that biochar permanence is typically greater than 80% over a 100-year period.

15.4 Leakages

15.4.1 General principles for leakage assessment and quantification

Project holders shall conduct a full leakage assessment in accordance with the applicable BioCarbon rules and CDM methodological references, particularly:

(a) TOOL12 (Project and leakage emissions from transportation of freight);

(b) TOOL16 (Project and leakage emissions from biomass)

The following sources of leakage shall be assessed and, if applicable, quantified:

(a) Displacement of pre-project activities or land uses

Quantify emissions arising from activities that are relocated outside the project boundary as a result of biomass cultivation (e.g., previous agricultural use displaced to another location, leading to land-use change).

(b) Diversion of biomass residues from alternative uses

Assess whether biomass residues used for biochar would otherwise have been used in other emission-reducing applications (e.g., composting, animal bedding, fuel substitution). Apply TOOL16 to estimate potential leakage emissions.

(c) Processing or treatment of biomass outside the project boundary

If any processing step occurs outside the spatial boundary, emissions resulting from this processing shall be accounted as leakage, unless robust evidence demonstrates that emissions are negligible or lower than in the baseline.

(d) Transportation of biomass, biochar or residues outside the project boundary

All transportation emissions beyond the defined project boundary shall be accounted for as leakage. These shall be quantified using TOOL12 and included in the project emission balance unless fully captured as project emissions under Section 15.2.3.

(e) Market leakage (indirect effects on supply and demand)

In large-scale activities or national-scale interventions, indirect market effects on biomass availability and prices shall be evaluated qualitatively. Where material, a quantitative buffer deduction shall be proposed and justified.

All assumptions, parameters and emission factors used in leakage calculations shall be:

(a) Conservative and based on verifiable data;

(b) Consistent with the guidance in TOOL16 and TOOL12;

(c) Fully documented and traceable.

15.4.2 Leakage emissions

The total leakage emissions are calculated as follows:

$$Lk_y = Lk_{s,y} + Lk_{bd,y} + Lk_{ts,y} + Lk_{tap,y} \qquad \text{Equation 27}$$

Where:

Lk_y	=	Total leakage emissions in year y; tCO2e
$Lk_{s,y}$	=	Leakage due to activity shift of pre-project activities resulting from cultivation of biomass in a dedicated plantation in year y; tCO2e
$Lk_{bd,y}$	=	Leakage due to diversion of biomass residues from other applications in year y; tCO2e
$Lk_{ts,y}$	=	Leakage due to the transportation of biomass residues (waste) outside of the project boundary in year y; tcO2e
$Lk_{tap,y}$	=	Leakage emissions from transportation of biochar from the production facility to the site of end application in year y; tCO2e.

15.4.3 Leakage due to shift of pre-project activities resulting from cultivation of biomass in a dedicated plantation in year y ($Lk_{s,y}$)

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 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 holders 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 shall be submitted for the approval of the Board.

15.4.3.1 Leakage due to diversion of biomass residues from other applications in year y ($Lk_{bd,y}$)

This section is applicable for project activities which utilize 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.

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

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 field;

(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.[25]

Project holder 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 project document and remain consistent throughout the quantification 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 be separately identified, covering the whole amount of biomass residues supposed to be used in the project activity along the quantification 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 as in paragraph 50 above);

(d) Explain and document transparently in the project document, using a table similar to Table 1 from Appendix 2 of Tool16, what quantities of which biomass residues

[25] This scenario is applicable in situations where the origin and fate of the biomass residues cannot be definitively established. For instance, this applies if the biomass residues are procured from a public market or third-party suppliers, or if processed biomass is acquired from facilities that are not included within the defined project boundary.

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 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[26], or burnt without energy generation (e.g. field burning). This approach is only applicable to biomass residues categories for which project holders 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 quantification 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.

Calculation of leakage due to diversion of biomass residues

[26] For biomass left in the field to decay, the project holder shall demonstrate the fraction that exceeds the amount required to fulfill its soil enrichment function. Only this surplus fraction may be considered unutilized.

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 holders shall calculate leakage emissions as follows:

$$Lk_{BR,Div,y} = EF_{CO_2,lk} \times \sum BR_{Pj,n,y} \times NCV_{n,y} \qquad \text{Equation 28}$$

Where:

$Lk_{BR,Div,y}$	=	Leakage emissions due to the diversion of biomass residues from other applications in year *y;* t CO_2e
$EF_{CO_2,lk}$	=	CO2 emission factor of the most carbon intensive fossil fuel used in the country; tCO2/GJ
$BR_{Pj,n,y}$	=	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.

15.4.3.2 Leakage due to the transportation of biomass residues outside of the project boundary in year y ($Lk_{BRT,y}$)

If transportation of biomass residues occurs outside the project boundary, the requirements and equations in Section 5.2 shall be followed for estimation of leakage emissions, where the parameter $Lk_{BRT,y}$ corresponds to $Lk_{TR,m}$ from the TOOL12.

$Lk_{TR,m}$ is considered zero if transportation distance (to and from—round trip) is less than 200 km. Project emissions from transportation of biochar shall be calculated as per the latest version of Tool 12 (United Nations, 2012).

15.4.3.3 Leakage due to processing of biomass residues outside the project boundary in year y ($Lk_{BRP,y}$)

If processing of biomass residues occurs outside the project boundary, the requirements and equations in Section 15.4 shall be followed for estimation of leakage emissions, where:

(a) The parameter $PE_{BRP,electricity,y}$ corresponds to $LE_{EC,y}$ from the TOOL05;

(b) The parameter $PE_{BRP,fuel,y}$ corresponds to $PE_{FC,j,y}$ from the TOOL03;

(c) The parameter $PE_{BRP,CH_4,y}$ corresponds to $LE_{CH_4,SWDS,y}$ from the TOOL06;

(d) The parameter $PE_{BRP,COMP,y}$ corresponds to $PE_{COMP,y}$ from the TOOL13;

(e) The parameter $PE_{BRP,AD,y}$ corresponds to $LE_{AD,y}$ from the TOOL14.

15.5 Net GHG Emission reductions and removals

The net GHG emission reductions and removals shall be calculated as follows:

$$ER_{p,y} = \left(ER_{fp,y} - ER_{bp,y} - ER_{ba,y}\right) - Lk_y \qquad \text{Equation 29}$$

Where:

$ER_{p,y}$	=	Net GHG emissions reductions and removals in year y; tCO2e
$ER_{fp,y}$	=	GHG emissions reduction at feedstock production (sourcing stage) in year y; tCO2e
$ER_{bp,y}$	=	GHG emissions removals at biochar production stage in year y; tCO2e
$ER_{ba,y}$	=	GHG emissions at end-use (application) stage in year y; tCO2e

$ER_{ba,y}$ = Total leakage emissions in year y; tCO_2e

16 Leakage identification and management

All projects shall include a leakage prevention and management plan, consistent with the leakage sources. The plan shall:

(a) Demonstrate how the project minimizes the risk of leakage ex ante;

(b) Identify potential leakage pathways associated with biomass sourcing, land use displacement, transport and processing;

(c) Apply mandatory tools (e.g., TOOL12 and TOOL16) to quantify significant leakage emissions;

(d) Document measures taken to mitigate leakage risks;

(e) Describe monitoring procedures to detect and correct potential leakage during the quantification period.

Project holders shall identify and address all potential sources of leakage associated with the sourcing and use of biomass feedstock for biochar production.

Leakage is defined as any increase in GHG emissions occurring outside the project boundary that is attributable to project implementation, including:

(a) Displacement of biomass previously used for productive purposes, such as fuel, animal bedding, mulch, or compost;

(b) Indirect land-use change resulting from competition for biomass resources or land;

(c) Supply-chain emissions generated by market responses to changes in feedstock availability.

The following leakage mitigation hierarchy shall be applied:

(a) Avoidance: Preferentially use biomass with no prior market value or productive use.

(b) Substitution: Where displacement is likely, implement compensatory measures (e.g., supply of alternative material).

(c) Deduction: Apply a conservative deduction to net emission reductions if avoidance or substitution cannot be guaranteed.

The project holder shall:

(a) Conduct a leakage assessment at validation, updated at each verification;

(b) Document prior uses of each biomass type and its market context;

(c) Quantify leakage deductions in accordance with Appendix 3;

(d) Justify any assumption of "zero leakage" with evidence.

Projects using purpose-grown biomass shall additionally demonstrate that no indirect land-use change is triggered and that sufficient safeguards are in place, as specified in section 6 and Appendix 2.

The Project Document shall identify and describe all measures implemented to prevent leakage and shall provide a justification of how each measure contributes to reducing the likelihood and/or magnitude of emissions displacement.

17 Uncertainty assessment and conservative adjustment

Project holders shall assess and manage uncertainty in the quantification of GHG emission reductions in accordance with the BioCarbon Tool Conservative Approach and Uncertainty Management. The application of this tool is mandatory for all project activities.

This ensures that Verified Carbon Credits (VCCs) issued under this methodology are based on transparent, conservative, and verifiable assumptions, consistent with IPCC principles and the integrity safeguards of the BIOCARBON STANDARD.

The tool applies to all relevant parameters influencing the quantification of baseline and project emissions or removals.

17.1 Required Confidence Level and Adjustment Rule

Uncertainty shall be expressed as a two-sided 90% confidence interval. The relative half-width of the interval shall be used to determine whether conservative adjustments are required:

(a) If the relative half-width is ≤ 30%, no deduction applies;

(b) If it exceeds 30%, the excess percentage shall be deducted from the estimated net GHG benefit.

17.2 Documentation and transparency

Project holders shall document all uncertainty assessments in the Project Document and Monitoring Reports, including:

(a) Parameter-level uncertainty and source classification (input, model, fixed);

(b) Confidence interval calculation method (Tier 1 or Tier 2);

(c) Conservative adjustments and rounding;

(d) Spreadsheets and calculation tools enabling replication.

18 Monitoring requirements

Project holders shall submit a monitoring plan in accordance with the standard and additionally describe the procedures for monitoring project activities and GHG emission reductions within the project boundary.

Project holders shall include, as part of the project design document, a monitoring plan that provides for:

(a) The collection and archiving of all relevant data necessary for estimating or measuring anthropogenic emissions by sources of greenhouse gases occurring within the project boundary during the quantification period;

(b) The collection and archiving of all relevant data necessary for determining the baseline of anthropogenic emissions by sources of greenhouse gases within the project boundary during the quantification period;

(c) The identification of all potential sources of, and the collection and archiving of data on, increased anthropogenic emissions by sources of greenhouse gases outside the project boundary that are significant and reasonably attributable to the project activity during the quantification period;

(d) The collection and archiving of information relevant to the monitoring period;

(e) Quality assurance and control procedures for the monitoring process;

(f) Procedures for the periodic calculation of the reductions of anthropogenic emissions by sources by the proposed GHG project, and for leakage effects;

(g) Documentation of all steps involved in the calculations referred to GHG emissions and removals in the GHG project.

The GHG Project holder shall demonstrate that emission reductions or removals are quantified, monitored, reported and verified, through the application of the BCR Tool "Monitoring, reporting and verification (MRV) (BioCarbon Standard, 2024).

18.1 Monitoring procedures

The project holder shall describe and specify in the Project Document all monitoring procedures, including the type of measurement instrumentation used, the responsibilities for monitoring and QA/QC procedures that will be applied. Where the methodology provides different options (e.g. use of default values or on-site measurements), specify which option will be used. Equipment should be installed, maintained, and calibrated according to the equipment manufacturer's instructions and in accordance with national standards or, if these are not available, international standards (e.g., IEC, ISO).

All data collected as part of monitoring should be archived electronically and be kept at least for 2 years after the end of the last quantification period. 100% of the data should be monitored if not indicated differently in the comments in the tables below.

18.2 Data and parameters available at validation

The following data and parameters shall be available at validation. These values shall be based on credible, transparent sources (e.g., peer-reviewed literature, national statistics, IPCC guidelines, technical standards) or conservative assumptions supported by relevant justification. All documentation shall be included in the Project Document and be verifiable by the Conformity Assessment Body (CAB).

Table 4. Data and parameters available at validation

Parameter	Unit	Description	Source/Justification
DOCj	Fraction	Degradable organic carbon content of the biomass or waste used in baseline scenarios	IPCC 2006 Guidelines, Vol. 5 or national waste composition studies
MCF	Fraction	Methane correction factor for the waste disposal or storage system in the baseline scenario	TOOL04 or IPCC default values
EF_CH4, EF_N2O	tCH_4/t, tN_2O/t	Emission factors for CH_4 and N_2O from composting or combustion in baseline	TOOL13 / TOOL16 / national studies
Emission factors for fossil fuels	tCO_2 / liter or tCO_2 / GJ	Emission factors for diesel, gasoline or other fuels used in project operations	TOOL03 or national energy balance
Grid emission factor	tCO_2/MWh	Emission factor for electricity consumed in processing or transportation	CDM TOOL07 or official national grid factor
Transportation distance	km	Average distance from feedstock source to processing site and to application site	Project-specific logistics data or maps
Mode of transport	—	Type of vehicle or transport system used for biomass and biochar	Project logistics records
H/Corg ratio	—	Hydrogen to organic carbon ratio of biochar for permanence classification	Laboratory analysis or certification under EBC or IBI
Feedstock classification	—	Confirmation that the feedstock qualifies as renewable biomass	Appendix 3 and CDM EB23 Annex 18 criteria
Intended end-use	—	Description of the biochar application matrix (e.g., soil, concrete)	Project design documentation
Applicable baseline scenario	—	Justified selection among possible baseline disposal scenarios	As per Additionality Tool outcome and Section 15.1

18.3 Soil health monitoring for agricultural applications

For projects applying biochar to soils, the monitoring plan shall include specific requirements to ensure that long-term soil health and environmental integrity are maintained. Project holders shall monitor, at a minimum, the following parameters:

(a) Soil organic carbon (SOC);

(b) Soil pH;

(c) Key macronutrients (nitrogen, phosphorus, potassium);

(d) Indicators of microbial activity or biomass (using standardized field or laboratory methods).

These parameters shall be measured at baseline prior to biochar application and subsequently at least once per quantification period. Monitoring shall follow recognized national or international standards for soil sampling and analysis to ensure consistency and comparability across sites.

Results shall be documented and reported as part of the project's MRV system. Any significant adverse changes in soil health attributable to biochar application shall be assessed and addressed through corrective measures, which shall be transparently reported during verification.

18.4 Data and parameters monitored

The following data and parameters shall be monitored during the quantification period. Monitoring shall follow the procedures and frequency described in the monitoring plan and be consistent with the MRV Tool of the BioCarbon Standard. All data shall be recorded, archived, and made available for verification.

Table 5. Data and parameters monitored

Parameter	Unit	Description	Monitoring Method	Frequency
Moisture content of feedstock	%	Average moisture content of biomass input	Laboratory analysis or moisture sensors	Per batch or weekly

Parameter	**Unit**	**Description**	**Monitoring Method**	**Frequency**
Type and source of biomass feedstock	—	Classification and origin of each biomass type used	Delivery records, declarations	Continuous
Quantity of biochar produced	t	Mass of biochar output from the production unit	Weighbridge or calibrated scales	Continuous / per batch
Biochar properties (e.g., fixed carbon, H/Corg ratio, pH)	—	Physicochemical characteristics for stability and eligibility	Laboratory analysis	Per production lot
Energy consumption (fuel)	liters or GJ	Fossil fuel used for seeding, harvesting, transport or processing	Fuel logs, invoices, meters	Monthly
Energy consumption (electricity)	kWh	Electricity used during biochar processing	Meters or invoices	Monthly
Transport distances	km	Distance from feedstock origin to plant and to application site	GPS, delivery logs	Continuous / per delivery
Transport mode and vehicle type	—	Type of vehicle and fuel used	Project records	As needed
Biochar application rate	t/ha	Mass of biochar applied per hectare (soil) or per volume (non-soil)	Field logs, application records	Per application event
Location of application	GPS / map	Coordinates of biochar use sites	GIS / delivery records	Continuous
Soil incorporation method or application matrix	—	Description of how and where biochar is applied	Field monitoring / design records	Per application event
Leakage control measures (if applicable)	—	Evidence of mitigation actions to avoid biomass displacement	Declarations, contracts, reports	Annually or as needed
Reversals or loss events (if applicable)	tCO_2e	Quantification of any loss of carbon stored	Field inspections, lab testing	As required / per event

In addition to field-based monitoring, project holders are encouraged to complement their monitoring plans with remote sensing and interoperable sensor technologies. The use of satellite data with low latency and integration with ground-based optical or thermal sensors may support the detection of environmental conditions relevant to permanence and risk monitoring. Any such integration shall remain technology-neutral and globally applicable.

19 Quality Assurance and Quality Control (QA/QC)

Project holders shall establish and implement a Quality Assurance and Quality Control (QA/QC) system to ensure the accuracy, consistency, transparency, and completeness of all data, measurements, calculations, and documentation related to the mitigation activity.

The QA/QC system shall include, at a minimum, the following components:

19.1 Roles and Responsibilities

(a) Assign clear responsibilities for data collection, management, QA/QC, and reporting.

(b) Designate qualified personnel or third-party laboratories for laboratory analysis and calibration.

19.2 Calibration and Maintenance of Instruments

Ensure that all measurement equipment (e.g., weighing scales, gas analyzers, moisture sensors, electricity meters) is regularly calibrated according to manufacturer specifications or recognized standards.

(a) Maintain logs of calibration dates, maintenance activities, and corrective actions.

19.3 Data Management

(a) Establish procedures for consistent and secure storage of all monitored data, both in digital and physical form.

(b) Maintain audit trails for data collection, transfer, processing, and reporting.

(c) Implement backup systems to prevent data loss.

19.4 Verification and Cross-Checking

(a) Perform internal cross-checks of data against independent sources (e.g., compare fuel invoices with meter readings; biomass input vs. biochar output).

(b) Apply plausibility checks to detect outliers, gaps, or inconsistencies.

Where relevant, project holders may cross-validate monitoring data with historical datasets (e.g., satellite-based hotspot records or previous disturbance events) to strengthen robustness and replicability. All data sources used for cross-validation shall be transparent, verifiable, and auditable.

19.5 Documentation and Record-Keeping

(a) Maintain comprehensive records for all monitoring activities, laboratory results, QA/QC procedures, corrective measures, and equipment logs.

(b) All records shall be retained for at least two years beyond the end of the last quantification period, or longer if required by the BioCarbon Standard or national regulation.

For monitoring systems that generate alerts (including remote sensing or early-warning systems), project holders shall ensure that alert records include metadata such as data source, resolution, acquisition time, and probability level, to ensure transparency and accountability. These records shall be retained and made available for verification.

19.6 Corrective Actions

(a) Establish a procedure to identify and correct errors or anomalies in data or monitoring practices.

(b) Document all corrective actions taken and report any material errors to the Conformity Assessment Body (CAB).

19.7 Independent Review (Optional)

Project holders may engage third-party experts or institutions to conduct periodic independent QA reviews to strengthen data integrity.

The QA/QC procedures shall be described in the Project Document and shall be subject to validation and verification.

20 Document Status and Publication Format

20.1 Status

This methodology has been developed and approved in accordance with the BioCarbon procedures for the development of mitigation methodologies. The current version is authorized for use in the GHG Crediting Program as of August 2025.

20.2 Version

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Approved by: Technical Committee of BioCarbon Cert

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20.3 Publication Format

This methodology is published in digital format (PDF) on the official website of BioCarbon Cert. Any printed copies or unofficial reproductions shall be cross-checked against the version available in the official registry. In case of discrepancy, the digital version in force shall prevail.

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Appendix 1. Production processes and technological requirements

In production of biochar, thermochemical processes that can be used to treat biomass include pyrolysis, gasification, hydrothermal processing, and combustion. Each of these processes is defined by specific operating conditions (e.g., temperature, presence of oxygen) and feedstock requirements for optimal conversion to the product of primary interest. Each process results in varying fractions of gaseous, liquid and solid products (Pecha et al., 2022).

Eligible production processes include:

(a) ***Pyrolysis***

(b) ***Gasification*** (if biochar is a co-product)

(c) ***Biomass boilers*** (limited use; high-carbon fly ash ≤5% of throughput)

The general conditions of pyrolysis (slow and fast), gasification and combustion are described in the following table.

	Slow Pyrolysis	Fast Pyrolysis	Gasification	Combustion
Time required for reaction	minutes - hours	seconds	seconds	seconds
Typical particle size for operation	Biochar yield (wt. %)	saw dust - milled wood	milled wood – wood chips	wood chips
Temperature (°C)	300 - 800	400 - 700	750 - 1,000	1,000 - 1,200
Main product	biochar	bio-oil	syngas	heat
Biochar yield (wt. %)		15 - 30	5 - 10	<2

The technological requirements are the following:

Temperature monitoring required:

(a) *≥600°C ensures long-term biochar stability.*

(b) *350-600°C allows moderate stability with controlled degradation.*

**At least 70% of process heat* shall be recovered.

Technological Parameters:

(a) *Residence Time: Minimum of 30 minutes in pyrolysis/gasification reactors to ensure complete carbonization.*

(b) *Oxygen Limitation: Strict control over oxygen levels to prevent combustion and optimize char yield.*

(c) *Moisture Content: Feedstock moisture should not exceed 20% to maintain process efficiency.*

(d) *Emission Controls: Systems shall include thermal oxidizers, particulate filters, and gas scrubbers.*

(e) *Energy Recovery: Process waste heat shall be utilized for drying feedstock or co-generation purposes.*

Appendix 2. List of permissible biomasses to produce biochar

This methodology allows the use of two categories of biomass feedstock for biochar production:

(a) Residual Biomass

(i) Biomass residues and by-products that are not used for other productive purposes and would otherwise be left to decay, openly burned, or disposed of in a non-beneficial manner (e.g., agricultural residues, sawdust, pruning waste).

(ii) These feedstocks are eligible without additional justification, provided that:

(iii) Their collection does not result in negative soil carbon impacts or increased erosion;

(iv) They are not diverted from an existing use with equal or higher climate or ecosystem value;

(v) They are documented and traceable throughout the value chain.

(b) Purpose-Grown Biomass (Dedicated Crops)

Purpose-grown biomass may be used as feedstock if all the following conditions are met:

(i) No land-use change has occurred that involved the conversion of natural ecosystems;

(ii) All cultivation-related emissions are included in the project boundary and accounted for in the net GHG results;

(iii) The biomass is not diverted from other high-value uses (e.g., food production, fodder, energy crops) unless the project demonstrates that carbon credit revenues are essential for viability;

(iv) Documentation is provided to verify land tenure, planting history, inputs applied, and biomass yields.

(c) **Not allowed Feedstocks**

(i) The following biomass types are not eligible under this methodology:

(ii) Biomass derived from deforestation or land-use change involving native ecosystems;

(iii) Biomass grown on peatlands or drained wetlands;

(iv) Biomass that is legally required to be used for other purposes (e.g., animal bedding, soil amendment);

(v) Biomass from sources that involve human rights violations or environmental harm.

In consistency with the description above, this methodology considers eligible the permissible biomass established in the short list of permissible biomasses to produce biochar according to the European Biochar Certificate (EBC) (European Biochar Certificate, 2022).

Agricultural Biomass	Annual & perennial energy crops (e.g., corn, miscanthus, sunflowers) Woody biomass from short rotation plantations (SRC) Tree, vine, and shrub prunings Harvest residues (straw, leaves, husks) Old straw and grain dust Vegetables (only residual/waste materials) Seeds (expired ones)
Forestry & Wood Processing	Bark Wood chips (mechanically treated, firewood) Wood residues (sawdust, shavings) Untreated waste wood (A1) (e.g., wood shavings, bark, wood wool)
Landscape & Urban Biomass	Foliage Root stocks (with max. 10% soil content) Biomass from nature conservation General landscaping residues Urban green cuttings Wastepaper (limited to low mineral filler and varnish content)

Food & Industrial Biomass	Kitchen & canteen waste (limited contamination by plastic) Processing residues (e.g., pomace, kernels, grist, oil mill residues) Expired food residues (only vegetable-based) Spices and seasoning residues Starch production residues (potato, corn, rice) Alcohol distillery residues (fruit, grain, potato mashes) Brewery residues (spent grains, lees, sludge) Winery residues (pomace, lees, sludge) Coffee, tea, tobacco residues Mushroom substrates (peat content not credited)
Water & Marine Biomass	Screenings, floating debris, mowed material (low plastic contamination) Aquatic plants & algae (controlled water quality required)
Anaerobic Digestion Residues	Non-animal digestate (animal source materials <40%)
Note that this methodology excludes the treated wood, fossil-derived materials, and purpose-grown crops. The land in which biomass is produced does not contain forest and/or 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.	

The approved additives (Max. 10% DM):

(a) Lime, Bentonite, Rock powder, Clay, Soil

(b) Wood & plant ashes (certified only)

Leakage Risk Considerations

Biomass feedstocks with a prior productive use or market value shall be subject to leakage assessment. The following are considered to carry a high risk of leakage and may only be used if the project can demonstrate that carbon credit revenue enables a transition to higher-benefit end-uses:

(a) Biomass previously used for energy generation (e.g., domestic fuelwood, agroindustry boilers);

(b) Biomass used as animal bedding, mulch, or soil amendment in the local context;

(c) Crop residues harvested from nutrient-poor systems where their removal may degrade soil fertility.

In such cases, the project holder shall apply a leakage deduction in accordance with Appendix 3.

Appendix 3. Renewable biomass[27]

Biomass is "*renewable*" if one of the following five conditions applies:

1. The biomass is originating from land areas that are **forests**[28] where:

    (a) The land area remains a forest; and

    (b) Sustainable management practices are undertaken on these land areas to ensure, in particular, that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and,

    (c) Any national or regional forestry and nature conservation regulations are com- plied with.

2. The biomass is woody biomass and originates from croplands and/or grasslands where:

    (a) The land area remains cropland and/or grasslands or is reverted to forest; and

    (b) Sustainable management practices are undertaken on these land areas to ensure that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

    (c) Any national or regional forestry, agriculture and nature conservation regulations are complied with.

3. The biomass is **non-woody** biomass and originates from **croplands and/or grasslands** where:

[27] Renewable biomass is defined as biomass originating from sustainably managed land areas (either forest or non-forest) where the level of carbon stocks does not systematically decrease over time and where all applicable national and regional land-use laws are complied with (United Nations, n.d.).
[28] The applicable forest definition shall be that which was officially established by the host country, in accordance with the provisions of decision 11/CP.7 ("Land use, land-use change and forestry") and decision 19/CP.9 ("Modalities for the inclusion of afforestation and reforestation project activities under article 12 of the Kyoto Protocol").

(a) The land area remains cropland and/or grasslands or is reverted to forest; and

(b) Sustainable management practices are undertaken on these land areas to ensure that the level of carbon stocks on these land areas does not systematically decrease over time (carbon stocks may temporarily decrease due to harvesting); and

(c) Any national or regional forestry, agriculture and nature conservation regulations are complied with.

4. The biomass is a **biomass residue**[29] and the use of that biomass residue in the project activity does not involve a decrease of carbon pools, in particular dead wood, litter or soil organic carbon, on the land areas where the biomass residues are originating from. For example, if bagasse from sugar production would in the absence of the CDM be dumped or left to decay and is used for energy generation under the CDM, it can be assumed that the use of the bagasse does not affect the sugar cane cultivation practices and hence the carbon pools of the respective soils. In contrast, where a CDM project involves the collection of dead wood from a forest, which would not be collected in the absence of the CDM, the extracted biomass cannot be regarded as renewable, since it would result in a decrease of carbon stocks.

5. The biomass is the non-fossil fraction of an **industrial** or **municipal waste**.

Otherwise, where none of these conditions applies, the biomass is considered as *"non- renewable"*.

Baseline Emissions Assumptions

In accordance with section 15.1, baseline emissions from biomass decomposition shall be conservatively assumed to be zero unless verifiable, site-specific evidence demonstrates that significant methane (CH_4) or other greenhouse gas emissions would occur in the absence of the project.

[29] For the purposes of this methodology, "biomass residue" is defined as biomass by-products, residues, and waste streams originating from agriculture, forestry, and related industries (Executive Board of the Clean Development Mechanism, 2005).

Project holders shall not apply default emission factors from literature or other standards (e.g., IPCC landfill CH_4 factors) unless those factors are demonstrably applicable to the local biomass type, decomposition conditions, and waste management practices.

In the absence of such validation, avoided decomposition emissions (e.g., avoided CH_4 from biomass left in piles or dumps) shall not be credited. This conservative default ensures alignment with the BioCarbon Standard's environmental integrity safeguards and prevents the overestimation of mitigation outcomes.

Leakage Assessment and Deduction

Project holders shall identify any leakage risks associated with biomass sourcing, including displacement of prior uses or market impacts. Where leakage is likely, a conservative deduction shall be applied to the net emission reductions. Suggested default deductions, unless more precise data are available:

(a) 10% for biomass previously used for animal bedding or mulch;

(b) 15% for biomass diverted from energy use;

(c) 0% for biomass classified as waste with no prior use.

If leakage mitigation measures are implemented (e.g., substitution with alternative materials, on-site compensation), the deduction may be reduced with justification.

Table A3.1 – Feedstock Leakage Risk Classification and Deduction Factors

This table shall be used to assess the potential leakage associated with each feedstock type. Project holders shall apply the corresponding deduction unless they provide site-specific evidence that leakage is fully mitigated or does not occur.

Feedstock Type	***Prior Use or Market Value***	***Leakage Risk Level***	***Default Deduction (%)***	***Mitigation Notes***
Agricultural residues with no prior use (e.g., burnt straw, field waste)	None	Low	0%	No deduction required. Shall demonstrate lack of prior utilization.

Feedstock Type	***Prior Use or Market Value***	***Leakage Risk Level***	***Default Deduction (%)***	***Mitigation Notes***
Residues currently used as fuel (e.g., bagasse, fuelwood)	Energy use (local combustion, boilers)	High	15%	Deduction applies unless equivalent substitution is documented.
Crop residues used for animal bedding or mulch	Livestock sector, soil management	Medium	10%	May be reduced to 5% if substitution measures are in place.
Purpose-grown biomass (non-food crops)	Competes with land for other production	Variable	10–30%	Shall assess indirect land-use change. Deduction depends on context.
Sawdust from industrial milling	By-product, potential use for pellets or boards	Low to Medium	5%	May be exempt if deemed waste by facility and not sold.
Urban green waste (landscaping)	Intermittent use, variable	Low	0–5%	Site-specific assessment required.
Forest residues (non-commercial thinning)	Left in field, minimal use	Low	0%	Demonstrate no existing market or ecosystem role.
The deduction is applied to the total net project GHG emissions (before applying the buffer). If the project implements leakage mitigation measures (e.g., alternative supply to previous users), the percentage may be reduced, with justification. If the absence of prior use is documented and validated, a 0% deduction may be applied.				

Appendix 4. Soil and Non-Soil Uses of Biochar

Biochar has a wide range of soil and non-soil applications. Its primary role in agriculture helps improve soil health and crop productivity, while its non-soil uses include environmental protection, energy storage, industrial applications, and consumer products.

Soil Applications of Biochar

Biochar is widely used in agriculture and environmental applications to improve soil quality and plant growth. Some key soil-related uses include:

(a) *Soil Amendment*

- Enhances soil fertility by improving nutrient retention and availability.
- Reduces soil acidity, acting as a pH buffer.
- Boosts microbial activity and promotes beneficial soil organisms.

(b) *Water Retention and Drainage*

- Increases water-holding capacity in sandy soils, reducing drought stress.
- Improves drainage in clay soils, preventing waterlogging.

(c) *Carbon Sequestration*

- Stores carbon in the soil for hundreds to thousands of years, reducing atmospheric CO_2 levels.

(d) *Contaminant Remediation*

- Absorbs heavy metals, pesticides, and organic pollutants, reducing soil contamination.
- Prevents nutrient leaching into groundwater, improving water quality.

(e) *Compost Enhancement*

- Improves the quality of compost by stabilizing nutrients and reducing odors.
- Enhances microbial decomposition and speeds up composting.

Non-Soil Applications of Biochar

Beyond agriculture, biochar has a variety of industrial and environmental applications:

(a) *Water Filtration*

- Acts as an adsorbent to remove toxins, heavy metals, and pollutants from water.
- Used in wastewater treatment plants and household water filters.

(b) *Livestock and Animal Feed Additive*

- Enhances digestion and nutrient absorption in animals.
- Reduces methane emissions and ammonia odors from manure.

(c) *Air Purification*

- Used in air filters to remove harmful gases, odors, and volatile organic compounds (VOCs).

(d) *Construction Materials*

- Incorporated into concrete and bricks to improve insulation and carbon capture.
- Used as an eco-friendly alternative in asphalt and building materials.

(e) *Energy Production*

- Can be used as a renewable fuel source in biomass energy systems.
- Enhances efficiency when mixed with coal or other biofuels.

(f) *Industrial and Chemical Applications*

- Acts as a precursor for activated carbon production.
- Used in catalysis and chemical adsorption processes.

(g) *Textile and Consumer Goods*

- Added to fabrics for moisture-wicking and odor-absorbing properties.
- Used in cosmetics and personal care products for skin detoxification.

Appendix 5. Default values for biomass cultivation

Table 1. Relative stock change factors for different management activities on cropland[30]

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 50 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	1.05	
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
			Moist	1.09	
		Tropical	Dry	1.04	
			Moist/Wet	1.10	

[30] Adapted from 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 4, Table 5.5), by the Intergovernmental Panel on Climate Change, (IPCC, 2019c)

Factor type	Level	Temperature regime	Moisture regime	Factor value	Description and criteria
		Warm temperate	Dry	1.04	used for weed control
			Moist/Wet	1.10	

Table 2. Relative stock change factors for different levels of nutrient input on cropland[31]

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 practiced.
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

[31] Adapted from 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 4, Table 5.5), by the Intergovernmental Panel on Climate Change, (IPCC, 2019c).

Factor type	Level	Temperature regime	Moisture regime	Factor value	Description and criteria
		-	Moist/ Wet	1.44	systems due to an additional practice of regular addition of animal manure
		Tropical Montane	n/a	1.41	

Table 3. Relative stock change factors (fLU, fMG, and fIN) for grassland management[32]

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)

[32] Adapted from 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Vol. 4, Table 6.2), by the Intergovernmental Panel on Climate Change, (IPCC, 2019c).

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