

METHODOLOGY

GS4GG PAA M400-XX

SDG 13

PRODUCTION AND APPLICATION FOR THE REMOVAL OF CARBON VIA BIOCHAR (PARC)

Publication Date: -

Version: Public consultation

Next Planned Update: -

SUMMARY

This methodology is applicable to project activities that involve the thermochemical conversion of sustainably sourced biomass into biochar and its subsequent application in eligible end-uses that ensure durable carbon storage. It provides a standardized framework for quantifying the net Greenhouse Gas (GHG) removals associated with the production and application of biochar.

To accommodate diverse production scales while ensuring rigorous quantification, the methodology establishes a Modular Architecture with three distinct compliance tracks. The selection of a track shall be determined by the production technology and scale:

- **Track 1 (Distributed Production):** Applicable to micro-scale activities utilizing manual or semi-manual production units (e.g., flame curtain kilns) with a biomass input capacity of < 1 metric tonne per day (TPD) per unit. This track employs an aggregated operational structure and allows for the use of conservative standardized default factors and composite sampling to minimize transaction costs while ensuring environmental integrity. To strictly prevent de-bundling, this track is capped at a cumulative limit of $\leq 60,000$ tCO_{2e} per year across the entire standalone activity or Programme of Activities (PoA) including its VPAs.
- **Track 2 (Mechanized Transition):** Applicable to mid-scale activities utilizing mechanized batch retorts or containerized continuous systems with a biomass input capacity between 1 and 15 metric tonnes per day (TPD) per unit. Activities under this track shall utilize direct weighing for biomass inputs but are

permitted to use Thermal Proxy Monitoring for process emissions verification, serving as a bridge between artisanal and industrial quantification standards.

- **Track 3 (Industrial Precision):** Applicable to large-scale industrial activities utilizing continuous production facilities with a biomass input capacity of > 15 metric tonnes per day (TPD) per unit. This track mandates high-precision direct measurement, including Continuous Emissions Monitoring Systems (CEMS) and batch-specific laboratory analysis.

The methodology defines specific eligibility modules for biomass sourcing and end-use applications. Activities shall strictly adhere to the restrictions assigned to their selected Compliance Track. The Biomass Sourcing Modules include:

- **Module F1 (Field Residues):** Agriculture and forestry residues left after harvest or logging operations (e.g., straw, stover, logging slash, branches, tops, and stumps).
- **Module F2 (Processing Residues):** Residues generated at centralized agro-industrial processing facilities (e.g., rice husks, bagasse).
- **Module F3 (Restorative Biomass):** Biomass sourced from the removal of Invasive Alien Species (IAS) or bush encroachment.
- **Module F4 (Disaster & Sanitary):** Biomass removed for verified wildfire prevention or sanitary disease control (Permitted for Track 2 and Track 3; Restricted for Track 1).
- **Module F5 (Purpose-Grown):** Biomass cultivated specifically for biochar on degraded or marginal land (**Restricted to Track 3**).
- **Module F6 (Organic Waste):** Biogenic waste streams requiring pathogen control, and advanced emissions filtration, such as animal manure, digestate, biosolids, or segregated Biogenic fraction MSW (**Restricted to Track 3 Only**).

End-Use Application Modules are restricted to verifiable, non-combustion sinks:

- **Module A1 (Soil Application):** Application to agricultural or forestry soil (including remediation).
- **Module A2 (Engineered Materials):** Encapsulation in non-combustible, inert concrete, asphalt, or composite building materials.
- **Module A3 (Geologic & Anoxic Storage):** Storage in engineered, oxygen-limited subterranean environments (specifically dedicated earth vaults). Active or capped Municipal Solid Waste (MSW) landfills are strictly prohibited. Restricted to Track 2 & 3.

To reflect dynamic modern value chains, the methodology utilizes a "Flexible Activity Boundary" framework, allowing biochar production and application to involve distinct compliant entities linked via digital chain-of-custody tracking. The quantification approach allows issuing Gold Standard Verified Emission Removals (GSVERs) derived exclusively from the durable sequestration of pyrogenic carbon. To align with the goals of the Paris Agreement, the methodology incorporates mechanisms for dynamic

baseline adjustment (Downward Adjustment Factors), ensuring that activities contribute to the Host Country's Net Zero trajectory.

ACKNOWLEDGMENT

This methodology was developed with support from our consultant, Chetan Agarwal at Climate Spring. We would also like to thank the independent external experts who provided valuable feedback during the review process.

TABLE OF CONTENTS

1 KEY INFORMATION.....	7
2 DEFINITIONS	8
3 SCOPE, APPLICABILITY, AND ENTRY INTO FORCE.....	11
3.1 SCOPE	11
3.2 APPLICABILITY	11
3.3 ENTRY INTO FORCE	17
3.4 MANDATORY COMPLIANCE AND SAFEGUARDS	17
4 NORMATIVE REFERENCES.....	19
5 ACTIVITY BOUNDARY AND GHGS SOURCES/SINKS	20
5.1 ACTIVITY BOUNDARY	20
5.2 GHG SOURCES AND SINKS	21
5.3 BASELINE EMISSIONS	22
5.4 ACTIVITY EMISSIONS	23
5.5 LEAKAGE EMISSIONS	24
6 DEMONSTRATION OF ADDITIONALITY	25
6.1 REQUIREMENTS	25
6.2 REGULATORY SURPLUS ANALYSIS (MANDATORY)	26
6.3 LOCK-IN RISK ANALYSIS (MANDATORY)	27
6.4 ADDITIONALITY PATHWAY SELECTION.....	27
6.5 COMMON PRACTICE ANALYSIS:	29
6.6 ONGOING FINANCIAL NEED	30
7 BASELINE SCENARIO.....	31
7.1 BASELINE DETERMINATION (STEPWISE APPROACH)	31
7.2 STEP 1: SELECTION OF AND JUSTIFICATION OF THE BASELINE APPROACH.....	31
7.3 STEP 2: DETERMINATION OF UNADJUSTED BASELINE	32
7.4 STEP 3: APPLICATION OF THE DOWNWARD ADJUSTMENT & UNCERTAINTY	32
7.5 STEP 4: IDENTIFICATION AND CALCULATION OF THE CONSERVATIVE BAU SCENARIO	33
7.6 STEP 5: SELECTION OF THE CREDITING BASELINE	34
8 ACTIVITY REMOVALS	34
8.1 IDENTIFICATION OF THE ACTIVITY REMOVALS	34
8.2 CALCULATION OF ACTIVITY REMOVALS.....	34
8.3 DETERMINATION OF BIOCHAR QUANTITY <i>Q_{biochar}</i> AND MOISTURE (<i>MC</i>)	35
8.4 DETERMINATION OF ORGANIC CARBON CONTENT (<i>C_{org}</i>)	36
8.5 DETERMINATION OF PERMANENCE FACTOR (<i>F_{perm}</i>)	37
8.6 APPLICATION LOSS FACTOR (<i>L_{app}</i>)	38
8.7 UNCERTAINTY DEDUCTION (<i>UNCAR</i>):	39
9 ACTIVITY EMISSIONS	39
9.1 IDENTIFICATION OF ACTIVITY SCENARIO	39
9.2 CALCULATION OF TOTAL ACTIVITY EMISSIONS	40
9.3 EMISSIONS FROM BIOMASS SUPPLY (<i>AE_{supply, y}</i>)	40
9.4 EMISSIONS FROM BIOCHAR PRODUCTION (<i>AE_{process}</i>)	41
9.5 TRANSPORTATION EMISSIONS (<i>AE_{trans, y}</i>).....	43
9.6 APPLICATION EMISSIONS (<i>AE_{app, y}</i>)	44
9.7 UNCERTAINTY ACCOUNTING FOR ACTIVITY EMISSIONS (<i>UNCAE</i>).....	44
10 LEAKAGE EMISSIONS	45
10.1 IDENTIFICATION OF LEAKAGE SOURCES.....	45
10.2 AVOIDANCE AND MINIMIZATION STRATEGIES	46

10.3	CALCULATION OF TOTAL LEAKAGE EMISSIONS	46
10.4	EMBODIED EMISSIONS (<i>LEEmbodied, y</i>).....	46
10.5	MARKET LEAKAGE (<i>LEMarket, y</i>):.....	47
10.6	ECOLOGICAL LEAKAGE (<i>LEeco, y</i>).....	48
10.7	ACTIVITY SHIFT LEAKAGE (<i>LEshift, y</i>)	48
10.8	UNCERTAINTY ACCOUNTING (<i>UNCLE</i>).....	48
11 	NET GHG EMISSION REMOVALS	49
11.1	NET QUANTIFICATION APPROACH.....	49
11.2	CALCULATION OF TOTAL DEDUCTIONS (<i>Deductions_y</i>).....	49
11.3	CALCULATION OF NET VERIFIED REMOVALS AND AND DEFICIT CARRYOVER	49
11.4	NET CARBON EFFICIENCY RATIO (NCER) CHECK	50
11.5	BUFFER POOL CONTRIBUTION & RISK DEDUCTION	50
11.6	APPLICATION OF THE DOWNWARD ADJUSTMENT FACTOR (DAF)	51
11.7	FINAL ISSUABLE GSVERS	52
12 	REVERSALS	52
12.1	DEFINITIONS AND SCOPE	52
12.2	REVERSAL RISK ASSESSMENT RATES (BUFFER CONTRIBUTION).....	52
12.3	MITIGATION AND MANAGEMENT MEASURES	54
12.4	QUANTIFICATION OF REVERSALS (<i>REV_y</i>)	55
12.5	ADDRESSING REVERSALS (COMPENSATION)	56
13 	UNCERTAINTY QUANTIFICATION	57
13.1	APPROACH FOR UNCERTAINTY MANAGEMENT	57
13.2	SUMMARY OF UNCERTAINTY REQUIREMENTS	58
13.3	CALCULATION OF AGGREGATE UNCERTAINTY (TRACK 3)	58
13.4	SYSTEMATIC ERROR CHECK (CALIBRATION):	60
14 	MEETING METHODOLOGICAL PRINCIPLES	60
14.1	ENCOURAGING AMBITION OVER TIME	60
14.2	EQUITABLE SHARING OF MITIGATION BENEFITS.....	61
14.3	AVOIDANCE OF DOUBLE COUNTING	62
14.4	ALIGNING WITH NDC AND LT-LEDS.....	62
14.5	ENCOURAGING BROAD PARTICIPATION.....	63
14.6	INCLUDING DATA SOURCES, ACCOUNTING FOR UNCERTAINTY, AND MONITORING	63
14.7	TAKING INTO ACCOUNT POLICIES, MEASURES, AND RELEVANT CIRCUMSTANCES	64
15 	MONITORING METHODOLOGY	64
15.1	GENERAL REQUIREMENTS.....	64
15.2	DATA AND PARAMETERS NOT MONITORED	65
15.3	DATA AND PARAMETERS MONITORED	69
15.4	QA/QC AND DATA MANAGEMENT	80
15.5	CORRELATED PROXY PROTOCOL (ASH PROXY).....	81
16 	MONITORING REQUIREMENTS FOR ACTIVITIES WITH REVERSAL RISKS	82
16.1	GENERAL REQUIREMENTS.....	82
16.2	RESPONSIBILITY	82
16.3	MONITORING METHODS BY END-USE MODULE	82
16.4	REVERSAL REPORTING AND QUANTIFICATION	84
16.5	DATA AND PARAMETERS MONITORED	84
17 	APPLICATION TO PROGRAMME OF ACTIVITIES.....	85
17.1	GENERAL REQUIREMENTS.....	85
17.2	BASELINE AND ADDITIONALITY DEMONSTRATION.....	86
17.3	MONITORING AND SAMPLING IN PoAs.....	87

18| RENEWAL OF CREDITING PERIOD 87

18.1 | CREDITING PERIOD RENEWAL REQUIREMENTS 87

18.2 | REASSESSMENT OF THE BASELINE SCENARIO 87

18.3 | REASSESSMENT OF ADDITIONALITY 88

18.4 | TECHNOLOGY GRADUATION (TRACK 1 SUNSET CLAUSE) 88

ANNEX -1 FEEDSTOCK MODULES & SUSTAINABILITY CRITERIA

ANNEX -2 REQUIREMENTS FOR TRAINING, CAPACITY BUILDING & OPERATIONS

ANNEX -3 ELIGIBLE END-USE APPLICATION MODULES

ANNEX -4 LABORATORY TESTING & ANALYTICAL METHODS

ANNEX -5 CONSERVATIVE STANDARDIZATION FACTORS FOR TRACK 1 & 2

ANNEX -6 BIOCHAR PERMANENCE FACTORS (200-Year)

ANNEX -7 REVERSAL RISK ASSESSMENT TOOL

ANNEX -8 REFERENCES

1| KEY INFORMATION

1.1.1 | The following table describes the key information for the application of methodology.

Table 1. Key information

Term	Description
Activity summary	The activity involves the thermochemical conversion of eligible biomass feedstocks into biochar—a stable, porous, carbon-rich solid—via pyrolysis or gasification, and its subsequent durable storage in eligible soil or engineered materials or dedicated anoxic earth vaults to remove carbon dioxide from the atmosphere.
Mitigation type	☒ Removals
Applicable activity scale	☒ Micro scale (e.g., ≤10,000 tCO ₂ e per year) ☒ Small scale (≤60,000 tCO ₂ e per year) ☒ Large scale (>60,000 tCO ₂ e per year) *Track 1 – activities are restricted to micro or small-scale standalone activities or at the cumulative PoA level.
Sectoral Scope	Sector 13: Waste Handling and Disposal Sector 15: Agriculture, Forestry, and Other Land Use (AFOLU) Sector 4: Manufacturing Industries (Specific to engineered materials)
Activity Requirement	Engineered Removals Activity Requirements
Activity start date	a. Track 1 & Track 2: The date of commissioning of the first biochar production unit. b. Track 3: The earliest date on which the Activity Developer has committed to implementation of the activity (e.g., equipment purchase or facility construction).
Crediting Period start date	The start date of the Crediting Period is the date of the start of operations or a maximum of two years prior to the date of Project Design Certification, whichever occurs later.
Crediting period length	a. Standard: 5 years, renewable twice (Total 15 years). b. Restorative Biomass (Module F3) and Purpose-Grown (Module F5): 5 years, renewable once (Total 10 years).
Geographical applicability	Global <i>Note: Module F3 (Restorative) and Module F5 (Purpose-Grown) have specific regional limitations based on national regulations (e.g., Invasive Species Lists) and land classification data.</i>

Limitations	Activities utilizing fossil-fuel based feedstocks (e.g., waste tires, plastics) or feedstocks containing non-biogenic carbon are strictly prohibited. Waste tires are entirely ineligible as the fossil elements are chemically bound. Municipal Solid Waste (MSW) is only permitted under Track 3 where rigorous physical sorting of the biogenic fraction is mandated. Mixed biomass sources are permitted provided they comply with the strict requirements of all applicable Feedstock Modules.
-------------	---

2| DEFINITIONS

2.1.1 | The definitions outlined in the [Glossary of Gold Standard for the Global Goals](#) and the [Activity Requirements](#) shall apply, in addition to those outlined below:

Table 2. Terms and definitions

TERM	DEFINITION
Activity developer	The central entity that signs the Gold Standard terms and conditions, holding ultimate legal and financial liability for the activity's environmental integrity, assuming responsibility for monitoring, and retaining exclusive rights to the issued GSVERs. [For Legal interpretation, the definition included in Terms and Conditions supersedes this definition]
Aggregator	The entity responsible for organizing and managing multiple distributed production facilities (Track 1) or community clusters (Track 2). The Aggregator can be the same entity as the Activity Developer, or an appointed third party, assuming full liability for data aggregation, monitoring, quality assurance, and verification on behalf of the individual producers.
Anoxic Storage	The storage of biochar in an oxygen-limited environment (specifically sealed, dedicated earth vaults)) designed to inhibit oxidative decay and ensure long-term stability. Active methanogenic MSW landfills are strictly excluded.
Biochar	A solid material generated by heating biomass to a temperature in excess of 450°C under conditions of controlled and limited oxidant supply (pyrolysis or gasification) to prevent total combustion. To be eligible under this methodology, the material shall meet the definition of "stable". For Track 1, to ensure maximum conservativeness in the absence of advanced continuous testing, the biochar shall exhibit a molar Hydrogen to Organic Carbon ratio ($H:C_{org}$) of ≤ 0.4 . For Track 2 and Track 3, the biochar shall exhibit an $H:C_{org}$ ratio of ≤ 0.7 for standard 200 year durability claims, or demonstrate via petrography - a Mean Random Reflectance (R_o) $\geq 2\%$ for 1000 year high durability claims.

Biogenic Carbon	Carbon derived from organic matter of recent biological origin (plants, animals, microorganisms), distinct from fossil carbon which is derived from geological deposits.
Composite Sampling	A monitoring approach permitted for Track 1 and Track 2 activities where physical subsamples from multiple distinct production batches are systematically mixed to form a single "Master Sample" for laboratory analysis. This method ensures cost-effectiveness while maintaining statistical representativeness of the aggregated volume. A Master Sample shall represent a maximum of 50 metric tonnes (Track 1) or 100 metric tonnes (Track 2), or a maximum time boundary of 1 calendar month.
Continuous Emissions Monitoring System (CEMS)	The total equipment necessary for the determination of a gas or particulate matter concentration or emission rate using pollutant analyser measurements and a conversion equation, graph, or computer program. Mandatory for Track 3.
Earth Vault	A dedicated, engineered subterranean storage unit for biochar, characterized by a low-permeability liner and a sealed cap, distinct from active or capped municipal solid waste (MSW) disposal sites.
Feedstock Modules	The specific categories of biomass eligibility defined in this methodology: (Refer to Annex 1 for details) F1 (Field Residues): Crop/forestry residues left on field or forestry logging slash, branches, tops, and stumps left post-harvest. F2 (Processing Residues): Residues from industries such as agro processing (e.g., husks, mills), food processing (e.g., coffee), etc. F3 (Restorative): Invasive species/bush encroachment (e.g., water hyacinth). F4 (Disaster/Sanitary): Wildfire/pest prevention thinning (e.g., de-weeding). F5 (Purpose-Grown): Crops on degraded land (Track 3 only). F6 (Organic Waste): Manure/Biosolids/Biogenic MSW fraction (Track 3 only).
Flexible Activity Boundary	An operational model recognizing dynamic value chains. Physical boundaries (e.g., application fields) can be dynamically added to the registered project over time via digital registries, provided the Activity Developer maintains strict contractual Chain of Custody and retains exclusive carbon rights.
Inertinite	The highly stable, non-reactive fraction of organic carbon in biochar, characterized by a Random Reflectance (R_o) $\geq 2\%$. This fraction is petrographically similar to geological coal, is insensitive to soil temperature decay and is considered to have a mean residence time

	exceeding 1,000 years. This serves as the primary high-durability metric for Track 2 and Track 3.
Net Carbon Efficiency Ratio (NCER)	A mandatory efficiency metric calculated as the ratio of Total Gross Activity Removals to Activity Emissions encompassing project supply, processing, transport, and application. Eligible activities shall maintain an NCER ≥ 10 to ensure the climate benefit outweighs the operational footprint.
Purpose-Grown Biomass	Biomass cultivated specifically to serve as feedstock for biochar production (Module F 5). Under this methodology, this is restricted to biomass grown on confirmed degraded, marginal, or contaminated lands and is eligible only for Track 3 activities.
Restrictive Covenant	A legal obligation imposed in a deed or lease by the landowner that restricts the use of the land (e.g., prohibiting excavation) to ensure the permanence of the carbon sink.
Restorative Biomass	Biomass sourced from the removal of Invasive Alien Species (IAS) or bush encroachment vegetation (Module F3), where the removal contributes to ecosystem restoration and biodiversity recovery.
Social Permanence	The concept utilized in Track 1 where the durability of a carbon sink (biochar in soil) is reinforced by the tangible agronomic and economic benefits it provides to the user (e.g., increased crop yield), thereby creating a rational disincentive for reversal (excavation or misuse).
Sustainable Biomass	Biomass (waste or purpose-grown) that is sourced without causing a long-term decrease in carbon stocks and without causing negative impacts on biodiversity, water, or food security. Shall strictly comply with the Biomass Sustainability Criteria in Annex 1.
Thermal Proxy Monitoring	A simplified monitoring approach permitted for Track 2 where the destruction of methane and other pyrolysis gases is verified by continuously monitoring the temperature and residence time of a secondary combustion chamber (e.g., $T > 850^{\circ}\text{C}$) for $>2\text{s}$, serving as a proxy for direct emissions measurement.
Track 1: Distributed Production	A compliance track characterized by networked, micro-scale operations (Individual unit capacity < 1 TPD) where biochar production is integrated into agricultural or livelihood systems. Strictly limited to activities generating $\leq 60,000$ tCO ₂ e/yr across an entire PoA). Verification relies on Aggregated Assurance and Conservative Standardization.
Track 2: Mechanized Transition	A compliance track characterized by mechanized batch retorts or containerized continuous systems (Individual unit capacity between 1 to 15 TPD). Verification relies on direct weighing of inputs and Thermal Proxy Monitoring for emissions, serving as a bridge between artisanal and industrial quantification.

Track 3: Industrial Precision	A compliance track characterized by centralized, continuous-flow facilities with integrated process controls (Individual unit capacity > 15 TPD). Verification mandates Direct Instrumental Measurement (e.g., CEMS, automated weighbridges) and batch-specific laboratory analysis.
Waste Biomass	Biomass residues from agriculture, forestry, or industrial processes (Modules F1, F2, F4, F6) that are diverted from their baseline fate exclusively for the purpose of durable carbon removal.

3| SCOPE, APPLICABILITY, AND ENTRY INTO FORCE

3.1 | Scope

- 3.1.1 | This methodology is applicable to activities that sequester carbon dioxide (CO₂) through the thermochemical conversion of sustainably sourced biomass into biochar and its subsequent application in sinks that ensure durable storage.
- 3.1.2 | The activity boundary covers the cradle-to-grave lifecycle, encompassing biomass sourcing, pre-processing, biochar production, transport, and final application. An activity shall be considered eligible only when it demonstrates compliance with all criteria defined in this section. This methodology operates strictly as a pure Carbon Dioxide Removal (CDR) framework. The crediting of avoided baseline emissions (e.g., avoided methane from decay or counterfactual open burning) is explicitly excluded.

3.2 | Applicability

The methodology is applicable to activities that demonstrate compliance with the following conditions.

3.2.1 | Compliance Track Selection (Technology Tiers):

- 3.2.1.1 | To accommodate diverse production scales while ensuring rigorous quantification, the activity shall be implemented under one of three Compliance Tracks. These tracks align with the technological maturity tiers (Low, Mid, and High-Tech) of the sector.
- 3.2.1.2 | The Activity Developer shall select the applicable Track at the time of Design Certification and adhere to the specific MRV requirements defined in **Table 3**.
- 3.2.1.3 | Track 1 (Distributed Production) activities are subject to the following restrictions:
- a. **Standalone Activity Cap:** Individual activities are limited to a maximum issuance of 60,000 tCO₂e per annum.
 - b. **Large-Scale Aggregation (PoA):** Volumes generated by a Programme of Activities (PoA) utilizing Track 1 shall not exceed a

cumulative aggregate of 60,000 tCO₂e per year across all combined Voluntary Project Activities (VPAs)..

- c. **Consequence of Exceedance:** When the volume of certified removals exceeds 60,000 tCO₂e threshold, the issuance shall be capped at 60,000 tCO₂e. To claim excess volume, the activity shall upgrade to Track 2 or Track 3 (digital logging and direct weighing of all outputs).

Table 3. Compliance Track Selection Matrix

Attribute	Track 1: Distributed production	Track 2: Mechanized Transition	Track 3: Industrial Precision
Primary Scale	Artisanal Input: < 1 tonne/day (per unit)	Mechanized Input: > 1 to 15 tonnes/day (per unit)	Industrial Scale Input: > 15 tonnes/day (per unit)
Scale cap	≤ 60,000 tCO ₂ e/yr (Cumulative across PoA/Activity)	None	None
Typical Technology	Open-flame or semi-open batch systems	Semi-controlled retorts or modular continuous systems	Fully engineered continuous or batch pyrolysis plants or gasification plants with integrated syngas combustion ¹ .
Process Control	Manual Operation. Temperature estimation via portable sensors.	Semi-Automated. Integrated control of residence time and air flow. Partial temperature feedback.	Fully Automated. Real-time SCADA control of temperature, feed rate, and residence time.
Emissions Strategy	Methane Minimization. Relies on "Flame Curtain" to combust pyrolysis gases.	Thermal Destruction. Secondary combustion chamber or thermal oxidizer to destroy gases.	Advanced Abatement. Full syngas combustion/CHP. Compliant with industrial air quality standards.

¹ It is recognized that even for lower capacity units such machines would be available commercially. For such cases, the activity shall select the appropriate track (track 2 or track 3, Track 1 will not be eligible)

MRV Approach	Conservative Standardization. Use Default Factors (Annex 5).	Hybrid Measurement. Direct weighing of input required. Thermal Proxy permitted for emissions.	Direct Measurement. Automated weighing and Continuous Emissions Monitoring (CEMS) required.
Biomass Eligibility	Restricted to Modules F1, F2, F3 and F4 (Wildfire Only)	Restricted to Modules F1, F2, F3, F4.	All Modules (F1–F6).
End-Use Eligibility	Restricted to Module A1 (Soil).	All Modules (A1–A3).	All Modules (A1–A3).
Applicability	Global	Global	Global

3.2.2 | **Financial and Economic Screening:** To ensure environmental integrity and prevent the subsidization of established fossil-dependent industries, the activity shall meet the following criteria:

3.2.2.1 | **High-Value Product Exclusion:** Activities producing commercial high-value carbon products such as Activated Carbon (Iodine Number > 500 mg/g) or Metallurgical Coke are fundamentally incompatible with the durable storage requirements of this methodology. Because these products are ultimately oxidized during filtration or industrial combustion, they violate the permanence requirements. The volume of these specific commercial products shall be strictly ineligible for Carbon Dioxide Removal (CDR) crediting under any circumstances. (Note: If a facility produces a mix of products, all upstream and processing GHG emissions associated with the production of the ineligible volume shall still be fully accounted for as project emissions to ensure conservative net accounting).

3.2.2.2 | **Net Carbon Efficiency Ratio (NCER):** The activity shall demonstrate a **NCER** of greater than **10**.

- For every 1 tonne of CO₂ emitted by the project's logistics and processing, at least 10 tonnes shall be sequestered. NCER for each monitoring period shall be calculated as per Eq 25 (Section 11).
- Activities where logistics and processing emissions exceed 10% of the sequestration benefit are **Ineligible**.

3.2.3 | **Biomass Sourcing Eligibility:** The activity shall utilize biomass complying with one of the approved Feedstock Modules (F1–F6) and the Positive List criteria below.

3.2.3.1 | **General Eligibility:** The feedstock shall be biogenic. Feedstocks containing fossil carbon (e.g., coal, waste tires, plastics) or hazardous electronic waste are strictly prohibited.

- a. Exception for Track 3 (Module F6): Municipal Solid Waste (MSW) containing fossil fractions is eligible only if processed in a Track 3 facility with advanced sorting. The waste shall be strictly segregated such that only the verifiable biogenic fraction of the waste is used as feedstock for biochar production. Recognizing that 100% mechanical purity is physically unfeasible, residual fossil fractions entering the reactor are strictly accounted for via mandatory Radiocarbon (^{14}C) isotope testing of the final biochar. The corresponding fossil CO_2 emissions shall be fully accounted for, and the fossil fraction of the resulting biochar is fundamentally ineligible for Carbon Dioxide Removal (CDR) crediting.

3.2.3.2 | **Approved Feedstock Modules:**

- a. Module F1 (Field Residues): Agriculture/forestry residues (e.g., straw, stover, logging slash, branches, tops, and stumps).
- b. Module F2 (Processing Residues): Agro-industrial waste (e.g., husks, bagasse, nutshells).
- c. Module F3 (Restorative): Invasive Alien Species (IAS) and bush encroachment.
- d. Module F4 (Disaster/Sanitary): Wildfire fuel reduction and pest-infected timber. For pest-infected biomass, the production unit shall maintain a minimum temperature of $> 500^\circ\text{C}$ to ensure complete phytosanitary sterilization.
- e. Module F5 (Purpose-Grown): Crops grown on degraded land (Restricted to Track 3 Only).
- f. Module F6 (Organic Waste): Manure, Digestate, Biosolids, Biogenic MSW fraction (Restricted to Track 3 Only).

3.2.3.3 | **Mixed Feedstocks:** Activities demonstrating compliance to Track 2 or Track 3 production processes may utilize biomass that falls into more than one Feedstock Module. In such cases, the activity shall demonstrate compliance with the strict sustainability requirements of all the relevant modules.

3.2.3.4 | **Biomass Sustainability Requirements:** Feedstock eligibility, surplus testing, and sustainable extraction rates shall be strictly governed by the Gold Standard Biomass Sustainability Requirements and aligned tools.

3.2.3.5 | **Biomass Storage Requirements:** To prevent anaerobic decay and methane generation prior to pyrolysis, the biomass shall be stored in appropriate conditions based on the quality of the biomass (e.g., type, moisture content, degradability). The activity developer shall follow national, regional, or local guidelines on the storage of biomass. Where unavailable, international best practices shall apply, including but not limited

- a. **Temperature and Shade:** Maintaining appropriate temperature and preventing direct sunlight exposure (to prevent combustion or accelerated decay). Where biomass is stored in open sites, the developer shall justify the practice (e.g., via daily mixing or upturning of biomass to prevent anaerobic pockets).
- b. **Moisture control:** Ensuring adequate moisture control (via aeration or partial drying before storage) such that it physically prevents accelerated anaerobic degradation but is not low enough to inculcate spontaneous combustion.

3.2.3.6 | **Jurisdictional Limit:** Biomass shall be sourced from within the Host Country jurisdiction. Transboundary import of biomass for the purpose of biochar production under this methodology is prohibited. The cross-border export of the final biochar product for downstream application is permitted; however, any biochar applied outside the Host Country boundary cannot be verified and shall be strictly ineligible for Carbon Dioxide Removal (CDR) crediting.

3.2.4 | **Biochar Production Criteria**

3.2.4.1 | **Minimum Temperature:** The reactor shall maintain a minimum temperature of 450°C during the conversion phase to ensure proper carbonization and prevent the creation of degradable torrefied biomass.

3.2.4.2 | **Track 1 Requirement:** To minimize methane slip and ensure stability without advanced controls, Track 1 units shall operate approved technologies (e.g., Flame Curtain) capable of achieving **> 450°C** in the carbonization zone. The Activity Developer shall demonstrate that the equipment used in Track 1 is certified or empirically proven to achieve the required temperature range and adequate residence time.

3.2.4.3 | **Fossil Fuel Restriction:** Fossil fuels (e.g., diesel, LPG) shall be used only for the start up/initiation. Use of fossil fuels (or mixed MSW plastics) to sustain the thermochemical reaction is prohibited.

3.2.4.4 | **Additives:** Consumables or additives (e.g., clay, ash) added to the biomass or biochar shall not exceed 2% by weight (w/w). No hazardous substances shall be added.

3.2.5 | **Biochar Quality**

3.2.5.1 | **Stability:** The produced biochar shall meet stability thresholds. For Track 1, the biochar shall exhibit a molar Hydrogen to Organic Carbon ratio (H:Corg) of ≤ 0.4 to ensure maximum conservativeness in the absence of advanced testing. For Track 2 and 3, the biochar shall exhibit an H:Corg ratio of ≤ 0.7 for standard durability claims. Any batch or composite sample exceeding these thresholds is deemed ineligible for crediting.

3.2.5.2 | **Durability Stratification:** Activities aiming to claim High Durability (1,000+ years) shall utilize the inertinite Method (Annex 4) and demonstrate that the inertinite fraction exhibits a mean Random Reflectance (R_o) of $> 2.0\%$.

- 3.2.5.3 | **Prohibition of Impregnation:** The re-injection, spraying, or soaking of liquid pyrolysis by-products (e.g., bio-oil, wood vinegar, tars) onto the solid biochar output is strictly prohibited.
- 3.2.5.4 | **Exception:** "Charging" biochar with non-pyrolytic agricultural additives (e.g., manure, compost, microbial tea) is permitted under Module A1, provided the mass of these additives is measured and deducted from the Net Creditable Weight ($Q_{biochar}$) during monitoring.
- 3.2.5.5 | **Track 3 Monitoring:** For Track 3 (Industrial), the facility shall not have piping or other connections that connect the condensation unit back to the biochar output stream.
- 3.2.6 | **Biochar Storage and Transport:** To prevent degradation, spontaneous combustion, and weathering losses, the activity shall adhere to the following limits:
- 3.2.6.1 | **Temporary Storage:** Biochar is deemed "temporarily stored" if kept at the production or intermediate site.
- a. **Heap Storage:** If stored in heaps, biochar shall not remain on site for more than 10 days. Heaps shall be managed to prevent spontaneous combustion.
 - b. **Bagged Storage:** If stored in bags, biochar shall not remain on site for more than 30 days unless protected from moisture and direct sunlight.
 - c. **Transport:** Non-packaged biochar transported via truck or rail shall be covered (e.g., tarpaulin) to prevent wind-blown loss and cross-contamination. Biochar shall not be transported alongside flammable fossil fuels.
- 3.2.7 | **End-Use Application:** The activity shall apply biochar to a sink that ensures durable storage. Eligible application modules are:
- 3.2.7.1 | **Module A1 (Soil):** Application to agricultural, forestry, or remediation soils.
- 3.2.7.2 | **Module A2 (Engineered Materials):** Encapsulation in non-combustible, inert concrete materials such as asphalt, or composite building materials. 100% pure biochar may be utilized provided strict B2B non-combustion encapsulation contracts are executed.
- 3.2.7.3 | **Module A3 (Geologic & Anoxic Storage):** Storage in engineered, oxygen-limited subterranean environments (specifically Dedicated Earth Vaults). Active or capped Municipal Solid Waste (MSW) landfills are strictly prohibited. Restricted to Track 2 & 3.
- 3.2.7.4 | The Activity Developer shall provide proof of application (e.g., geo-tagged photos, weighing receipts, or end-user agreements) to satisfy verification requirements.

3.3 | Entry into force

3.3.1 | The date of entry into force is the publication date of this methodology.

3.4 | Mandatory Compliance and Safeguards

3.4.1 | Contractual Obligation & Aggregation

3.4.1.1 | **Ownership:** The Activity developer shall demonstrate clear legal ownership of the carbon credits rights. This includes establishing contractual agreements with biomass suppliers and biochar producers and downstream application entities to ensure no double counting occurs. The Activity Developer shall confirm that they retain an exclusive right to the net GHG removals achieved.

3.4.1.2 | **Aggregator Liability:** For Track 1 (Distributed) and Track 2 (Community Clusters), the Aggregator acts as the primary operational manager and assumes full liability for data accuracy, safety compliance, and credit distribution on behalf of the distributed producers.

3.4.1.3 | **Mass Balance Check (Yield Safeguard):** The Aggregator shall verify that the aggregated biochar output volume is physically consistent with the recorded biomass input volume.

3.4.2 | Double Counting Mitigation

3.4.2.1 | **End-User Claims:** The Activity Developer shall conform with the *GHG Emissions Reduction & Sequestration Product Requirements*. Where biochar is used in non-soil applications (Module A2), the developer shall obtain a contractual "Assignment of Rights" from the downstream manufacturer to prevent the manufacturer from claiming the removal in their own GHG inventory (e.g., Environmental Product Declaration).

3.4.2.2 | **Scope 3 "Insetting":** To prevent Double Claiming between the Voluntary Carbon Market and Corporate GHG Inventories: if the activity is funded by a supply chain partner (e.g., an off-taker paying a premium for low-carbon crops to claim the removals in their supply chain or carbon negative cement) are ineligible for GSVER issuance unless a Carbon Rights Waiver is provided.

3.4.2.3 | **Stacking with other projects:** Where the biochar is incorporated into soil (Module A1), the activity developer shall confirm that the target fields are not part of an existing Soil Organic Carbon (SOC) project aiming to claim net removals. If the fields are part of another carbon project, the specific volume of biochar applied to those overlapping fields shall not be eligible to claim the removal benefit due to biochar under this methodology to prevent double crediting on the same land polygon.

3.4.3 | Health and Safety

3.4.3.1 | **Risk Assessment:** A risk assessment shall be conducted for all hazardous and potentially hazardous materials used (e.g., solvents). Storage areas shall be physically separated from fossil fuels or ignition sources.

3.4.3.2 | **Air Quality (PM2.5/CO):**

- a. **Track 1:** Production units shall be operated in open-air environments or well-ventilated structures. Operation within enclosed residential spaces is prohibited.
- b. **Track 2&3:** Facilities shall comply with all applicable national regulations regarding flue gas emissions and workplace safety.

3.4.4 | **Environmental Safeguards**

3.4.4.1 | **Methane Abatement:** Traditional earth-mound kilns (charcoal clamps) are prohibited.

3.4.4.2 | **Soil Toxicity:** Biochar applied to soil (Module A1) shall meet recognized quality standards (e.g., EBC, IBI) for heavy metals and Polycyclic Aromatic Hydrocarbons (PAHs). Where local or national regulations provide more conservative (stricter) thresholds for eligible heavy metals, the local regulations shall take absolute precedence.

- a. Track 1& 2 activities may utilize Composite Sampling to demonstrate compliance.
- b. Track 3 activities shall utilize Batch-specific analysis.

3.4.5 | **Social Safeguards (Social Permanence)**

3.4.5.1 | **Agronomic Security:** The biochar application rates shall strictly align with documented regional agronomic best practices, local agricultural extension recommendations, or peer-reviewed literature (e.g., a cap of 50 tonnes per hectare), preventing soil pH shock or nutrient immobilization.

3.4.5.2 | **"No-Burn" Guarantee:** Any biochar sold or diverted without explicit, geo-tagged proof of application in an eligible, non-combustible sink is strictly ineligible for crediting.

3.4.6 | **"Technology Graduation" (Sunset Clause – Track 1)**

3.4.7 | Track 1 activities are strongly recommended to evaluate a structural upgrade at the time of Crediting Period Renewal. While a mandatory phase-out of purely manual, non-digital kilns is not strictly enforced in Version 1.0, developers are encouraged to transition to mechanization (Track 2) or install IoT digital verification ("Smart Kiln" status). A formal evaluation of mandatory graduation requirements will occur during the 2028 methodology revision.

3.4.8 | **Safeguards for Anoxic Storage (Module A3)**

- a. **Groundwater Protection:** The base of the Dedicated Earth Vault shall be separated from the seasonal high water table by a minimum of 1.5 meters.
- b. **Future-Proofing:** The storage site shall be subject to a legal instrument (e.g., Environmental Covenant or Deed Restriction or Easement) prohibiting excavation for a minimum of 100 years.

4| NORMATIVE REFERENCES

- 4.1.1 | The following standards, methodologies, tools, and guidelines are normative references for the application of this methodology. Activity developers shall apply the latest valid version of these documents.
- 4.1.2 | References to CDM tools are valid until equivalent tools are published under Gold Standard (GS4GG) or the Article 6.4 Mechanism (A6.4)/Paris Agreement Crediting Mechanism (PACM).
- 4.1.2.1 | GS4GG Standards and Requirements
- a. GS4GG [Principles And Requirements](#)
 - b. [Safeguarding Principles and Requirements](#)
 - c. GHG Emissions Reduction & Sequestration Product Requirements
 - d. GS4GG Engineered Carbon Removal Activity Requirements
 - e. GS4GG Programme of Activities (PoA) Requirements (Applicable to aggregated activities)
 - f. GS4GG Land Use & Forests (LUF) Activity Requirements (Applicable for Buffer Pool governance)
 - g. GS4GG Gender Equality Guidelines and Requirements
- 4.1.2.2 | GS4GG Methodologies, Standards, and Tools
- a. Methodology Standard: [Requirements for Additionality Demonstration](#)
 - b. Methodology Standard: Requirements for Baseline Setting
 - c. Methodology Tool: Downward Adjustment Factor (DAF) Determination
 - d. Methodology Tool: Emissions from Freight Transport
 - e. Methodology Tool: Common Practice Analysis **(MT400-06)**
- 4.1.2.3 | UNFCCC/A6.4 Tools and Standards:
- a. CDM Tool 16: Project and leakage emissions from biomass
 - b. CDM Tool 12: Project and leakage emissions from transportation of freight
- 4.1.2.4 | Other Sources:
- a. ISO/IEC 17025: General requirements for the competence of testing and calibration laboratories. (Mandatory for laboratory elemental analysis).
 - b. ASTM D1762 / ISO 18134: Standard test methods for moisture, volatile matter, and ash in biomass/charcoal.
 - c. ISO 7404-5:2009 / ASTM D2798: Methods of determining microscopically the reflectance of vitrinite/inertinite.

- d. European Biochar Certificate (EBC) / International Biochar Initiative (IBI): Normative thresholds for heavy metals, PAHs, and Dioxins/Furans to ensure safe agricultural soil application (Module A1).
- e. Detailed scientific and analytical references are provided in **Annex 6**

5| ACTIVITY BOUNDARY AND GHGS SOURCES/SINKS

5.1 | Activity boundary

- 5.1.1 | The activity boundary encompasses all anthropogenic sources of GHGs and carbon sinks that are under the control of the activity developer, are related to the activity, or are significantly affected by the activity.
- 5.1.2 | The activity boundary shall be defined based on the Cradle-to-Grave lifecycle of the biochar, comprising the physical sites and transport links associated with biomass sourcing, facility construction, biochar production, and durable application.

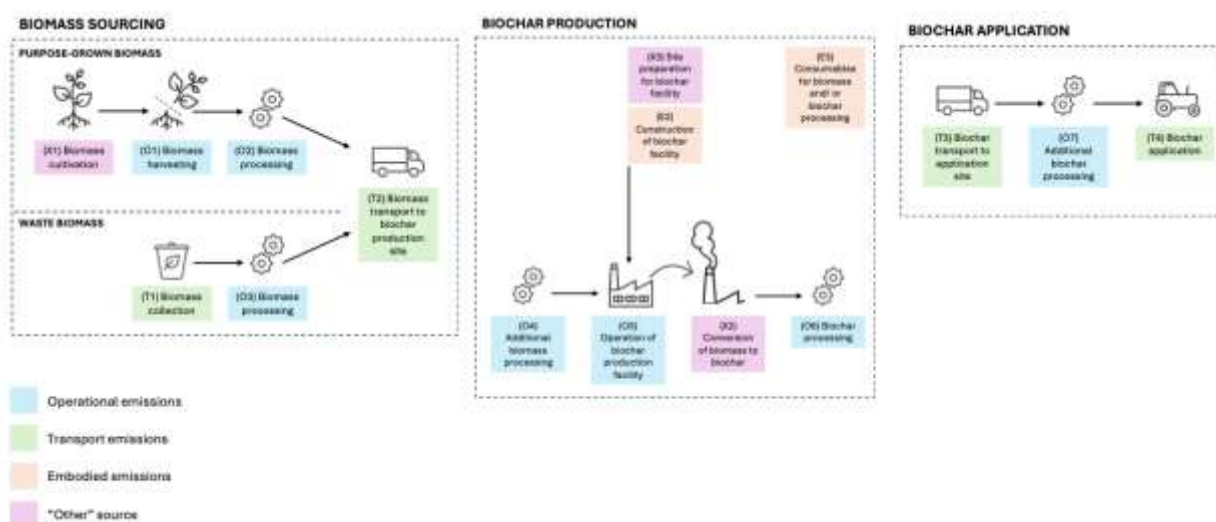


Figure 1: Activity Boundary.

- 5.1.3 | **Spatial Boundary Components:** The activity developer shall clearly identify the spatial extent of the activity sites as follows:
 - 5.1.3.1 | **Biomass Sourcing Area:** The geographical locations where biomass is generated, harvested, or collected.
 - a. **Modules F1, F2, F3, F4 (Residues/Waste Biomass):** The specific collection zones (e.g., farms, mills, invaded rangelands, fire-risk forests).
 - b. **Module F5 (Purpose-Grown):** The specific land parcels where cultivation occurs (Restricted to Track 3).
 - c. **Module F6 (Organic Waste):** The municipal or agricultural waste facilities where the specific biogenic fraction is generated and segregated.

- 5.1.3.2 | **Biochar Production Site:** The physical sites where biomass processing (e.g., drying, chipping) and thermochemical conversion (pyrolysis/gasification) occur.
- a. **Track 1:** Includes the network of artisanal kilns and the central Aggregator Hub.
 - b. **Track 2:** Includes the mechanized facility (e.g., containerized retorts) and any satellite pre-processing depots.
 - c. **Track 3:** The industrial plant footprint.
- 5.1.3.3 | **Biochar Application Site:** The geographical areas where biochar is applied to ensure durable storage.
- a. **Module A1 (Soil):** Agricultural, forestry, or remediation lands.
 - b. **Module A2 (Engineered Materials):** The manufacturing facilities (e.g., concrete plants) where encapsulation occurs.
 - c. **Module A3 (Geologic & Anoxic Storage):** The physical footprint of the Dedicated Earth Vault, vertically defined from the base liner to the surface cap.
- 5.1.3.4 | **Transportation:** The mobile sources and routes used to transport biomass from source to production, and biochar from production to application.
- 5.1.4 | **The Flexible Activity Boundary:** To reflect dynamic modern value chains, physical application boundaries (e.g., specific downstream agricultural fields or construction projects) are not required to be permanently fixed at the time of Design Certification. New application sites or distributed production units may be dynamically added to the registered project during the crediting period via the Digital Monitoring System (DMS), provided the Activity Developer maintains a strict contractual Chain of Custody and retains exclusive carbon rights across all entities.
- 5.1.5 | **The Aggregation Boundary (Track 1 & 2):** For activities utilizing an Aggregated or Cluster Structure:
- a. The Hub/Cluster: The central facility controlled by the Aggregator serves as the primary "Control Point" for weighing, sampling, and data management.
 - b. The Spokes: The boundary extends to include all registered distributed production units.
 - c. Liability: The Aggregator assumes boundary liability for all emissions occurring at the distributed "Spoke" facilities.
- 5.1.6 | **Temporal Boundary:** The boundary covers the time from the start of facility construction and biomass collection up to the end of the crediting period.

5.2 | GHG Sources and sinks

- 5.2.1 | Emissions from fuels and biogenic processes can occur during biomass production, conversion, transport, and application. The following sections

identify the relevant GHG sources for the baseline scenario, the activity scenario, and leakage.

5.2.2 | **Carbon Sinks (Removals)**

5.2.2.1 | **Biochar Carbon:** The durable storage of pyrogenic biogenic carbon in biochar is the primary and exclusive removal sink (CO₂).

5.2.3 | **Emission Sources (Activity emissions)**

5.2.3.1 | **Biogenic CO₂:** Emissions of CO₂ from the combustion or decay of sustainable biogenic biomass are considered climate-neutral and are **Excluded** from quantification (CO₂ = 0).

5.2.3.2 | **Methane (CH₄):** CH₄ slip from pyrolysis is a Critical Source and shall be included.

5.2.3.3 | **Nitrous Oxide (N₂O):** Included for Module F5 (Purpose Grown) fertilizer emissions.

5.2.4 | **Materiality and Simplification Rules (Track1):** If the combined total transport distance (Biomass → Source → Production hub → Application site) is less than 200 km, transport emissions may be deemed negligible and omitted for simplification in alignment with the conservative thresholds established in CDM Tool 12.

5.3 | **Baseline Emissions**

5.3.1 | The following table details the GHGs included in, or excluded from, the baseline scenario(s).

Table 4. Sources of Baseline Emissions

SOURCE	DESCRIPTION	GAS	INCLUDED ?	JUSTIFICATION
Biomass Decay & Open Burning	The baseline aerobic/anaerobic decay or counterfactual open combustion of waste/residue biomass (Modules F1, F2, F4, F6).	CO ₂ , CH ₄ , N ₂ O	No	Pure CDR Exclusivity: Avoided baseline emissions from decay or burning are explicitly excluded. The natural baseline formation of multi-century pyrogenic carbon is natively zero
Biomass Cultivation (Applicable to Module F3)	Modules F3, F4, F5 Baseline vegetation dynamics.	CO ₂ , N ₂ O	No	Zero Baseline Rule: For Restorative (F3) and Purpose-Grown (F5), it is assumed no durable carbon storage occurs in the baseline. $BR_{unadj} = 0$

Energy Generation	Displacement of grid electricity or heat.	CO ₂	No	Excluded. This methodology utilizes a "CDR only" approach. Displacement of grid electricity or heat is not credited.
-------------------	---	-----------------	----	--

5.4 | Activity emissions

5.4.1 | The following table details the GHGs emissions included in, or excluded from, the activity scenario(s).

Table 5. Sources of Activity Emissions

SOURCE	DESCRIPTION	GAS	INCLUDED?	JUSTIFICATION
Biomass Supply (<i>Cultivation</i>)	Fertilizer and machinery use for crop production.	CO ₂ e, N ₂ O	Conditional	Included for Module F5 (Purpose-Grown) only. Excluded for all Waste/Residue modules.
Biomass Processing (Pre-treatment)	Chipping, drying, shredding, or pelletizing.	CO ₂ e	Yes	Emissions from fossil fuels (diesel chippers) or grid electricity used for pre-processing.
Biochar Production (<i>Pyrolysis – Methane Slip</i>)	Methane Slip: Uncombusted pyrolysis gases released from the reactor.	CH ₄	Yes	Critical Source. • Track 1: Default Factors. • Track 2: Thermal Proxy. (T < 850°C triggers deduction). • Track 3: Measured via CEMS.
Biochar Production (<i>Pyrolysis – Methane Slip</i>)	Fossil carbon volatilized and combusted from MSW plastics.	CO ₂ e	Conditional	Mandatory inclusion for Track 3 facilities utilizing Module F6 (MSW) to account for incomplete biogenic sorting.
Auxiliary Energy	Energy for startup (ignition) or sustaining reactor controls.	CO ₂	Yes	Emissions from LPG/Diesel (startup) and electricity (blowers/feeders).

Transportation (Biomass & Biochar)	Logistics for Feedstock and Biochar.	CO ₂	Yes	Emissions from trucks, rail, or shipping. <i>Exemption:</i> Track 1 activities with combined distance < 200km.
Biochar Application	Machinery for application/burial.	CO ₂	Yes	Emissions from tractors/spreaders (Module A1) or mixing equipment (Module A2). Emissions from excavators, compactors, and capping machinery (Module A3).
Soil Disturbance (SOC Loss)	Loss of baseline Soil Organic Carbon (SOC) due to deep mechanical tilling.	CO ₂	Conditional	Included only if biochar application (Module A1) forces severe mechanical disturbance on verifiable no-till agriculture or perennial grasslands.

5.4.2 | Specific Provisions for Track 2 (Mechanized)

5.4.2.1 | **Thermal Proxy Monitoring:** Track 2 activities utilizing mechanized retorts shall account for methane slip. If the unit is equipped with a Secondary Combustion Chamber (SCC) or Thermal Oxidizer:

- Compliant State:** Emissions are deemed Zero for periods where the SCC temperature is continuously verified as > 850°C with a residence time > 2 seconds.
- Excursion:** For periods where temperature drops below the threshold, the penalty factor (Annex 5) shall be applied to the volume produced during the failure window.
- Electricity:** Track 2 units requiring electricity for automation/fans shall meter consumption and apply the grid emission factor.

5.5 | Leakage emissions

5.5.1 | Leakage is the net change of GHG emissions occurring outside the activity boundary, attributable to the activity. The following table details the potential sources of leakage emissions that shall be assessed.

Table 6: Sources of Leakage Emissions

SOURCE	DESCRIPTION	GAS	INCLUDE D?	JUSTIFICATION
Embodied Emissions (Upstream)	Cradle-to-gate emissions associated with the manufacturing, construction and transport of the activity devices.	CO _{2e}	Yes	Mandatory Inclusion. • Track 1 & 2: Standardized deduction per kiln. • Track 3: LCA-based deduction.
Market Effects (Biomass Diversion)	Non-participants switch to fossil fuels because biomass (e.g., F1, F2) was diverted to the project.	CO _{2e}	Yes	Conditional. Mitigated via Surplus Test (Biomass Sustainability Requirements). If biomass is proven "Waste" or "Surplus," Leakage = 0. If test fails, replacement emissions are quantified.
Ecological Leakage (Nutrients & SOC)	Nutrient Displacement and foregone Soil Organic Carbon (SOC) accumulation due to residue removal.	CO _{2e} , N ₂ O	Yes	Mandatory for Module F1. Accounts for N-P-K fertilizer replacement and foregone natural carbon input.
Activity Shift (<i>Land Use</i>)	Displacement of food production to other lands due to biomass cultivation (Module F5).	CO _{2e}	Yes	Mandatory for Track 3 (Module F5). Excluded for all other waste/residue modules. Avoided by proving > 10 year land abandonment.

6 | DEMONSTRATION OF ADDITIONALITY

6.1 | Requirements

- 6.1.1 | The activity developer shall demonstrate that the activity would not have occurred in the absence of the incentives provided by the carbon revenues. The demonstration of additionality shall be conducted in accordance with the latest version of the *GS4GG Standard: Requirements for Additionality Demonstration*.

- 6.1.2 | All activities, regardless of the Compliance Track selected, shall successfully complete the following mandatory analyses:
- a. Regulatory Surplus Analysis (Section 6.2)
 - b. Lock-In Risk Analysis (Section 6.3)
 - c. Additionality analysis as per selected option (6.4)
 - d. Common practice analysis (section 6.5)
 - e. Ongoing Financial Need (at Renewal as per Section 18) (Section 6.8).

6.2 | Regulatory Surplus Analysis (Mandatory)

- 6.2.1 | The activity developer shall demonstrate that the activity is not mandated by any existing laws, regulations, or mandates (legal requirements), or binding obligations within the host Party's jurisdiction.
- 6.2.2 | The analysis shall verify that legal requirements do not:
- a. **Mandate Biomass Conversion:** Explicitly require the biomass feedstock (e.g., crop residues) to be converted into biochar or a stabilized carbon product.
 - b. **Prohibit Baseline Fate:** Explicitly prohibit the baseline scenario (e.g., open burning or decay) *and* systematically enforce this prohibition. (Note: Because this is a pure CDR methodology, laws banning the open burning of residues do not impact regulatory surplus, as avoided emissions from burning are not credited, however it is to be systematically assessed to confirm compliance status).
 - i. **Systematic Non-Enforcement:** If a legal ban on open burning exists but is systematically unenforced (Common Practice of non-compliance > 50%), the activity is considered to have Regulatory Surplus. The Developer shall provide evidence (e.g., government reports, remote sensing burn scar data) of widespread non-compliance. In high income countries this exemption is not applicable.
 - c. **Mandate Application:** Explicitly require the application of biochar to soil or materials.
- 6.2.3 | **Host Country Eligibility (Positive/Negative List):** The activity developer shall confirm that the mitigation activity type (Biochar Production and durable storage) is legally eligible to operate and issue credits within the Host Country.
- 6.2.3.1 | **Demonstration of Compliance:** Compliance with the above requirement shall be demonstrated through one of the following, as applicable, at the time of Validation and Crediting Period Renewal:
- a. **Official policy document:** A policy document or a legal framework of the country prohibiting generation of carbon credits from proposed activity.

- b. **Official List Review:** A citation of the Host Country's most recent official Article 6 policy framework, decrees, or public eligibility lists (e.g., a "Negative List" or "Ineligible Activity List") published by the Designated National Authority (DNA) or Article 6 Focal Point, confirming the activity is not excluded.
- c. **Explicit Authorization:** Provision of a Letter of Authorization (LoA) or No Objection from the Host Country's DNA that explicitly authorizes the mitigation activity type or sector.
- d. **Confirmation of No Exclusion (Default):** In the absence of a published negative list, positive list, or specific regulatory exclusion, the Activity Developer shall provide a formal declaration confirming that no official communication or regulation has been issued by the Host Country identifying the specific technology as ineligible for carbon crediting.

6.2.3.2 | The regulatory surplus assessment shall be conducted at the start of the 1st crediting period and reassessed at each renewal of the crediting period.

6.3 | Lock-In Risk Analysis (Mandatory)

- 6.3.1 | In accordance with the GS4GG Lock-In Assessment Tool, mitigation activities shall not lock the Host Country into high-emitting technologies or perverse baseline practices.
- 6.3.2 | **Methodology-Level Assessment:** Activities applying this methodology natively satisfy the requirements of the Lock-In Assessment Tool without conducting a project-specific analysis, as the risk is fully mitigated by the methodology's eligibility criteria:
 - a. **Fossil Fuel Lock-In:** As per Section 3, the use of fossil fuels to sustain the pyrolysis reaction is prohibited. This inherent technology restriction negates the risk of locking in fossil-dependent thermal infrastructure.
 - b. **Feedstock Lock-In (Biomass Diversion):** The activity shall demonstrate that the valorisation of the waste stream does not create a perverse incentive to generate more waste. Compliance is demonstrated via the "Surplus Test" defined in the GS4GG Biomass Sustainability Requirements.
 - c. **Technology Lifetime:** Biochar production units generally have a technical lifetime of 10–20 years. The activity is consistent with Long-Term Low-Emission Development Strategies (LT-LEDS) as it provides Net Negative Emissions (CDR), a prerequisite for deep decarbonization scenarios.

6.4 | Additionality Pathway Selection

- 6.4.1 | Following the mandatory analyses above, the Activity Developer shall demonstrate additionality through one of the options defined in **Table 7**, determined by the **Compliance Track** and **Activity Scale**.

Table 7: Additionality Pathway Selection

Compliance Track	Eligible Scale	Permitted Approaches
Track 1 (Distributed)	Micro/Small Scale ($\leq 60,000$ tCO ₂ e/yr cumulatively)	Option A: Deemed Additionality (if LDC/SIDS/LLDC). Option B: Barrier Analysis. Option C: Financial Viability.
Track 2 (Mechanized)	Micro/Small Scale ($\leq 60,000$ tCO ₂ e/yr)	Option A: Deemed Additionality (if LDC/SIDS/LLDC) Option B: Barrier Analysis. Option C: Financial Viability.
	Large Scale ($> 60,000$ tCO ₂ e/yr)	Option C: Financial Viability Analysis (Mandatory).
Track 3 (Industrial)	All Scales	Option C: Financial Viability Analysis (Mandatory). <i>Barrier Analysis is Prohibited as a standalone demonstration.</i>

A. Option A: Positive List

6.4.2 | In accordance with Section 5.4 of the GS4GG Common Practice Tool (MT400-06), activities meeting the criteria below are Deemed Additional and are exempt from conducting a separate Financial or Barrier Analysis.

6.4.2.1 | **Category 1: Nascent Technology in Priority Regions (TMC-1)**

- Location:** The activity is located in a Least Developed Country (LDC), Small Island Developing State (SIDS), or Landlocked Developing Country (LLDC).
- Technology:** The activity utilizes Track 1 or Track 2 technology.
- Scale:** The standalone activity or PoA meets the definition of Micro-Scale or Small-Scale ($\leq 60,000$ tCO₂e/yr).

6.4.2.2 | **Category 2: Restorative Biomass (Module F3) Feedstock:** The activity exclusively utilizes biomass from Module F3 (Restorative), specifically the removal of Invasive Alien Species (IAS) or bush encroachment. The developer shall demonstrate an absence of existing, systemic government subsidies that are already actively funding the specific invasive species removal.

B. Option B: Barrier Analysis:

6.4.3 | **Applicability:** Permitted exclusively for Track 1 (Distributed) and Micro/Small-Scale Track 2 activities.

6.4.4 | **Eligible Barriers:** The developer shall demonstrate that at least one significant barrier prevents implementation:

- a. **Investment Barrier:** Inability to access debt financing due to lack of collateral or high interest rates (>15%).
- b. **Technological Barrier:** Lack of local capacity to operate pyrolysis units safely, requiring the project to fund extensive training and aggregation infrastructure (Biochar Hubs).
- c. **Institutional Barrier:** Absence of established supply chains for biomass collection in the target region.

6.4.5 | **Evidence** Barriers shall be substantiated by independent evidence (e.g., bank rejection letters, industry reports, surveys) and not anecdotal claims

C. Option C: Investment/Financial Analysis

6.4.6 | **Applicability:** Mandatory for Track 3 and Large Scale Track 2.

6.4.7 | The Activity Developer shall conduct an **Investment Analysis** (Benchmark or Investment Comparison) following Section 6.3 of the *Additionality Standard*.

6.4.7.1 | Approach The activity developer shall conduct a Benchmark Analysis or Investment Comparison Analysis.

- a. **Input Parameters:** The analysis shall account for CAPEX (Equipment, Site), OPEX (Labor, Energy, Maintenance), Feedstock Logistics and all operational revenues, including Sales of Biochar, Energy (if applicable), Co-products (e.g., Bio-oil), Municipal Waste Tipping/Gate Fees, and active Host Country government green-technology subsidies.
- b. **Outcome:** The analysis shall demonstrate that the Project IRR (without carbon) is falls below the relevant Sectoral Benchmark, proving the facility requires carbon finance to achieve commercial viability.

6.5 | Common Practice Analysis:

6.5.1 | This methodology establishes a Methodology-Level Common Practice Analysis as permitted by Section 5.3 of the *GS4GG Common Practice Tool (MT400-06)*.

6.5.1.1 | **Methodology-Level Assessment (Valid for 3 years)** Activity Developers may rely on the following assessment without conducting a project-specific analysis, provided the activity falls within the scope below. This global exemption is strictly valid for 3 years from the date of methodology publication. Upon expiration, Activity Developers shall conduct regional, sub-national common practice assessments.

- a. **Applicable Geographical Area (AGA):** Global.
- b. **Target Market (P_{all}):** Total global biomass residue management and soil amendment market.
- c. **Similar Activities (P_{sim}):** Commercial biochar production for durable storage without carbon finance.

d. **Technology Maturity Category (TMC):**

- i. **LDC/SIDS/LLDC:** TMC-1 (Nascent).
- ii. **Rest of World:** TMC-2 (Early Adopter).
- e. **Threshold (F_{max}):** 15% (LDC/SIDS) and 10% (Rest of World).
- f. **Conclusion:** Based on the 2023 Global Biochar Market Report, the autonomous adoption of biochar production for durable storage is < 1% of the total market potential.
- a. **Result:** $F < F_{max}$. The activity is Deemed Not Common Practice.

6.5.2 | If the validity of the Methodology-Level Assessment expires (after 3 years) or the Activity Developer chooses a sub-national AGA, they shall conduct a specific analysis using the **Attribute Matrix** below.

Table 8. Attribute Matrix for Essential Distinction

Attribute	Project activity	Distinct Activity (Excluded from P_{stm})
Primary Output	Solid carbonaceous material (Char) (H:Corg ratio > 0.7)	Charcoal (Fuel), Activated Carbon (Filtration)
Technology	Thermochemical conversion (Pyrolysis/Gasification) at >450°C	Incineration, Torrefaction
End-Use Application	Durable Storage / Sequestration (e.g., Soil Amendment, Concrete, Asphalt)	Combustion / Energy
Scale	Track 1, 2 or Track 3	Mismatched Scale
Exclusion of Carbon Finance	Technologies distributed, subsidized, or maintained via voluntary or compliance carbon market mechanisms shall be explicitly excluded from the count when calculating the common practice penetration rate.	Yes

6.6 | Ongoing Financial need

6.6.1 | At the renewal of the crediting period, the additionality of the activity shall be reassessed. The Activity Developer shall demonstrate Ongoing Financial Need in accordance with Section 7 of the Additionality Standard.

6.6.1.1 | Requirement: The developer shall provide an updated financial analysis or qualitative assessment demonstrating that the activity still requires carbon revenue to cover operational costs or overcome persistent market barriers. Binding, long-term carbon credit off-take agreements established prior to or during the first crediting period serve as proof of the project's carbon-dependent financial structure and do not retroactively void additionality.

6.6.1.2 | Track 3 Limitation: If the activity has achieved commercial viability (IRR > Benchmark) through biochar product sales alone, it is no longer additional and shall not be renewed.

7| BASELINE SCENARIO

7.1 | Baseline Determination (Stepwise Approach)

7.1.1 | The crediting baseline removals (BR_y), shall be determined following the stepwise approach mandated by the *GS4GG Standard: Requirements for Baseline Determination*:

- a. Step 1: Selection and Justification of the Baseline Approach (Section 7.2 |).
- b. Step 2: Application of the selected approach prior to downward adjustment (Section 7.3 |).
- c. Step 3: Application of the Downward Adjustment (Uncertainty and Ambition) (Section 7.4 |).
- d. Step 4: Identification of a conservative Business-as-Usual (BAU) baseline (Section 7.5 |).
- e. Step 5: Comparison and selection of the final Crediting Baseline (BE_y) (Section 7.6 |).

7.2 | Step 1: Selection of and Justification of the Baseline Approach

7.2.1 | Selection of Baseline Approach

7.2.1.1 | This methodology utilizes approach (c) from paragraph 5.6.2 of the Methodology Standard - Requirements for Methodology Development: *An approach based on existing actual or historical emissions, adjusted downwards*.

7.2.2 | Justification for the Baseline Approach

7.2.2.1 | The selection of approach (c) is justified as follows:

- a. **Absence of BAT:** Biochar production for durable sequestration represents less than 1% of global biomass management practices. A "Best Available Technology" (BAT) or "Ambitious Benchmark" is not applicable as no dominant commercial practice exists for durable biomass carbon storage in the baseline.
- b. **Site Specificity:** The baseline fate of biomass (e.g., anaerobic decay in wet piles vs. aerobic decay in fields vs. open burning) is highly heterogeneous and dependent on site-specific practices. An historical/actual approach allows for accurate modelling of these specific conditions.

- c. **Conservativeness:** This approach allows for the application of a Downward Adjustment Factor (DAF) to explicitly align the project with Host Country Net Zero trajectories.

7.3 | Step 2: Determination of Unadjusted Baseline

7.3.1 | **Unadjusted Baseline Removals** (BR_{unadj}): For all Feedstock Modules (F1-F6), the Baseline Removal is set to Zero (0).

7.3.1.1 | Justification: In the baseline scenario (aerobic decay, anaerobic decay, or open combustion), uncharred biomass carbon returns to the atmosphere within a short, active biogenic carbon cycle (<10 years). No natural or commercial mechanism exists in the baseline to stabilize carbon for the durable timeframe (>200 years) required by this methodology. The foregone natural accumulation of short-term Soil Organic Carbon (SOC) resulting from the removal of baseline crop residues is strictly accounted for as a penalty under Ecological Leakage (Section 10), ensuring the baseline remains conservative without artificially inflating pyrogenic calculations.

$$BR_{unadj} = 0 \quad \text{Eq 1.}$$

Where

Parameter	Description	Value
BR_{unadj}	Unadjusted Baseline Removals in monitoring period y (tCO ₂ e)	0

7.4 | Step 3: Application of the Downward Adjustment & Uncertainty

7.4.1 | **Adjustment for Uncertainty (UNC):** Because the Unadjusted Baseline Removals (BR_{unadj}) are statically defined as exactly zero (0) based on biogeochemical principles, there is zero mathematical variance in the baseline. Therefore, baseline uncertainty is strictly zero. All MRV uncertainty tracking (e.g., Track 3 statistical error propagation) is applied exclusively to the Ex-Post Activity Removals (AR_y) and Activity Emissions (AE_y) in strict accordance with Section 13.

7.4.2 | **Application to Removals (Ambition DAF):** To ensure alignment with the Paris Agreement, the activity shall apply the Downward Adjustment Factor ($DAF_{NetZero}$) derived from the *GS4GG Tool: Downward Adjustment Factor Determination*. Since $BR_{unadj} = 0$, the DAF is applied as a deduction from the **NET Removals** ($NET_{CDR,y}$).

$$BR_{adj,y} = NET_{CDR,y} \times DAF_{NetZero,y} \quad \text{Eq 2}$$

Where

Parameter	Description	Value
$BR_{adj,y}$	Adjusted Baseline Removals (Ambition Deduction) in period y .(tCO ₂ e)	Calculated

$NET_{CDR,y}$	Net Verified Removals (CDR) in monitoring period y (tCO _{2e})	Section 11
$DAF_{NetZero,y}$	For application Period (e.g., 2026-2030), use the Global Ambition Floor (0.0125 i.e., 1.25%). (decimal)	GS Tool MT400-05

Note: This effectively establishes a "Crediting Baseline" > 0 that rises over time, reducing the net credits issued.

7.5 | Step 4: Identification and Calculation of the Conservative BAU Scenario

- 7.5.1 | The activity developer shall identify the most plausible **Business-as-Usual (BAU)** scenario, taking into account current laws, regulations, and enforcement levels.
- 7.5.2 | **Regulatory Surplus Screen** The developer shall verify the specific production and durable application of biochar is legally mandated by the Host Country or local jurisdiction.
- 7.5.2.1 | **Regulated & Enforced:** If a law explicitly mandates the conversion of the specific feedstock into biochar and its application to soils/materials, and is enforced (>50% compliance), the Conservative BAU Emissions for that source shall be set to Zero ($BR_{BAU,y} = 0$).
- 7.5.2.2 | **Geographic Specificity:** If state or provincial laws differ significantly from national laws, the regulatory compliance check shall be conducted at the state or provincial level from which the biomass is procured.
- 7.5.2.3 | **Systematically Unenforced:** If a ban exists but non-compliance is Common Practice (>50%), the developer may proceed. The Activity Developer shall provide independent evidence (e.g., peer-reviewed studies, government audit reports) not older than 3 years from the date of validation to prove systematic non-compliance..

$$BR_{BAU,y} = Mandated_Volume_y \times Compliance\ factor \quad \text{Eq 3}$$

Where

Parameter	Description	Value
$BR_{BAU,y}$	Conservative BAU Removals mandated by law in year y . (tCO _{2e})	Calculated
$Mandated_volume_y$	The physical volume of biochar removals legally required by the host jurisdiction.	Legal text
$Compliance\ factor$	Factor accounting for legal enforcement. (Decimal)	1.0 (Enforced Ban) 0.5 (Unenforced Ban – verified 3-year evidence) 0.0 (No Ban)

7.6 | Step 5: Selection of the Crediting Baseline

- 7.6.1 | **Crediting Baseline for Removals** ($BR_{crediting}$): Because the natural baseline formation of highly stable pyrogenic carbon is zero, and the activity shall pass the Regulatory BAU screen to be eligible, the final Crediting Baseline Removals shall be the higher (most conservative) of the Unadjusted Baseline and the BAU scenario.

$$BR_{crediting,y} = MAX(BR_{unadj}, BR_{BAU,y}) \quad \text{Eq 4}$$

Where

Parameter	Description	Value
$BR_{crediting,y}$	Final Crediting Baseline Removals (Deduction) in year y . (tCO ₂ e)	Calculated
BR_{unadj}	Unadjusted baseline removals (0).	Calculated
$BR_{BAU,y}$	Legally mandated removals calculated in Eq 3.	Calculated

8 | ACTIVITY REMOVALS

8.1 | Identification of the Activity Removals

- 8.1.1 | The activity scenario involves the thermochemical stabilization of biogenic carbon (biochar production) and its subsequent application in a sink that ensures durable storage (biochar application).
- 8.1.2 | Activity Removals (AR_y) quantify the net mass of biogenic carbon dioxide equivalent (tCO₂e) that is durably sequestered as a result of the activity during the monitoring period y .
- 8.1.3 | **Ineligible Volumes:** Biochar that lacks comprehensive digital Chain of Custody evidence, is utilized for energy (fuel), is lost during transport, is applied to ineligible sinks, or is exported and applied outside the Host Country jurisdiction, shall have an activity removal value of Zero (0).

8.2 | Calculation of Activity Removals

- 8.2.1 | The Activity Removals in monitoring period y are calculated as the total mass of stable organic carbon sequestered, adjusted for moisture, stability, application losses, and uncertainty.

$$AR_y = \sum_i \left[Q_{biochar,i,y} \times (1 - MC_{i,y}) \times C_{org,i,y} \times F_{perm,i,y} \times (1 - L_{app,i}) \times \frac{44}{12} \right] \times (1 - UNC_{AR})$$

Eq 5

Where

Parameter	Description	Value
AR_y	Total activity removals during period y (tCO ₂ e)	Calculated

i	Batch or Continuous production lot of biochar (differentiated by feedstock/technology).	-
$Q_{biochar,i,y}$	Mass of biochar type i distributed/applied during period y (tonnes, wet basis t_{wet}).	Eq 5
$MC_{i,y}$	Moisture Content of biochar type i (fraction, decimal).	Section 8.3
$C_{org,i,y}$	Organic Carbon Content of biochar type i (fraction, decimal, dry basis).	Section 8.4
$F_{perm,i,y}$	Permanence Factor: Fraction of organic carbon ($C_{org,i,y}$) remaining sequestered after the defined durability timeframe.	Section 8.5
$L_{app,i}$	Application Loss Factor (Material lost during transport/application).	Section 8.6
$\frac{44}{12}$	Stoichiometric conversion factor from Carbon (C) to CO ₂ (3.664).	Constant
UNC_{AR}	Aggregate Uncertainty Deduction (Track-dependent). (decimal)	Section 8.7

8.3 | Determination of Biochar Quantity ($Q_{biochar}$) and Moisture (MC)

8.3.1 | Tracking Units: To maintain strict chain-of-custody, production volumes shall be segregated into tracking units. A "Batch" is defined as a discrete volume of biochar produced from a homogenous feedstock in a single firing cycle (Track 1/2). A "Continuous Production Lot" is defined as the volume produced by a continuous facility (Track 3) over a maximum of 24 hours.

8.3.2 | The activity developer shall determine the quantity using the method assigned to the compliance track.

8.3.2.1 | Option A: Aggregated Weighing (Track 1)

- Method 1 (Weighing):** Mass is measured at the Aggregator Hub or any authorized, calibrated weigh-station within the defined project boundary using calibrated hanging scales or platform scales. This measured weight serves as the primary variable for quantifying Activity Removals.
- Method 2 (Calculation of Biomass Input):** Where highly heterogeneous, wet biomass is processed in unpowered, off-grid artisanal settings, direct weighing of the input biomass is "difficult to weigh". To simplify monitoring for smallholders, the mass of dry biomass input ($Q_{biomass,dry}$) — required solely for quantifying leakage — may be back-calculated from the weighed biochar output using the Conservative Default Yield Factor ($Y_{default}$) from Annex 5.

$$Q_{biomass,dry} = \frac{Q_{biochar,dry}}{Y_{default}} \quad \text{Eq 5}$$

Where

Parameter	Description	Value
$Q_{biochar,dry}$	Calculated mass of dry biochar output. (t_{dry})	Calculated
$Q_{biomass,dry}$	Mass of dry biomass input. (t_{dry})	Monitored
$Y_{default}$	Conservative Default Yield Factor (e.g., 0.15 for crop residue). (Fraction)	Annex 5

- c. **Mass Balance Safeguard:** Regardless of the method, if calculated yield (Q_{char}/Q_{bio}) > 0.30 (30%), the creditable quantity is capped at 30% of the input biomass.
- d. **Moisture (MC):** Determine via moisture meter or apply a conservative Default Deduction of 20% ($MC = 0.20$) if rapid testing is unavailable.

8.3.2.2 | Option B: Direct Weighing (Track 2)

- a. **Method:** Mandatory direct weighing of biochar output batches using facility scales.
- b. **Moisture (MC):** Determine via onsite moisture analyser (e.g., gravimetric oven or IR sensor) per batch. Default deductions are prohibited.

8.3.2.3 | Option C: Precision Weighing (Track 3)

- a. **Method:** Weight measured via calibrated weighbridge or industrial load cells integrated with SCADA.
- b. **Moisture (MC):** Determine via laboratory analysis (ISO 18134) or inline calibrated sensors.

8.4 | Determination of Organic Carbon Content (C_{org})

8.4.1 | The Organic Carbon Content (C_{org}) represents the sequestration potential. Total Carbon (C_{tot}) shall not be used as a proxy unless inorganic carbonates have been chemically removed via acid washing (Annex 4).

8.4.1.1 | **Option A: Composite Sampling (Track 1 & 2):** To reduce transaction costs while ensuring statistical validity

- a. **Method:** Physical sub-samples shall be collected from every batch. These are mixed to form a Composite Master Sample representing a maximum of 50 tonnes or 1 calendar month of production (whichever is sooner) for Track 1, and a maximum of 100 tonnes or 1 calendar month of production (whichever is sooner) for Track 2.
- b. **Analysis:** The Master Sample is analysed by an accredited lab.
- c. **Default (Track 1 Only):** If lab access is restricted in the host country, Track 1 activities may use tiered conservative default C_{org}

from Annex 5 (e.g., 0.65 for woody biochar, **0.40** for standard herbaceous residues, and **0.35** for high-ash herbaceous residues).

8.4.1.2 | **Option B: Batch Analysis (Track 3)**

8.4.1.3 | **Method:** Every production lot (>1 tonne) or continuous run (24h) is sampled and analysed individually by an ISO 17025 accredited laboratory or via continuously cross-calibrated proximate analysis (Annex 4).

8.5 | **Determination of Permanence Factor (F_{perm})**

8.5.1 | The Permanence Factor represents the fraction of Organic Carbon that remains sequestered in the soil or matrix after the defined durability timeframe.

8.5.2 | **Method 1: H:C Ratio Decay Model (Standard/200-Year Durability)**

8.5.2.1 | **Applicability:** Applicable to all Tracks activities claiming standard 200-year permanence.

8.5.2.2 | **Method:** The stability is calculated based on the molar Hydrogen to Organic Carbon ratio ($H:C_{org}$) and the Mean Annual Soil Temperature ($MAST$) of the application site, utilizing the Woolf et al. (2021) model.

8.5.2.3 | **Lookup Requirement:** The Activity Developer shall select the F_{perm} value from the detailed tables in Annex 6. Track 1 developers without site-specific soil temperature data shall assume a conservative temperature of 25°C.

$$F_{perm} = \text{Lookup}(H:C_{org}, MAST) \quad \text{Eq 6}$$

Where

Parameter	Description	Value
F_{perm}	Permanence Factor (200-year stability). Fraction	Annex 5
$H:C_{org}$	Molar Hydrogen to Organic Carbon ratio. Ratio	Lab Analysis
$MAST$	Mean Annual Soil Temperature (0–30 cm depth). °C	Global Data / Site

8.5.3 | **Method 2: Inertinite Petrography (High Durability/1000 Year)**

8.5.3.1 | **Applicability:** Mandatory for Track 2 & 3. Activities aiming to claim geological scale high durability (**1,000+ years**).

8.5.3.2 | **Method:** The Activity Developer shall utilize the Inertinite Reflectance method (Sanei et al., 2024). The laboratory shall conduct optical microscopy to determine the fraction of the carbon matrix that has transitioned to highly recalcitrant inertinite, which is proven insensitive to soil temperature variations.

$$F_{perm,i} = \%Intertinite_{org} \quad \text{Eq 7}$$

Where

Parameter	Description	Value
$F_{perm,i}$	Permanence Factor for High Durability. Fraction	Calculated
% <i>Intertinite</i> _{org}	Fraction of Organic Carbon with Random Reflectance (R_o) $\geq$ 2% . (Fraction)	Lab Analysis (Annex 4)

8.5.4 | Method 3: Anoxic Storage (Module A3):

8.5.4.1 | **Applicability:** Applicable to Track 2 & 3 activities utilizing Module A3. For biochar stored in verified anoxic environments (Module A3), the oxidative decay pathway is inhibited.

8.5.4.2 | **Method:** Because the biochar is stored in a verified anoxic environment, the oxidative decay pathway is physically inhibited. However, due to the impossibility of enforcing active physical monitoring over centuries, an ex-ante risk deduction is permanently applied to account for the theoretical risk of long-term cap failure.

8.5.4.3 | **Permanence Factor:** $F_{perm} = [0.95]$ (95% Permanence).

8.5.4.4 | The Activity Developer shall demonstrate via engineering reports that the biochar is stored in a sealed environment with a hydraulic conductivity $K \leq 10^{-7}$ cm/s (or equivalent clay cap) that effectively halts oxidation.

8.5.4.5 | **Breach condition:** If the vault cap integrity is breached during the durability monitoring period and not repaired within 30 days, the Permanence Factor shall revert to the default Soil Decay Model (Method 1) based on the local temperature (MAST), and the difference shall be treated as a Avoidable Reversal.

8.6 | Application Loss Factor (L_{app})

8.6.1.1 | A deduction is applied to account for biochar mass lost (fugitive dust, wind, spillage) during transport and application. These represent untracked upfront removals excluded for conservativeness, not reversals.

Table 9. Application Loss Factors:

End-Use Module	Application context	L_{app} Value	Justification
A1: Soil	Mechanized Surface Incorporation	0.05 (5%)	Standard loss during broad spreading and mechanized tilling
A1: Soil	Precision/Track 1	0.02 (2%)	Precision manual placement (e.g., planting pits, root-zone injection). shall be photographically verified.
A2: Engineered Materials	Industrial Encapsulation	0.01 (1%)	Conservative discount for spillage/dust during transit and

			mixing at the batch plant prior to encapsulation.
A3: Anoxic Storage	Earth Vaults)	0.01 (1%)	Minimal loss during bulk tipping/compaction; closed dedicated system.

8.7 | Uncertainty Deduction (UNC_{AR}):

8.7.1 | The total Activity Removals shall be adjusted for uncertainty based on the precision of the MRV system.

Table 10. Uncertainty Factors (UNC_{AR})

Compliance Track	UNC_{AR}	Conditions
Track 1 (Distributed)	0.00 (0%)	Deemed Zero. The Default Yields, Carbon Content, and Moisture Deductions in Annex 5 are statistically calibrated to the 10 th percentile (Lower Bound), natively fulfilling the confidence interval..
Track 2 (Mechanized)	0.05 (5%)	Fixed deduction to account for variance in Composite Sampling limits and basic platform scale precision.
Track 3 (Industrial)	Calculated	Based on error propagation Based on error propagation of Mass Measurement (Scale Precision Error) and Lab Sampling variance at a 90% Confidence Interval. • If Total Error $\leq 1\%$, $UNC_{AR} = 0$. • If Total Error $> 1\%$, deduct the excess percentage.

9 | ACTIVITY EMISSIONS

9.1 | Identification of Activity Scenario

9.1.1 | Activity Emissions (AE_y) represent the total GHG emissions associated with the implementation of the project activity during the monitoring period y . The Activity Developer shall quantify emissions from the following sources identified in the Activity Boundary:

- Biomass Supply** (AE_{supply}): Cultivation (Module F5 only) and pre-processing.
- Biochar Production** (AE_{prod}): Energy use and Methane Slip (CH_4) from pyrolysis.
- Transportation** (AE_{trans}): Logistics for feedstock and biochar, and laboratory samples.
- Application** (AE_{app}): Machinery used for soil or material application.

- e. Embodied Emissions ($AE_{embodied}$): Manufacturing of production and potential SOC loss from soil disturbance.

9.1.2 | **Significance and Materiality:** Individual emission sources representing < 2% of the total estimated activity emissions (e.g., off-site cloud computing for general data hosting) may be omitted, provided the sum of all omitted sources does not exceed 5% of the total (AE_y).

9.1.2.1 | **Exception:** Methane (CH_4) emissions from the pyrolysis reactor and N_2O from fertilizer use (Module F5) are deemed Significant and shall never be omitted.

9.1.2.2 | **Digital MRV Materiality:** Electricity consumption from onsite SCADA systems, CEMS equipment, and local facility server infrastructure shall be metered and included.

9.2 | Calculation of Total Activity Emissions

9.2.1 | The total Activity Emissions in monitoring period y (AE_y) shall be calculated as the sum of all component sources, adjusted for uncertainty:

$$AE_y = (AE_{supply,y} + AE_{prod,y} + AE_{trans,y} + AE_{app,y}) \times (1 + UNC_{AE}) \quad \text{Eq 8}$$

Where

Parameter	Description	Section
AE_y	Total Activity Emissions in period y . (tCO ₂ e)	Calculated
$AE_{supply,y}$	Emissions from biomass supply and pre-processing. (tCO ₂ e)	Sec 9.3
$AE_{prod,y}$	Emissions from biochar production operations. (tCO ₂ e)	Sec 9.4
$AE_{trans,y}$	Emissions from transportation. (tCO ₂ e)	Sec 9.5
$AE_{app,y}$	Emissions from biochar application. (tCO ₂ e)	Sec 9.6
UNC_{AE}	Aggregate Uncertainty Factor for Activity Emissions. (decimal)	Sec 9.7

9.3 | Emissions from Biomass Supply ($AE_{supply,y}$)

9.3.1 | Emissions from biomass supply include the energy used for pre-processing (chipping, drying) and, for Purpose-Grown biomass, the emissions from cultivation.

$$AE_{supply,y} = AE_{pre-proc,y} + AE_{cultivation,y} \quad \text{Eq 9}$$

Where

Parameter	Description	Value
$AE_{pre-proc,y}$	Total pre-processing Emissions in period y . (tCO ₂ e)	Calculated

$AE_{cultivation,y}$	Total emissions associated with cultivation in period y . (tCO ₂ e)	Calculated
----------------------	--	------------

9.3.2 | **Pre-Processing** ($AE_{pre-proc,y}$): Applies to All Feedstock Modules (F1–F6).

Includes emissions from electricity (grid/off-grid) and fossil fuels (e.g., diesel chippers) used to prepare biomass.

$$AE_{pre-proc,y} = \sum_j (FC_{proc,j,y} \times NCV_j \times EF_{fuel,j}) + (EC_{pre-proc,y} \times EF_{grid,y}) \quad \text{Eq 10}$$

Where

Parameter	Description	Value
$FC_{proc,j,y}$	Quantity of fuel type j consumed for pre-processing in period y . (Mass/Volume)	Metered/Invoices
NCV_j	Net Calorific Value of fuel type j (TJ/unit)	National or IPCC default
$EF_{fuel,j}$	Emission factor for fuel type j (tCO ₂ e/TJ)	GS Tool 01
$EC_{proc,y}$	Quantity of electricity consumed for processing. (MWh)	Metered
$EF_{grid,y}$	Grid Emission Factor for the Host Country. tCO ₂ e/MWh	Official Data

9.3.2.1 | **Track 1 Exemption:** Manual processing (e.g., sun drying, hand chopping) is deemed Zero. Small-scale electric shredders used in Aggregated Hubs shall be accounted for.

9.3.3 | **Cultivation** ($AE_{cultivation,y}$):

9.3.3.1 | Modules F1, F2, F3, F4, F6 (Waste/Residues): $AE_{cultivation,y} = 0$. These are residues or waste streams; upstream production emissions are allocated to the primary product (e.g., grain) or waste generator.

9.3.3.2 | Module F5 (Purpose-Grown): Mandatory Inclusion. The activity developer shall calculate the full lifecycle emissions of cultivation (N₂O from fertilizer, CO₂ from farm machinery) using PACM or *CDM Tool 16: Project and leakage emissions from biomass*. To prevent double-counting, if the biomass is sourced from an actively credited GS4GG AFOLU project, the upstream emissions already accounted for in that project boundary are excluded here.

9.4 | **Emissions from Biochar Production** ($AE_{process}$)

9.4.1 | This component captures auxiliary energy use and the critical source of **Methane Slip** (uncombusted pyrolysis gases).

$$AE_{prod,y} = AE_{energy,y} + AE_{CH_4,y} \quad \text{Eq 11}$$

Where

Parameter	Description	Value
-----------	-------------	-------

$AE_{process,y}$	Activity emissions from production of biochar in period y (tCO _{2e})	calculated
$AE_{energy,y}$	Activity emissions due to auxiliary energy use during biochar production (tCO _{2e})	calculated
$AE_{CH_4,y}$	Activity emissions due to methane emissions from incomplete combustion (tCO _{2e})	calculated

9.4.2 | **Auxiliary Energy ($AE_{energy,y}$):** Includes emissions from startup fuels (LPG/Diesel) and metered electricity for fans, automation, SCADA systems, and CEMS hardware. (Note: Sustained fossil fuel use for pyrolysis is prohibited). (Note: Variables mirror Equation 10 but are specifically tracked for the pyrolysis production phase).

$$AE_{energy,y} = \sum_j (FC_{prod,j,y} \times NCV_j \times EF_{fuel,j}) + (EC_{prod,y} \times EF_{grid,y}) \quad \text{Eq 12}$$

9.4.2.1 | **Track 1:** May be deemed Zero if no electricity is used and startup fuel is negligible (<1% of energy output).

9.4.3 | **Methane Slip ($AE_{CH_4,y}$):** The activity developer shall calculate methane emissions based on the specific Compliance Track and technology performance.

9.4.3.1 | **Option A: Track 1 (Conservative Default):** Track 1 activities shall apply the conservative Upper-Bound Methane Emission Factor ($EF_{CH_4,tech}$) corresponding to the specific kiln technology listed in Annex 5.

$$AE_{CH_4,y} = Q_{biochar,y} \times EF_{CH_4,tech} \times GWP_{CH_4} \quad \text{Eq 13}$$

Where

Parameter	Description	Source
$Q_{biochar,y}$	Quantity of biochar produced (dry basis).(t)	Monitored
$EF_{CH_4,tech}$	Technology-specific Methane Emission Factor. t_{CH_4}/t_{char}	Annex 5
GWP_{CH_4}	Latest applicable Global Warming Potential of Methane.	Gs4GG

9.4.3.2 | **Option B: Track 2 (Thermal Proxy Monitoring):** Track 2 activities utilizing mechanized retorts with a Secondary Combustion Chamber (SCC) or Thermal Oxidizer calculate emissions based on the continuity of the destruction temperature.

- Compliant State:** If $T_{SCC} \geq 850^{\circ}\text{C}$ AND Residence Time $\geq 2\text{s}$, methane slip is deemed effectively zero.
- Excursion State:** If $T_{SCC} < 850^{\circ}\text{C}$, the thermal proxy fails. The absolute worst-case Penalty Factor ($EF_{CH_4,penalty}$) from Annex 5 (e.g., 0.15 tCH₄/tchar) shall be applied to all biochar produced during the

excursion window. This penalty supersedes the standard 5% Track 2 uncertainty buffer.

$$AE_{CH_4,y} = Q_{non-compliant,y} \times EF_{CH_4,penalty} \times GWP_{CH_4} \quad \text{Eq 14}$$

Where

Parameter	Description	Source
$Q_{non-compliant,y}$	Quantity of biochar produced during periods where $T_{SCC} < 850^{\circ}\text{C}$ (t)	Datalogger
$EF_{CH_4,penalty}$	Conservative Penalty Factor for retorts without oxidation (Default: 0.15). $t\text{CH}_4/t\text{char}$	Methodology Default
GWP_{CH_4}	Latest applicable Global Warming Potential of Methane.	GS4GG

9.4.3.3 | **Option C: Track 3 (Direct Measurement):** Track 3 activities shall use Continuous Emissions Monitoring Systems (CEMS) to measure actual CH_4 concentration in the flue gas.

$$AE_{CH_4,y} = \sum_t (Conc_{CH_4,t} \times Vol_{gas,t} \times 10^{-9}) \times GWP_{CH_4} \quad \text{Eq 15}$$

Where

Parameter	Description	Source
$Conc_{CH_4,t}$	Concentration of CH_4 at time t . (mg/m^3)	Datalogger
$Vol_{gas,t}$	Stack gas volume at time t . m^3	Flow Meter
10^{-9}	Conversion factor from milligrams (mg) to metric tonnes (t).	Constant
GWP_{CH_4}	Latest applicable Global Warming Potential of Methane..	GS4GG

9.5 | Transportation Emissions ($AE_{trans,y}$)

9.5.1 | Includes emissions from the transport of biomass (Source to Production) and biochar (Hub to Application), and the shipment of physical biochar samples to external laboratories for testing including the return trips.

$$AE_{trans,y} = \sum_k (Dist_k \times Mass_k \times EF_{trans,k}) \quad \text{Eq 16}$$

Where

Parameter	Description	Source
$Dist_k$	Distance per trip k (return included if empty).km	Monitored
$Mass_k$	Weight of payload per trip k . (t)	Monitored
$EF_{trans,k}$	Emission factor for vehicle type k . ($t\text{CO}_2\text{e}/t_{\text{km}}$)	GS Tool 02

9.5.2 | Track 1 Exemption (Simplification): If the activity utilizes an Aggregated Hub structure and the total transport radius (Collection + Distribution) is < 200 km, transport emissions may be deemed negligible and set to Zero, in alignment with conservative bounds established in CDM Tool 12.

9.6 | Application Emissions ($AE_{app,y}$)

9.6.1 | Includes emissions from machinery used to apply biochar (e.g., tractors, spreaders, concrete mixers, excavators for earth vaults) and potential soil carbon losses..

$$AE_{app,y} = \sum_j (FC_{app,j,y} \times NCV_j \times EF_{fuel,j}) + AE_{SOC-loss,y} \quad \text{Eq 17}$$

9.6.1.1 | Machinery Emissions:

- a. Manual Application: If biochar is applied manually by hand (Track 1), $EF_{application} = 0$.
- b. Mechanical Application: The Activity Developer shall calculate actual diesel consumption using operational logs ($FC_{app,j,y}$) or utilize verified, conservative regional average factors specific to the exact machinery used (e.g., standard agricultural tractors vs. heavy earthmoving equipment).

9.6.2 | Soil Disturbance Penalty: To maintain strict CDR boundaries, any counterfactual avoided soil N₂O emissions post-application shall not be credited. However, if the incorporation of biochar (Module A1) requires deep mechanical tilling on verifiable no-till agriculture or perennial grasslands, the resulting pulse of mineralized Soil Organic Carbon (SOC) shall be quantified as an application emission penalty in accordance with the GS Biomass Sustainability tool.

9.7 | Uncertainty Accounting for Activity Emissions (UNC_{AE})

9.7.1 | Activity emissions shall be adjusted for uncertainty depending on the MRV approach used.

9.7.1.1 | Track 1 (Defaults): $UNC_{AE} = 0$. The Methane Emission Factors in Annex 5 are calibrated to the 90th Percentile (Upper Bound) of literature values, ensuring inherent conservativeness.

9.7.1.2 | Track 2 (Proxy/Simplified): $UNC_{AE} = 0.05$ (5%). This acts as a fixed, conservative buffer explicitly covering standard thermocouple instrument drift (e.g., $\pm 2.2^{\circ}\text{C}$) and the theoretical correlation variance of the thermal proxy. (*Note: During proxy thermal excursions, the 0.15 penalty factor natively supersedes this buffer*).

9.7.1.3 | Track 3 (Precision): $UNC_{AE} = \text{Calculated}$. Uncertainty is determined by the instrument precision ($\pm$ error) of the CEMS and metering equipment at a 95% Confidence Interval. Utility-invoiced energy consumption is deemed to have zero measurement uncertainty.

10| LEAKAGE EMISSIONS

10.1 | Identification of Leakage Sources

10.1.1 | Leakage is defined as the net change of anthropogenic GHG emissions occurring outside the activity boundary that is attributable to the activity. The Activity Developer shall apply the stepwise approach defined in GS4GG PAA MS400-05 to Identify, Minimize, and Quantify leakage emissions.

10.1.2 | If the calculated leakage is negative (i.e., emission reductions occur outside the boundary), it shall be set to Zero (0) for conservativeness.

10.1.3 | The Activity Developer shall identify potential leakage sources based on the selected Compliance Track and Feedstock Module using the table below.

Table 11. Sources of Leakage Emissions

Source	Description	Module Relevance	Inclusion Requirement
Embodied Emissions	Cradle-to-gate emissions associated with the manufacturing and transport of biochar production equipment (e.g., steel kilns, industrial plants) and facility construction.	All Tracks	Mandatory. • Track 1: Standardized Default. • Track 3: LCA Deduction, deducted 100% upfront in Year 1 or may be amortized over 1 st crediting period.
Market Leakage	Biomass Diversion: Non-participants who previously used biomass (e.g., for fodder, fuel) switch to fossil fuels or non-sustainable resources due to supply diversion.	F1, F2	Mandatory. Mitigated via "Surplus Test." If fails, emissions shall be quantified.
Ecological Leakage	Nutrient & SOC Displacement: Removal of crop residues (F1) depletes soil nutrients (N-P-K) and halts natural Soil Organic Carbon (SOC) accumulation.	F1	Mandatory. • Track 1 & 2: Conservative Default Factors. • Track 3: Calculated based on N-content.
Activity Shift	Land Use Change: Displacement of agricultural production to other lands due to the cultivation of purpose-grown biomass.	F5	Mandatory. Restricted to Track 3. Requires remote sensing proof of abandonment.

10.2 | Avoidance and Minimisation Strategies

10.2.1 | Minimizing Market & Ecological Leakage:

10.2.1.1 | The logic governing the "Surplus Test" (to prevent market diversion to fossil fuels) and sustainable extraction rates (to prevent ecological depletion) shall be formally stripped from standalone project design and governed strictly by the GS4GG PACM Biomass Sustainability Requirements.

10.2.2 | Minimizing Activity Shifting (LE_{shift})

10.2.2.1 | For Module F5, the activity shall demonstrate that the land utilized for biomass cultivation is Degraded or Marginal. Leakage is deemed Zero only if the Activity Developer rigorously demonstrates **both** of the following conditions:

- Remote sensing data (e.g., NDVI Land Use Change analysis) or Participatory Rural Appraisals verifying that the land has not supported productive agriculture or grazing for at least 10 years prior to the project starts.
- Documentary evidence demonstrating the verifiable absence of parallel, pre-existing government restoration or subsidy programs that would have regenerated the target land.

10.3 | Calculation of Total Leakage Emissions

10.3.1 | Leakage sources that cannot be avoided shall be quantified and deducted from the Net GHG Removals.

10.3.2 | Total leakage emission (LE_y) is calculated as follows

$$LE_y = (LE_{Embodied,y} + LE_{Market,y} + LE_{eco,y} + LE_{shift,y}) \times (1 + UNC_{LE}) \quad \text{Eq 18}$$

Where

Parameter	Description	Section
LE_y	Total Leakage Emissions in period y.	
$LE_{Embodied,y}$	Embodied emissions in year y	10.5
$LE_{Market,y}$	Emissions from Market Leakage (Biomass Diversion). (tCO ₂ e)	
$LE_{eco,y}$	Emissions from Ecological Leakage (Nutrient Displacement). (tCO ₂ e)	
$LE_{shift,y}$	Emissions from Activity Shifting (Land Use). (tCO ₂ e)	
UNC_{LE}	Aggregate Uncertainty Factor for Leakage. (tCO ₂ e)	

10.4 | Embodied Emissions ($LE_{Embodied,y}$)

10.4.1 | The activity shall account for the upstream emissions associated with manufacturing and construction of the production facility infrastructure.

10.4.2 | **Option A: Standardized Deduction (Track 1, 2)** A fixed deduction per tonne of biochar is applied to account for the steel/materials of the kiln. This factor covers the steel/materials of the reactor amortized over a conservative 1st crediting period or in 1st year of CP.

$$LE_{Embodied,y} = Q_{biochar,y} \times EF_{embodied,default} \quad \text{Eq 19}$$

Where

Parameter	Description	Value
$EF_{embodied,default}$	Conservative default for embodied emissions. (tCO ₂ e/t _{char})	0.01 (Track 1) 0.05 (Track 2)

10.4.3 | **Option B: Life Cycle Assessment (Track 3)** facilities shall conduct a Life Cycle Assessment (LCA) of the facility (Cradle-to-Gate). Total emissions are amortized over the first Crediting Period (5 Years) or in 1st year of CP.

$$LE_{Embodied,y} = \left(\frac{\text{Total LCA emissions}}{5} \right) \quad \text{Eq 20}$$

10.5 | Market Leakage ($LE_{Market,y}$):

10.5.1.1 | Quantification of Diverted Use Track:

- Option A (Track 1 & 2): If the biomass fails the Surplus Test (i.e., it is diverted from fuel, fodder, or bedding), the activity shall quantify the emissions of the replacement resource.

$$LE_{Market,y} = \sum_i (Q_{diverted,y} \times EF_{replace,i}) \quad \text{Eq 21}$$

Where

Parameter	Description	Source
$Q_{diverted,y}$	Quantity of biomass type i diverted from valuable use (dry basis). (t _{dry})	Monitored
$EF_{replace,i}$	Default Emission Factor for the replaced resource. (tCO ₂ e/t _{dry})	Table 13

Table 12. Default Replacement Factors ($EF_{replace,i}$)

Prior Use of Biomass	Assumed Replacement	Factor (tCO ₂ e/t _{dry})
Thermal Energy	Fossil Coal or Non-Renewable Wood	0.45
Animal Fodder	Commercial Grain/Soy Feed	0.15
Bedding/Mulch	Synthetic Fertilizers	0.05

10.5.1.2 | **Option B: Specific Analysis (Track 3)** Track 3 activities may calculate a site-specific replacement factor based on the actual alternative fuel/feed

used by the displaced consumers (e.g., LPG substitution), using standard calorific and emission factors.

10.6 | Ecological Leakage ($LE_{eco,y}$)

10.6.1 | Applicable exclusively to Module F1 (Field Residues). Since Section 8 sets $BR_{undj} = 0$ for residues, this section accounts for the emissions associated with replacing the soil nutrients (N, P, K) exported from the farm in the biomass.

10.6.2 | **Foregone SOC & Nutrient Penalty:** The Activity Developer shall calculate an Ecological Leakage deduction encompassing both the emissions required to synthetically replace exported soil nutrients (N, P, K) AND the mathematical penalty for halting the natural accumulation of foregone Soil Organic Carbon (SOC). The exact quantification mechanisms and regional default penalty factors shall be natively adopted from the GS PACM Biomass Sustainability Requirements.

10.7 | Activity Shift Leakage ($LE_{shift,y}$)

10.7.1 | Applicable **exclusively to Module F5 (Purpose-Grown)** under **Track 3**.

10.7.2 | **Avoidance (Degraded Land):** Leakage is deemed Zero ($LE_{shift,y} = 0$) if the Activity Developer demonstrates that the land used for cultivation was Degraded or Marginal (producing <10% of regional average yields) for at least 3 years prior to project start.

10.7.3 | **Quantification (iLUC):** If cultivation occurs on land that previously supported economic activity (grazing/crops), leakage is calculated as:

$$LE_{shift,y} = A_{displaced,y} \times EF_{iLUC} \quad \text{Eq 22}$$

Where

Parameter	Description	Value
$A_{displaced,y}$	Area of land where production was displaced. (ha)	Monitored
EF_{iLUC}	Indirect Land Use Change factor (Forest Conversion).(tCO ₂ e/ha)	CDM Tool 16

10.8 | Uncertainty Accounting (UNC_{LE})

10.8.1 | To ensure conservativeness in estimating external effects:

a. Track 1 (Defaults): $UNC_{LE} = 0$. (Default factors in Table 13 are set at conservative upper bounds).

b. Track 2 & 3:

a. If using **Option A (Defaults)**, $UNC_{LE} = 0$.

- b. If using **Option B (Specific Calculation)**, a 15% Uncertainty factor is applied ($UNC_{LE} = 0.15$) to account for external data variability.

11 | NET GHG EMISSION REMOVALS

11.1 | Net Quantification Approach

- 11.1.1 | To ensure environmental integrity and conservativeness, the Total Project Deductions (Activity Emissions and Leakage) shall be deducted fully against Activity Removals to ensure the Net Removal represents a true "Net-Negative" atmospheric withdrawal i.e. a net atmospheric withdrawal, having fully compensated for the project's own lifecycle footprint.

11.2 | Calculation of Total Deductions ($Deductions_y$)

- 11.2.1 | First, the Activity Developer shall aggregate all debit sources calculated in Sections 9 and 10.

$$Deductions_y = AE_y + LE_y \quad \text{Eq 23}$$

Where

Parameter	Description	Section
$Deductions_y$	Total GHG debits to be subtracted in monitoring period y . (tCO ₂ e)	Calculated
AE_y	Total Activity Emissions (Supply, Process, Transport, Application). (tCO ₂ e)	9.2
LE_y	Total Leakage Emissions (Market, Eco, Shifting). (tCO ₂ e)	10.3

11.3 | Calculation of Net Verified Removals and Deficit Carryover

- 11.3.1 | Net Verified Removals represent the quantity of carbon durably sequestered, minus the Ambition Deduction (DAF) and Total Deductions.
- 11.3.2 | Emission Deficit Condition: If the Total Deductions exceed the Activity Removals (i.e., $Net_{CDR,y} < 0$), the project operated at an "Emission Deficit" for that period. Zero (0) credits shall be issued, and the exact negative mathematical balance ($Deficit_{y-1}$) shall be carried over and explicitly deducted from the $Net_{CDR,y}$ of the subsequent monitoring period.

$$Net_{CDR,y} = AR_y - BR_{crediting,y} - Deductions_y - Deficit_{y-1} \quad \text{Eq 24}$$

Where

Parameter	Description	Section
-----------	-------------	---------

$NET_{CDR,y}$	Net Verified Removals (CDR) in monitoring period y (Pre-Buffer and Pre-DAF). (tCO ₂ e)	Calculated
AR_y	Activity Removals: Total gross durable sequestration. (tCO ₂ e)	8.2
$BR_{crediting,y}$	Crediting Baseline Removals (Regulatory BAU mandate). (tCO ₂ e)	7.5
$Deductions_y$	Total Project Deductions (Emissions + Leakage). (tCO ₂ e)	Eq. 22
$Deficit_{y-1}$	Any negative removal balance carried over from the previous monitoring period. (tCO ₂ e)	Calculated

11.4 | Net Carbon Efficiency Ratio (NCER) Check

11.4.1 | Before proceeding to issuance, the Activity Developer shall verify compliance with the **Net Carbon Efficiency Ratio** defined in Section 3.2.2. This ensures that the logistical carbon footprint of the activity does not outweigh the sequestration benefit.

11.4.2 | Compliance Condition:

- If $NCER_y \geq 10$: The activity is Eligible for issuance.
- If $NCER_y \leq 10$: The activity is inefficient for the monitoring period y . Zero (0) GSVERs shall be issued, and the positive removal balance (if any) shall be banked until operational efficiency improves.

$$NCER_y = \frac{AR_y}{(AE_{pre-pro,y} + AE_{prod,y} + AE_{trans,y})} \quad \text{Eq 25}$$

Where

Parameter	Description	Section
$NCER_y$	Net Carbon Efficiency Ratio. (Ratio)	Calculated
AR_y	Total Activity Removals (Gross Sequestration). (tCO ₂ e)	8.2
$AE_{pre-proc,y}$	Emissions from biomass supply and pre-processing. (tCO ₂ e)	9.3
$AE_{prod,y}$	Emissions from biochar production (Energy + Methane Slip). (tCO ₂ e)	9.4
$AE_{trans,y}$	Emissions from transportation. (tCO ₂ e)	9.5

11.5 | Buffer Pool Contribution & Risk deduction

11.5.1 | To manage Reversal Risks associated with non-permanent carbon storage (e.g., anthropogenic soil disturbance, demolition), the methodology utilizes a Hybrid Risk approach dependent on the feasibility of long-term monitoring.

The developer shall apply one of the following mechanisms to the $NET_{CDR,y}$ volume.

- a. **Mechanism A: LUF Compliance Buffer (Track 2 & Track 3 - Module A1/A3).** Activities applying biochar to large-scale, monitorable sinks (e.g., contiguous agricultural land, anoxic earth vaults) shall contribute to the standard Gold Standard LUF Compliance Buffer. These credits are physically deposited in the pool and are utilized *only* to cover Unavoidable Reversals (Force Majeure).
- b. **Mechanism B: Fixed Non-Permanence Risk Deduction (Track 1 & Module A2).** Due to the physical impossibility of conducting 100-year monitoring on thousands of highly distributed smallholder farms or tracking generic concrete demolition across a century, these activities shall apply a Fixed Ex-Ante Risk Deduction. This volume is immediately cancelled (not deposited as an asset). It effectively adjusted for the statistical probability of long-term leakage and relies on the Aggregator's strict contractual liability to replace credits.

$$Risk_{penalty,y} = \text{MAX}(0, NET_{CDR,y}) \times Rate_{risk} \quad \text{Eq 26}$$

Where

Parameter	Description	Section
$Risk_{penalty,y}$	Quantity of credit transferred to the Buffer Pool (Mechanism A) OR permanently cancelled (Mechanism B). (tCO ₂ e)	Calculated
$NET_{CDR,y}$	Net Verified Removals. (tCO ₂ e)	Eq.XX
$Rate_{RISK}$	Reversal Risk Rating determined by the end-sue module (decimal)	Section 12.2

11.6 | Application of the Downward Adjustment Factor (DAF)

11.6.1 | To ensure transparent alignment with the Paris Agreement and Host Country ambition, the Downward Adjustment Factor ($DAF_{NetZero}$) is applied as:

$$DAF_{deduction,y} = NET_{CDR,y} \times DAF_{Netzero,y} \quad \text{Eq 27}$$

Where

Parameter	Description	Section
$DAF_{deduction,y}$	Quantity of credits deducted to align with Host Country Ambition. (tCO ₂ e)	Calculated
$DAF_{Netzero,y}$	Downward Adjustment Factor for the application Period (e.g., 0.0125 for 2026-2030).	GS Tool MT400-05

11.7 | Final Issuable GSVERs

- 11.7.1 | The total quantity of Gold Standard Verified Emission Removals (GSVERs) to be issued for monitoring period y is Net Removals (net of buffer and DAF deductions).

$$ER_{total,y} = NET_{CDR,y} - RISK_{penalty,y} - DAF_{Deduction,y} \quad \text{Eq 28}$$

12 | REVERSALS

12.1 | Definitions and Scope

- 12.1.1 | **Definition of Reversal:** A Reversal is defined as the unintentional or intentional release of sequestered biogenic carbon (CO_2) back into the atmosphere prior to the expiration of the committed Durability Timeframe (200 years or 1,000 years).
- 12.1.1.1 | **Excluded (Intrinsic Decline):** The gradual, biochemical oxidation of biochar in soil that naturally occurs within the bounds of the Permanence Factor (F_{perm}) calculated in Section 8 is considered "Expected Decay" and is not classified as a reversal. This intrinsic decline is fully accounted for ex-ante in the net quantification. Furthermore, the physical displacement of inert biochar via severe water runoff (e.g., flooding) represents an untracked system loss but does not equate to oxidative mineralization and is therefore excluded from chemical reversal quantification.
- 12.1.1.2 | **Included (Unexpected Loss):** Reversals refer to carbon losses in excess of the expected decay, caused by specific disturbance events (e.g., severe wildfire, combustion, excavation, demolition, cap failure).
- 12.1.2 | **Categories of Reversal:** The Activity Developer shall classify potential reversal events into two categories:
- 12.1.2.1 | **Avoidable Reversals (Developer Liability):** Reversals arising from human intent, negligence, or mismanagement within the control of the Activity Developer (e.g., excavating biochar to sell as cooking fuel, unauthorized demolition/incineration, systematic violation of application limits or failure to repair an engineered vault cap).
- 12.1.2.2 | **Unavoidable Reversals (Buffer Covered - Force Majeure):** Reversals arising from natural catastrophic events beyond human control (e.g., catastrophic high-severity wildfires that penetrate the deep root zone) or third-party acts (e.g., State expropriation of land).

12.2 | Reversal Risk Assessment Rates (Buffer Contribution)

- 12.2.1 | To manage reversal risks associated with non-permanent carbon storage, the methodology utilizes a Hybrid Risk approach dependent on the physical feasibility of long-term monitoring. The Activity Developer shall apply one of the following mechanisms to their Net Verified Removals ($NET_{CDR,y}$).

- A. **Mechanism A:** Standard Compliance Buffer (Track 2 & Track 3 - Module A1/A3). Activities applying biochar to large-scale, monitorable sinks (e.g., contiguous commercial agriculture, anoxic earth vaults) shall contribute to the standard Gold Standard LUF Compliance Buffer. These GSVERs are physically deposited into the central registry pool and are utilized exclusively to compensate for Unavoidable Reversals (Force Majeure).
- B. **Mechanism B:** Fixed Non-Permanence Risk Deduction (Track 1 & Module A2). Due to the physical impossibility of conducting 100-year monitoring on thousands of highly distributed smallholder farms, or tracking generic concrete demolition across a century, these activities shall apply a Fixed Ex-Ante Risk Deduction. This volume of credits is immediately and permanently cancelled prior to issuance (not deposited as a tradable asset). It effectively pre-pays for the statistical probability of long-term losses and relies on the Aggregator's strict contractual liability to replace any credits lost due to detected systemic fraud.

$$Risk_{penalty,y} = \max(0, NET_{CDR,y} \times Rate_{risk}) \quad \text{Eq 29}$$

Where

Parameter	Description	Section
$Risk_{penalty,y}$	Quantity of credit transferred to the Buffer Pool (Mechanism A) OR permanently cancelled (Mechanism B). (tCO ₂ e)	Calculated
$NET_{CDR,y}$	Net Verified Removals calculated in Section 11. (tCO ₂ e)	
$Rate_{risk}$	Reversal Risk Rating determined by the End-Use Module. (Decimal)	

12.2.2 | **Determination of Buffer Rate** the Activity Developer shall determine the Buffer Rate ($Rate_{Buffer}$) using one of two options:

12.2.2.1 | **Option A: Standard Default Factors (Simplified):** Activity Developers may apply the fixed default rates in Table 13 and Table 14. This is the Mandatory Approach for Track 1 activities to ensure administrative simplicity.

12.2.2.2 | **Option B: Site-Specific Risk Assessment (Precision):** Activity Developers under Track 2 and Track 3 may conduct a site-specific analysis using the GS4GG Reversal Risk Assessment Tool (Annex 7) to calculate a precise risk rating. This option allows the buffer to be lowered to the Minimum Floor.

Table 13. Mechanism A: Default Reversal Risk Ratings ($Rate_{Buffer}$)

Applicable exclusively to Track 2 and Track 3 activities capable of rigorous site monitoring.

End-use module	Application context	Default rate	Minimum floor*	Justification
A1: Soil	Track 2 & 3	20%	5%	Aligns with standard GS LUF defaults.
A3: Anoxic	Track 2 & 3 Geologic	2.0%	0.5%	Closed system; effectively permanent unless physically excavated.

Note: Developers may use the Reversal Risk Assessment Tool in Annex 6 to lower the default rate down to the Minimum Floor by proving site-specific geographical and legal safety)..

Table 14. Mechanism B: Mandatory Fixed Risk Deductions (*Rate_{deduction}*)

Applicable strictly to unmonitorable distributed or encapsulated systems. Volume is permanently cancelled ex-ante.

End-use module	Application context	Rate / Deduction	Justification
A1: Soil	Track 1 (Distributed)	10%	Standardized conservative cancellation covering potential unmonitorable fuel diversion by smallholders. Backed by Aggregator liability.
A2: Materials	Concrete/Asphalt	5%	Applied in lieu of impossible 100-year demolition "Asset Registry" tracking. Covers end-of-life unrecyclable demolition risks.

12.3 | Mitigation and Management Measures

12.3.1 | The Activity Developer shall implement mitigation safeguards appropriate to the compliance track.

12.3.2 | **Social Permanence (Track 1 Safeguard):** The primary avoidable reversal risk for distributed activities is the diversion or intentional excavation of biochar for use as cooking fuel (charcoal). Note - Any biochar diverted, stockpiled, or sold without explicit, geo-tagged photographic proof of physical incorporation into an eligible soil sink is immediately deemed an Avoidable Reversal and is ineligible for crediting.

12.3.3 | **Physical Security (Modules A2):** Contracts with off takers (e.g., concrete plants) shall stipulate that the physical biochar shall be encapsulated in non-

combustible mineral matrices and that the buyer waives all rights to the carbon attribute. Biochar shall not be integrated into combustible polymers or wood-plastic composites.

- 12.3.4 | **Legal Permanence (Module A3):** The Dedicated Earth Vault storage site shall be subject to a Legal Restrictive Covenant (or equivalent binding land-title notation) prohibiting future excavation or deep-rooting vegetation for a minimum of 100 years.

12.4 | Quantification of Reversals (REV_y)

- 12.4.1 | In the event of a confirmed reversal, the Activity Developer shall quantify the reversal tonnage using conservative damage factors. Note: Only the Credited Portion/Stable Fraction is counted as a reversal.

$$REV_y = \sum \left(Area_{event} \times Density_{char} \times C_{org} \times F_{perm} \times DF_{event} \times \frac{44}{12} \right) \quad \text{Eq 30}$$

Where

Parameter	Description	Section
REV_y	Quantity of reversed credits. (GS-CDR)	Calculated
$Area_{event}$	Land area or Volume of material affected by the event ha or m ³	Measured
$Density_{char}$	Concentration of biochar in the affected area/volume. (t/unit)	Monitoring Records
C_{org}	Organic Carbon Content of the affected biochar batch. (Fraction)	Section 8
F_{perm}	Permanence Factor previously credited for the batch. (Fraction)	Section 8
DF_{event}	Damage Factor: Fraction of carbon oxidized/lost during the event. (Fraction)	Table 14
$\frac{44}{12}$	Stoichiometric conversion to CO ₂ . (3.667)	Constant

- 12.4.2 | **Exemption:** Track 1 (Soil) and Module A2 (Materials) activities utilize the Fixed Risk Deduction (Mechanism B) effectively pre-pay for long-term statistical losses. Therefore, individual event reversal quantification using Equation 29 is Not Applicable to these end-uses unless systemic, intentional fraud at the Aggregator level is discovered by the VVB.

Table 15. Default Damage Factors (DF_{event})

Reversal Event	Context	Damage Factor (DF)	Justification
Wildfire	Surface Applied (<10cm)	0.50 (50%)	High exposure to atmospheric oxidation during severe canopy fire..

Wildfire	Incorporated (>10cm)	0.10 (10%)	Sub-soil effectively insulates pyrogenic carbon from peak heat.
Fuel Diversion	Unauthorized Combustion	1.00 (100%)	Near-total human-caused oxidation.
Cap Breach	Module A3 Vault (Unrepaired > 30 days)	Calculated $\frac{0.95 \times F_{perm,local}}{0.95}$	Biochar loses its 0.95 anoxic permanence rating and mathematically reverts to the standard F_{perm} model based on the local Mean Annual Soil Temperature (MAST).
Excavation	Module A3 (Removal from vault)	1.00 (100%)	Complete loss of anoxic protection and assumed combustion/degradation.

12.5 | Addressing Reversals (Compensation)

12.5.1 | **Unavoidable Reversals:** For verified Unavoidable Reversals impacting Track 2/3 monitorable sinks:

12.5.1.1 | **Notification:** The Activity Developer shall notify Gold Standard within 30 days

12.5.1.2 | **Retirement:** Gold Standard shall cancel an equivalent number of credits (REV_y) from the Global Compliance Buffer.

12.5.1.3 | **Baseline Update:** The Activity Developer is not financially liable but shall update the project baseline to reflect the reduced carbon stock.

12.5.2 | **Avoidable Reversals:** For verified Avoidable Reversals (e.g., fuel diversion, unauthorized excavation):

12.5.2.1 | **Compensation:** The Activity Developer is liable and shall purchase and retire valid GSVERs equivalent to REV_y from their own registry account within 90 days of detection. Avoidable reversals shall NEVER be compensated from the GS Buffer Pool.

12.5.2.2 | **Aggregator Liability (Track 1):** For Distributed activities, the Aggregator assumes strict liability for reversals occurring at individual farms. If the reversal is due to systemic negligence or fraud, the activity shall be suspended, and the Buffer Contribution for future issuances shall be doubled.

12.5.3 | **Aggregator Liability & Systemic Breach (Track 1):** For distributed activities, the Aggregator assumes strict contractual liability for reversals occurring at individual smallholder farms.

12.5.3.1 | **Systemic Breach Protocol:** If the annual Track 1 Sentinel Site monitoring (Section 16.3) detects verifiable Avoidable Reversals (e.g., fuel diversion)

on > 5.0% of the sampled sites, it constitutes a Systemic Breach of the "No-Burn" rule.

12.5.3.2 | The VVB shall trigger a full audit of the affected geographic stratum. The Activity Developer shall be liable to compensate the extrapolated REV_y across the entire stratum. Project crediting shall be suspended, and the Mechanism B Fixed Risk Deduction ($Risk_{rate}$) for all future issuances shall be permanently doubled (e.g., from 10% to 20%) until rigorous remedial training is proven.

13| UNCERTAINTY QUANTIFICATION

13.1 | Approach for Uncertainty Management

13.1.1 | The Activity Developer shall account for uncertainty in the quantification of GHG removals to ensure the environmental integrity of the issued GSVERs. This methodology employs a Tiered Uncertainty Approach determined by the selected Compliance Track to balance rigor with operational feasibility.

- 13.1.1.1 | **Track 1: Standardized Pre-deducted Uncertainty:** For Track 1 activities, explicit statistical error propagation is not required because uncertainty is accounted for ex-ante through the use of calibrated Conservative Lower-Bound Factors.
- a. Justification: The Standardized Default Factors in Annex 5 (e.g., Yield, Carbon Content) are statistically calibrated to the 10th/90th Percentile (Lower Bound) of global scientific literature. This effectively applies a built-in deduction fulfilling the confidence interval.
 - b. Requirement: The Uncertainty Deduction is set to Zero ($UNC = 0$) provided the activity strictly adheres to the default factors and eligibility constraints of Track 1.
- 13.1.1.2 | **Track 2: Standardized Deductions (Fixed):** For Track 2 activities, uncertainty is addressed through Fixed Deduction Factors applied to specific quantification components.
- a. Justification: These fixed percentages act as a standardized "Safety Buffer" to account for the variance inherent in simplified monitoring methods (e.g., Thermal Proxy, Composite Sampling) without requiring complex statistical analysis.
 - b. Requirement: The Activity Developer shall apply the fixed factors specified in Table 16.
- 13.1.1.3 | **Track 3: Statistical Precision (Calculated)** For Track 3 (Industrial) activities, the activity developer shall rigorously calculate the Aggregate Uncertainty of all measured parameters at a 90% Confidence Interval using the Error Propagation logic defined in Section 13.3. If the calculated aggregate uncertainty exceeds the allowable Precision Threshold (e.g., 10%

for Removals), the excess uncertainty shall be deducted from the credited volume.

13.2 | Summary of Uncertainty Requirements

13.2.1 | The Activity Developer shall apply the uncertainty factors (UNC_X) summarized below to the respective equations in Sections 8, 9, and 10.

Table 16. Uncertainty Deduction Matrix

Component	Parameter	Track 1 (Distributed)	Track 2 (Mechanized)	Track 3 (Industrial)	Application
Activity Emissions	UNC_{AE}	0.00	0.05 (5%)	Calculated (Threshold 5%)	Addition to AE_y (Eq 8)
Removals	UNC_{AR}	0.00	0.05 (5%)	Calculated (Threshold 1%)	Deduction from AR_y (Eq 4)
Leakage	UNC_{LE}	0.00	0.15 (15%)*	0.15 (15%)*	Addition to LE_y (Eq 18)

Note for Leakage: If Track 2/3 uses the Conservative Default Factors (Option A in Section 10), $UNC_{LE} = 0$. The 15% adjustment applies only if site-specific modeling (Option B) is used.

13.3 | Calculation of Aggregate Uncertainty (Track 3)

13.3.1 | **Applicability:** Mandatory for Track 3 activities. The Activity Developer shall identify all measured parameters (e.g., Mass, Moisture, Carbon Content) and quantify their uncertainty based on both instrument precision (Systematic Error) and sampling variance (Random Error). (*Note: Purely invoiced utility parameters, such as grid electricity bills or fuel receipts, are deemed to have zero measurement uncertainty*).

13.3.2 | **Sampling Uncertainty (Random Error):** Where a parameter is determined via sampling (e.g., C_{org} from batch samples), the uncertainty of the mean shall be calculated at the 90% Confidence Interval utilizing the Standard Error of the Mean.

$$U_{samp} = \left(\frac{t_{val} \times (SD / \sqrt{n})}{Mean} \right) \times 100 \quad \text{Eq 31}$$

Where

Parameter	Description	Source
U_{samp}	Percentage uncertainty of the sample mean. (%)	Calculated
t_{val}	Two-sided t-value for 90% confidence at $n - 1$ degrees of freedom.	Statistical Table

<i>SD</i>	Standard Deviation of the sample measurements.	Calculated
<i>n</i>	Number of samples collected during the period. (Integer)	Monitoring Record
<i>Mean</i>	Mean value of the samples.	Calculated

- 13.3.3 | **Combined Uncertainty(Product Rule):** Where the final component value is the product of independent parameters (e.g., Removals = Mass × Moisture × CarbonContent), the Combined Uncertainty ($U_{combined}$) is the square root of the sum of squares of the individual precision errors.

$$U_{Combined} = \sqrt{U_1^2 + U_2^2 + U_3^2 + U_n^2} \quad \text{Eq 32}$$

Where

Parameter	Description	Source
$U_{Combined}$	Combined relative percentage uncertainty of the product. (%)	Calculated
$U_{1..n}$	Percentage uncertainty of individual parameters (Measurement or Sampling). (%)	Eq 30/Specs

- 13.3.4 | **Combined Uncertainty (Addition Rule):** Where the final component value is the sum of independent parts (e.g., Total Emissions = Process + Transport), the Combined Uncertainty is weighted by the magnitude of each contributing part, adding the absolute uncertainties in quadrature.

$$U_{combined} = \frac{\sqrt{(U_1 \times V_1)^2 + (U_2 \times V_2)^2 + \dots}}{|V_1 + V_2 + \dots|} \quad \text{Eq 33}$$

Where

Parameter	Description	Source
$U_{Combined}$	Combined percentage uncertainty of the sum. (%)	Calculated
$U_{1..n}$	Percentage uncertainty of component n . (%)	Calculated
$V_{1..n}$	Absolute value (tonnes) of component n . (tCO ₂ e)	Calculated

- 13.3.5 | **Determination of Final Deduction Factors (Track 3)** Once the Aggregate Uncertainty (U_{calc}) is calculated for a component, the final Deduction Factor (UNC_x) is determined by comparing U_{calc} against the allowed Precision Threshold.

$$UNC_x = \max \left(0, \frac{U_{calc} - \text{Threshold}}{100} \right) \quad \text{Eq 34}$$

Where

Parameter	Description	Source
-----------	-------------	--------

UNC_x	Final Uncertainty Deduction Factor applied in quantification equations. (Decimal).	Calculated
U_{calc}	Calculated Aggregate Uncertainty for the component (%)	Calculated
Threshold	Allowable error margin per component: - Removals (AR): 1.0% (Strict Precision) - Activity Emissions (AE): 5.0%	Standard Limit
Example: If a Track 3 project calculates an aggregate uncertainty for Activity Removals of 2.8%, the deduction applied in Equation 5 is: $(2.8\% - 1.0\%) = 1.8\%$ or 0.018.		

13.4 | Systematic Error Check (Calibration):

- 13.4.1 | **Requirement:** To prevent systematic data drift, all mass measurement scales (Hub hanging scales, platform weighbridges), moisture meters, and Track 3 CEMS equipment shall be calibrated annually OR in strict accordance with the manufacturer's specifications, whichever is more frequent, against certified standard weights or reference gases. Utility-owned grid electricity meters governed by national standards are explicitly exempt from project-level calibration requirements. Track 1 low-cost spring scales may be calibrated monthly against a known "Standard Weight" at the Aggregator Hub.
- 13.4.2 | **Consequence:** If a calibration certificate is missing, expired or invalid during the verification audit, the specific Uncertainty Deduction linked to that instrument's data pool (e.g., UNC_{AR} for missing biochar scale calibrations, or UNC_{AE} for missing CEMS calibrations) is automatically overridden and raised to a punitive 0.20 (20%) for the undocumented monitoring period, superseding Equation 33 and the Track 1/Track 2 defaults.
- 13.4.3 | **Bias Correction:** If an instrument (e.g., a platform scale) is found to be over-reading (reading higher mass than actual) during the VVB audit or routine calibration check, the entire recorded volume for the affected parameter shall be uniformly discounted by the verified percentage error. This retrospective discount shall be applied strictly to all data logged since the exact date of the last successful calibration event.

14 | MEETING METHODOLOGICAL PRINCIPLES

14.1 | Encouraging ambition over time

- 14.1.1 | This methodology encourages increased ambition and aligns with the long-term temperature goals of the Paris Agreement through the following mechanisms, in accordance with *GS4GG PAA MS400-01 Requirement 5.2*:
- 14.1.1.1 | **Downward Adjustment of Baselines (DAF):** As detailed in Section 7, the activity calculates the Crediting Baseline by applying a Downward Adjustment Factor ($DAF_{Netzero,y}$) aligned with the Host Country's Net Zero

trajectory. This ensures that the volume of credited removals decreases over time relative to the unadjusted baseline, effectively "sharing" a portion of the atmospheric benefit with the Host Country to support its NDC.

14.1.1.2 | **Zero-Removal Baseline:** The methodology adopts a highly conservative "Zero-Removal" unadjusted baseline ($BR_{unadj} = 0$) for the pyrogenic CDR component. It assumes that in the absence of the activity, uncharred biomass carbon would decay or be combusted within a short timeframe (<10 years) and does not naturally form highly recalcitrant pyrogenic structures. To maintain environmental integrity regarding the foregone natural accumulation of short-term SOC resulting from the removal of these residues, a strict "Foregone SOC" penalty is quantified under Ecological Leakage (Section 10), ensuring the baseline remains mathematically conservative without artificially inflating pyrogenic calculations.

14.1.2 | **Prevention of Technology Lock-In:**

14.1.2.1 | **Fossil Restriction:** The methodology strictly prohibits the use of fossil fuels for sustaining the pyrolysis reaction (Section 2.5), inherently preventing the lock-in of fossil-dependent infrastructure.

14.1.2.2 | **Technology Progression:** For Track 1, the methodology incentivizes the transition from manual artisanal kilns to semi-industrial mechanized units over time by offering higher precision factors (and avoiding punitive ex-ante statistical risk deductions) for Track 2/3 technologies and establishing a framework for formal structural upgrades at crediting renewal. A formal evaluation of mandatory graduation requirements will occur during the **2028** methodology revision.

14.2 | Equitable sharing of mitigation benefits

14.2.1 | The methodology is explicitly designed to ensure that carbon finance revenues are shared equitably among participants, particularly those at the base of the supply chain.

14.2.2 | **Benefit Sharing Plan Mechanism:** For ANY activity utilizing an aggregation model across ANY Compliance Track (Track 1, Track 2, or Track 3) where biomass is sourced from distributed third-party smallholder farmers, the Activity Developer (or Aggregator) shall establish and document a transparent Benefit Sharing Plan.

14.2.2.1 | **Requirement:** The plan shall specify how carbon value is returned to the frontline biomass suppliers (e.g., via direct cash payments, heavily subsidized/free return of the biochar product for soil improvement, or funded community infrastructure).

14.2.2.2 | **Verification:** The implementation of this plan shall be audited during verification to ensure that smallholders are not excluded from the financial benefits of the assets they generated.

14.2.3 | **Social Permanence (SDG 2):** By safeguarding agricultural soil health (via heavy metal testing and PAH testing thresholds) and requiring the

demonstration of agronomic value, the methodology ensures that the physical asset (biochar) provides ongoing economic and yield resilience to the local community, independent of the carbon market.

14.3 | Avoidance of double counting

14.3.1 | The activity developer shall implement the following measures to prevent double counting, double issuance, or double claiming, consistent with *GS4GG PAA MS400-01 Requirement 5.4*:

- 14.3.1.1 | **End-Use Exclusivity (Materials):** Where biochar is used in Module A2 (Engineered Materials), the developer shall obtain a contractual "Assignment of Rights" from the downstream manufacturer (e.g., concrete batch plant). This ensures the manufacturer does not separately claim the sequestration benefit (e.g., producing "carbon-neutral" cement for an Environmental Product Declaration) without formally retiring the associated credits.
- 14.3.1.2 | **Scope 3 "Insetting" Mitigation:** To prevent double claiming between the Voluntary Carbon Market and Corporate GHG Inventories, any specific volume of biochar co-financed by a supply chain partner (e.g., an off-taker paying a premium for low-carbon crops to claim the removals in their Scope 3 inventory, or a carbon-negative cement buyer) is strictly ineligible for GSVER issuance. Issuance may only proceed if a formal "Carbon Rights Waiver" is executed by the corporate partner transferring the exclusive atmospheric claim to the Activity Developer.
- 14.3.1.3 | **Soil Overlap:** Where the biochar is incorporated into soil (Module A1), the Activity Developer shall confirm that the target fields are not concurrently registered under a separate Soil Organic Carbon (SOC) crediting project. If the fields are part of another carbon project, the biochar application is ineligible to claim removals under this methodology to prevent duplicate crediting on the same land polygon.
- 14.3.1.4 | **Jurisdictional Double Counting:** Where the activity intends to transfer credits internationally (e.g., for CORSIA or Article 6.2 bilateral agreements), the activity developer shall obtain a Letter of Authorization (LoA) from the Host Country.

14.4 | Aligning with NDC and LT-LEDS

- 14.4.1 | The activity shall demonstrate alignment with the Host Country's Nationally Determined Contribution (NDC) and Long-Term Low-Emission Development Strategy (LT-LEDS).
- 14.4.1.1 | **Broad Alignment:** The Activity Developer is not required to prove that "Biochar" is explicitly named in the NDC text. Alignment is successfully demonstrated if the activity broadly supports the Host Country's stated goals for the AFOLU or Waste sectors (e.g., "improving agricultural soil health," "reducing municipal waste," or "halting deforestation").

14.4.1.2 | **Conflict Screening:** The activity developer shall confirm that the diversion of biomass does not conflict with national strategies for Energy Security: (e.g., diverting biomass mandated for baseload grid power) or Food Security.

14.4.2 | **Adaptation Co-Benefits:** For Module F3 (Restorative), the removal of Invasive Alien Species directly supports National Adaptation Plans (NAPs) by recovering water tables and restoring native biodiversity, ensuring mitigation actions act synergistically with adaptation goals.

14.5 | Encouraging Broad Participation

14.5.1 | This methodology specifically addresses the barriers of "High Transaction Costs" and "Technical Complexity" that historically excluded LDCs and smallholders from the carbon removal market.

14.5.2 | The Inclusive "Three-Track" Architecture:

14.5.2.1 | **Track 1** lowers the barrier to entry by permitting Composite Sampling and Conservative Default Factors (Annex 5). This allows artisanal cooperatives in LDCs to participate without needing expensive onsite laboratory infrastructure or Continuous Emissions Monitoring Systems (CEMS) or daily laboratory infrastructure. Track 1 is globally available; however, the "Deemed Additionality" fast-track remains strictly reserved for LDCs/SIDS/LLDCs.

14.5.2.2 | **Track 2** acts as the vital bridging mechanism, allowing mid-scale actors to mechanize and utilize thermal proxies without requiring multi-million-dollar industrial sensor suites.

14.5.2.3 | **Track 3** ensures that industrial actors with higher capacity are held to maximum rigor, preventing the "watering down" of standards for large emitters.

14.6 | Including Data Sources, Accounting for Uncertainty, and Monitoring

14.6.1 | The methodology prioritizes the use of observed, accurate, and verifiable data while accommodating data scarcity in specific contexts through conservative defaults.

14.6.2 | **Data Hierarchy:**

14.6.2.1 | **Tier 1 (High Precision):** Direct Measurement (ISO 17025 accredited Labs, CEMS) used in continuously Track 3.

14.6.2.2 | **Tier 2 (Conservative Defaults):** Approved Standardized Factors (Annex 5) used in Track 1, strictly calibrated to the 10th/90th percentiles to ensure credits are never over-estimated.

14.6.2.3 | **Uncertainty Management:** All parameters are subject to uncertainty analysis. Where Track 1 projects utilize default factors to reduce MRV costs, the statistical penalty is natively baked into the highly conservative ex-ante

defaults, satisfying the confidence interval without requiring secondary ex-post deductions. For Track 2, a fixed percentage buffer is deducted from the final credit volume to account for proxy measurement variance. This mechanism ensures that the environmental integrity of the credit is maintained, effectively "charging" the project in credits for the lack of precision data.

14.7 | Taking into Account Policies, Measures, and Relevant Circumstances

14.7.1 | The Baseline Scenario and Additionality Demonstration explicitly account for national and sub-national policies.

14.7.1.1 | **Regulatory Surplus:** The activity shall demonstrate that biochar production is not mandated by law. However, the methodology recognizes "Systematic Non-Enforcement" of bans on open burning (Module F1), allowing activities to proceed in regions where burning is legally banned but practically ubiquitous (Common Practice >50%), provided a discount is applied.

14.7.1.2 | **Suppressed Demand (LDCs):** In accordance with Requirement 5.11, the methodology recognizes Suppressed Demand in LDC contexts (Track 1). The baseline scenario does not assume that subsistence farmers would have accessed advanced fertilizers or soil amendments in the absence of the project. The provision of biochar is recognized as a unique contribution to meeting the suppressed demand for soil fertility and agricultural productivity.

15 | MONITORING METHODOLOGY

15.1 | General Requirements

15.1.1 | The Activity Developer shall establish and maintain a Monitoring, Reporting, and Verification (MRV) system that ensures the continuous, accurate, and transparent quantification of GHG removals and operational emissions. The monitoring plan shall be defined in the PDD and executed according to the selected Compliance Track.

15.1.2 | **Roles and Responsibilities:** The MRV system shall clearly define roles across the entire cradle-to-grave lifecycle:

15.1.2.1 | **Track 1 (Distributed):** The Aggregator acts as the central data manager. They are responsible for maintaining the "Digital Registry" of all production units, collecting calibration logs, conducting composite sampling, and aggregating data for the Monitoring Report. Individual smallholders operate kilns and log data via the Aggregator's digital platform.

15.1.2.2 | **Track 2 (Mechanized) AND Track 3 (Industrial):** The Facility Operator/Plant Manager is responsible for onsite data logging (e.g., weighbridge, thermocouples, SCADA, CEMS) and Composite Sampling.

15.1.2.3 | **Logistics & Application Managers (All Tracks):** Designated personnel responsible for tracking the Chain of Custody during transport and formally documenting the final Proof of Application (Proof_{App}) at the downstream sink (e.g., field applicators logging geo-tagged planting pits, or site managers retaining B2B concrete batch invoices).

15.1.3 | **Data Management and Archiving**

15.1.3.1 | **Digital MRV:** For all Tracks, the use of a secure Digital Monitoring System (DMS) or SCADA data historian is mandatory. For Track 1 and 2, this shall include time-stamped and geo-tagged delivery receipts. Paper logs shall be digitized within 30 days.

15.1.3.2 | **Retention:** All data, including weighbridge tickets, lab reports, and spatial application polygons, shall be archived for a minimum of **two years** after the end of the Crediting Period or last verification, whichever is later.

15.1.4 | **Calibration**

15.1.4.1 | **Requirement:** All measurement equipment used for crediting (scales, moisture meters, thermocouples, CEMS) shall be calibrated according to manufacturer specifications or at least annually, if no specific manufacturer guideline exists. Due to rapid carburization and thermal drift in high-temperature corrosive environments, critical thermocouples utilized for Track 2 Thermal Proxies or Track 3 reactors shall be inspected, recalibrated, or replaced at least **bi-annually (every 6 months)**, or the facility shall utilize dual-redundant sensor arrays.

15.1.4.2 | **Track 1 Exception:** Low-cost Spring scales may be calibrated monthly against a "Standard Weight" at the Aggregator Hub.

15.1.4.3 | **Utility Exemption:** Utility-owned grid electricity meters, governed by national utility standards and sealed by the provider, are explicitly exempt from project-level calibration requirements.

15.2 | **Data and parameters not monitored**

15.2.1 | The following parameters are determined ex-ante and remain fixed for the duration of the crediting period, unless otherwise noted.

Parameter ID	PARC 1
Data/parameter:	GWP (CH ₄) GWP (N ₂ O)
Description	Global Warming Potential of Methane and Nitrous Oxide.
Data unit:	
Purpose of data:	☒ Activity emissions
Value(s) applied:	The most recent 100-year GWP value adopted by Gold Standard.
Source of data:	☐ Measured ☒ Other source

	The most recent IPCC Assessment Report currently adopted by Gold Standard for the Global Goals (e.g., AR6).
Choice of data or measurement methods and procedures:	
Treatment of uncertainty	N/A
Comments:	Used to convert non-CO ₂ gases into carbon dioxide equivalents. Applicable Track - All Tracks Applicable Module - All Modules

Parameter ID	PARC 2
Data/parameter:	$DAF_{Netzero,y}$
Description	Downward Adjustment Factor applied to align the activity with the Host Country's Net Zero trajectory.
Data unit:	Decimal Fraction
Purpose of data:	☒ Baseline emissions ☒ Activity emissions ☒ Applicability
Value(s) applied:	Country and Time-period specific value (e.g., 0.015 for 2026–2030) as published in the tool.
Source of data:	☐ Measured ☒ Other source GS4GG Tool: Downward Adjustment Factor Determination (MT400-05). Mandatory requirement for Paris Agreement Alignment (PAA).
Choice of data or measurement methods and procedures:	
Treatment of uncertainty	N/A
Comments:	Applicable Track - All Tracks Applicable Module - All Modules

Parameter ID	PARC 3
Data/parameter:	$Y_{default}$
Description	Conservative feedstock -specific Biochar Yield Factor used to calculate dry biomass input from weighed biochar output.
Data unit:	Ratio ($t_{char,dry}/t_{bio,dry}$)

Purpose of data:	☒ Leakage emissions
Value(s) applied:	Woody Biomass: 0.20 Crop Residues: 0.15
Source of data:	☐ Measured ☒ Other source Annex 5 of this methodology.
Choice of data or measurement methods and procedures:	Represents the 10 th percentile (lower bound) of artisanal kiln performance to prevent over-crediting when output weighing is difficult.
Treatment of uncertainty	N/A
Comments:	Applicable Track - Track 1 (Distributed) Only Applicable Module - Modules F1, F2, F3 & F4 Prohibited for Track 2 and Track 3.

Parameter ID	PARC 4
Data/parameter:	$EF_{Ch4,tech,i}$; $EF_{Ch4,penalty}$
Description	Technology-specific factor quantifying methane slip (uncombusted pyrolysis gases). and the Track 2 Proxy Excursion Penalty.
Data unit:	tCH_4/t_{char}
Purpose of data:	☒ Baseline emissions ☒ Activity emissions ☒ Applicability
Value(s) applied:	Flame Curtain Kilns: 0.018 TLUD Gasifiers: 0.01 Proxy Excursion Penalty (Track 2): 0.15
Source of data:	☐ Measured ☒ Other source Annex 5 of this methodology.
Choice of data or measurement methods and procedures:	Represents the 90 th percentile (upper bound) of emissions.
Treatment of uncertainty	N/A
Comments:	Unvented earth mounds are Prohibited. Applicable Track - Track 1 (Distributed) Only Applicable Module - All Modules

Parameter ID	PARC 5
Data/parameter:	$EF_{embodied,default}$

Description	Standardized deduction for embodied emissions of production infrastructure (steel, concrete).
Data unit:	$\text{tCO}_2/\text{t}_{\text{char}}$
Purpose of data:	☒ Baseline emissions ☒ Activity emissions ☒ Applicability
Value(s) applied:	0.01 (Track 1) 0.05 (Track 2)
Source of data:	☐ Measured ☒ Other source Methodology Default
Choice of data or measurement methods and procedures:	Simplifies MRV by avoiding full Life Cycle Assessment (LCA). Optional fallback for Track 3.
Treatment of uncertainty	N/A
Comments:	Applicable Track - Track 1 & Track 2 Applicable Module - All Modules Optional for Track 3.

Parameter ID	PARC 6
Data/parameter:	<i>MAST</i>
Description	Mean Annual Soil Temperature (0–30 cm depth) at the application site.
Data unit:	Degrees Celsius $^{\circ}\text{C}$
Purpose of data:	☒ Activity removals
Value(s) applied:	Activity specific
Source of data:	☐ Measured ☒ Other source Global geo-spatial datasets (e.g., BioClim, NASA POWER) or local meteorological station.
Choice of data or measurement methods and procedures:	Site-specific value (Centroid of Application Boundary). Required for the Woolf et al. (2021) decay model (F_{perm}).
Treatment of uncertainty	N/A
Comments:	Applicable Track - Track 1 & Track 2 Applicable Module - A1 (Soil), (Note: Module A3 only utilizes this parameter if an engineered cap breach occurs and reverts to the standard soil decay model) Track 1 may use a conservative default of 25°C if local data is unavailable.

- 15.2.2 | **PARC 7:** $C_{org,default}$ (Default Organic Carbon): Values of 0.65 (Woody), 0.40 (Herbaceous), and 0.35 (High-Ash). Sourced from Annex 5. Restricted to Track 1.
- 15.2.3 | **PARC 8:** MC_{deduct} (Default Moisture Deduction): Values of 0.15 (Air/Snuff Quenched) and 0.35 (Water Quenched). Sourced from Annex 5. Restricted to Track 1.
- 15.2.4 | **PARC 9:** L_{app} (Application Loss Factor): Values of 0.02 (Precision/Manual), 0.05 (Mechanized Surface), and 0.01 (Encapsulation/Burial). Sourced from Section 8.6. Applicable to all Tracks based on the End-Use Module.
- 15.2.5 | **PARC 10:** $EF_{replace,i}$ (Default Replacement Factors): Values of 0.45 (Thermal), 0.15 (Fodder), and 0.05 (Bedding/Mulch). Sourced from Section 10.5 (Table 13). Used to calculate Market Leakage.
- 15.2.6 | **PARC 11:** $Rate_{Risk}$ (Fixed Risk Deduction): Values of 10% (Track 1 Soil) and 5% (Module A2 Materials). Sourced from Section 12.2 (Table 14). Represents the Mechanism B mandatory cancellation rate.
- 15.2.7 | **PARC 12:** $F_{perm,engineered}$ (Fixed Permanence Factor): Value of 0.95. Sourced from Section 8.5. Applicable strictly to Module A2 (Engineered Materials) and Module A3 (Earth Vaults).

15.3 | Data and parameters monitored

15.3.1 | The following parameters shall be monitored during the crediting period.

Parameter ID	PARC 13
Data/parameter:	$Q_{biomass,i,y}$
Description:	Mass of biomass feedstock type i processed during the monitoring period.
Data unit:	Tonnes (t_{wet} or t_{dry})
Purpose of data:	☒ Leakage emissions
Measurement and updating frequency	a. Track 1: Aggregator logs. b. Track 2: Facility Weighbridge. c. Track 3: Automated Weigh feeder. Per Batch (Track 1/2) or Continuous (Track 3).
Measurement methods and procedures:	a. Track 1: Calculated via Yield-Back ($Q_{char}/Y_{default}$ OR measured with hanging scales. b. Track 2/3: Direct weighing of inputs. Records shall include timestamp and feedstock type.
Entity/person responsible for the measurement:	

Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	Scales are calculated per manufacturer specs/annually. Mass Balance Check: If recorded yield ($Q_{char}/Y_{default}$) > 0.30, the batch is flagged for audit.	
Treatment of uncertainty		
Comments:	Calculation of Baseline Emissions and Leakage. Applicable Track – All tracks Applicable Module - All modules	

Parameter ID	PARC 14	
Data/parameter:	$MC_{biomass}$	
Description:	Moisture content of the biomass feedstock input.	
Data unit:	Decimal Fraction	
Purpose of data:	☒ Baseline emissions ☒ Leakage emissions	
Measurement and updating frequency	Per Batch (Track 1/2) or Daily Composite (Track 3).	
Measurement methods and procedures:	Moisture Analyzer / Lab Report. a. Track 1: Handheld meter OR conservative default. b. Track 2: Gravimetric analysis (Oven 105°C). c. Track 3: Inline NIR sensors or Lab Analysis.	
Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A

QA/QC procedures:	Handheld meters calibrated against oven-dry method quarterly.
Treatment of uncertainty	
Comments:	Conversion of wet input weight to dry weight. Applicable Track – All tracks Applicable Modul - All modules

Parameter ID	PARC 15	
Data/parameter:	$EC_{pre-proc,y}$ $FC_{proc,y}$	
Description:	Electricity and Fossil Fuel consumed for processing, startup, and auxiliary equipment.	
Data unit:	MWh (electricity) Liters (or kg) (fuel)	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Monthly.	
Measurement methods and procedures:	Utility Meters / Fuel Purchase Invoices. Recording of meter readings at the start/end of the period.	
Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	Consistency check against equipment nameplate rating. Utility-owned grid meters are exempt from project-level calibration requirements.	
Treatment of uncertainty		
Comments:	Calculation of Activity Emissions.	

	Applicable Track – All tracks Applicable Module - All modules
--	--

Parameter ID	PARC 16	
Data/parameter:	$Q_{biochar,i,y}$	
Description:	Mass of final biochar output produced and distributed to eligible sinks.	
Data unit:	Tonnes (t_{wet})	
Purpose of data:	☒ Activity removals	
Measurement and updating frequency	Monthly. Every Batch (Track 1/2) or Continuous (Track 3).	
Measurement methods and procedures:	Direct weighing of final product prior to storage/transport. Weight tickets shall correspond to Batch IDs. Track 1: Aggregator Log (Bag Count $\times$ Std Weight via calibrated hanging scale). Track 2: Platform Scales (Bulk Bags). Track 3: Product Weighbridge.	
Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	Scales calibrated per manufacturer specs/annually. Cross-check against $Proof_{App}$. Primary variable for Activity Removals.	
Treatment of uncertainty		
Comments:	Applicable Track – All tracks Applicable Module - All modules	

Parameter ID	PARC 17	
Data/parameter:	$MC_{biochar}$	
Description:	Moisture content of the biochar output.	

Data unit:	Decimal Fraction	
Purpose of data:	☒ Activity removals	
Measurement and updating frequency	Per Lot/Batch. Track 1: Meter calibrated to charcoal setting OR the conservative defaults defined in Annex 5 (15% for Air/Snuff quench; 35% for Water quench). Moisture sampling shall occur simultaneously with the physical weighing of biochar to ensure mass-balance integrity Track 2/3: Gravimetric analysis - Dry sample at 105°C to constant weight.	
Measurement methods and procedures:	Direct weighing of final product prior to storage/transport. Weight tickets shall correspond to Batch IDs. Track 1: Meter/Default. Track 2: Oven. Track 3: Lab/Sensor.	
Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	Duplicate samples tested for 5% of batches (Track 2/3).	
Treatment of uncertainty		
Comments:	Conversion of wet output weight to dry weight. Applicable Track – All tracks Applicable Module - All modules	

Parameter ID	PARC 18
Data/parameter:	C_{org} , $H:C_{org}$
Description:	Organic Carbon Content (C_{org}) and Hydrogen-to-Organic Carbon Ratio ($H:C_{org}$).
Data unit:	Decimal Fraction, Molar Ratio

Purpose of data:	☒ Activity removals	
Measurement and updating frequency		
Measurement methods and procedures:	Accredited Laboratory Analysis (ISO 17025). Elemental Analysis (CHNS). Track 1/2: Composite Sampling permitted Track 3: Batch Sampling required.	
Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	If $H: C_{org} > 0.4$ (track 1) or > 0.7 (track 2/3), specific batch is Ineligible for crediting.	
Treatment of uncertainty		
Comments:	Calculation of Sequestration Potential and Permanence Factor. Applicable Track – All tracks Applicable Module - All modules	

Parameter ID	PARC 19	
Data/parameter:	T_{SCC} , $T_{process}$	
Description:	Operating temperature of the Secondary Combustion Chamber (SCC) or Carbonization Zone.	
Data unit:	Degrees Celsius ($^{\circ}\text{C}$)	
Purpose of data:	☒ Activity removals	
Measurement and updating frequency	Continuous.	
Measurement methods and procedures:	Thermocouple / Data Logger / SCADA. Track 2: Type-K thermocouple in SCC logging at 15-min intervals. Track 3: Continuous process monitoring.	

Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	Track 2 Safeguard: If $T_{SCC} < 850^{\circ}\text{C}$ the thermal proxy fails. The specific volume of biochar produced strictly during the undocumented/excursion period shall be subjected to the Excursion Penalty Factor as per Annex 5.	
Treatment of uncertainty		
Comments:	Verification of Methane Destruction (Thermal Proxy). Applicable Track – Track 2 & Track 3 (Mandatory) Applicable Module - All modules	

Parameter ID	PARC 20	
Data/parameter:	$Conc_{CH_4}$	
Description:	Concentration of Methane in the facility flue gas.	
Data unit:	mg/m^3	
Purpose of data:	☒ Activity removals	
Measurement and updating frequency	Continuous.	
Measurement methods and procedures:	Continuous Emissions Monitoring System (CEMS). NDIR or FID Analyzer installed in the stack.	
Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A

	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	Daily automated zero/span checks; Annual RATA.	
Treatment of uncertainty		
Comments:	Precise quantification of Activity Emissions. Applicable Track – Track 3 (Industrial) Only Applicable Module - All modules	

Parameter ID	PARC 21	
Data/parameter:	<i>Proof_{App}</i>	
Description:	Evidence confirming the biochar was applied to an eligible sink.	
Data unit:	Document / Record	
Purpose of data:	☒ Activity removals	
Measurement and updating frequency	Every Credited Batch.	
Measurement methods and procedures:	Digital Monitoring System / Sales Records. A1 (Track 1): Geo-tagged photos / Farmer Logbooks. A1/A2/A3 (Track 2/3): Signed Weighbridge Tickets / Sales Ledgers. A3: As-built Survey.	
Entity/person responsible for the measurement:		
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	VVB audits a random sample of end-locations during verification.	

Treatment of uncertainty	
Comments:	Eligibility condition for Removals (Chain of Custody). Applicable Track – All Tracks Applicable Module - All modules

Parameter ID	PARC 22	
Data/parameter:	$MC_{biomass}, MC_{biochar}$	
Description:	Moisture Content of the biomass feedstock input and biochar output.	
Data unit:	Percentage (%) (Wet Basis).	
Purpose of data:	☒ Activity removals	
Measurement and updating frequency	Per Batch (Track 1/2) or Daily Composite (Track 3)	
Measurement methods and procedures:	Track 1 (Distributed): Calibrated handheld moisture meter (resistive/capacitive) adjusted to wood/charcoal setting. Track 2/3 (Industrial): Gravimetric analysis (Oven drying at 105°C to constant weight) as per ASTM D1762-84 or ISO 18134.	
Entity/person responsible for the measurement:	Activity proponent or plant operator.	
Measuring instrument(s):	Type of instrument	Moisture Meter or Drying Oven + Precision Scale.
	Accuracy class	± 2% for handheld; ± 0.5% for gravimetric.
	Calibration requirements	Calibration procedures: Handheld meters shall be cross-checked against oven-dry samples. Calibration frequency: Quarterly for meters; Annually for lab scales.
	Location	Biomass reception (input) and Biochar packaging area (output)
QA/QC procedures:	Duplicate samples tested for 5% of batches to verify meter accuracy.	
Treatment of uncertainty		
Comments:	Essential for converting "Wet Weight" recorded in Parameter 7 and 13 into "Dry Weight" for crediting.	

Parameter ID	PARC 23	
Data/parameter:	FC_{proc}, EC_{proc}	
Description:	Quantity of Fossil Fuel and Electricity consumed for processing, startup, and auxiliary equipment.	
Data unit:	Liters/kg (Fuel); kWh/MWh (Electricity).	
Purpose of data:	☒ Activity emissions	
Measurement and updating frequency	Continuous recording; aggregated Monthly.	
Measurement methods and procedures:	Electricity: Utility Meters or dedicated sub-meters. Fuel: Purchase invoices or flow meters on generators/burners.	
Entity/person responsible for the measurement:	Plant Manager / Activity Proponent.	
Measuring instrument(s):	Type of instrument	Utility Meter, Flow Meter.
	Accuracy class	Utility grade (Class 1.0 or better)..
	Calibration requirements	Calibration procedures: As per national utility standards or manufacturer specs. Calibration frequency: Annually (for sub-meters).
	Location	Biochar production facility / Transport vehicles.
QA/QC procedures:	Duplicate samples tested for 5% of batches to verify meter accuracy.	
Treatment of uncertainty	Cross-check meter readings against monthly utility bills or fuel purchase receipts.	
Comments:	Required to calculate Activity Emissions from Operations.	

Parameter ID	PARC 24	
Data/parameter:	T_{SCC}	
Description:	Temperature of the Secondary Combustion Chamber (SCC) or Afterburner..	
Data unit:	Degrees Celsius (°C).	
Purpose of data:	☒ Activity emissions	

Measurement and updating frequency	Continuous (15-minute average logging).	
Measurement methods and procedures:	Continuous measurement via thermocouple located in the exhaust gas oxidation zone. (Distinct from Parameter 15 Reactor Temp).	
Entity/person responsible for the measurement:	Plant Operator	
Measuring instrument(s):	Type of instrument	Type-K Thermocouple or equivalent linked to Data Logger..
	Accuracy class	Class 2 ($\pm 2.5^{\circ}\text{C}$).
	Calibration requirements	Calibration procedures: As per manufacturer specifications. Calibration frequency: Annually.
	Location	Inside the Secondary Combustion Chamber / Flue Gas Stack.
QA/QC procedures:	If T_{SCC} drops below 850°C (or 600°C for Flame Curtain) while biomass is being processed, the methane destruction is deemed void. Apply penalty factor EF_{j,CH_4} .	
Treatment of uncertainty		
Comments:	Mandatory for Track 2 (Mechanized) to demonstrate methane destruction validity.	

Parameter ID	PARC 26
Data/parameter:	% <i>Interinite</i> and R_0
Description:	Fraction of data points in the biochar samples that have Random Reflectance of more than 2%.
Data unit:	Percentage (%).
Purpose of data:	☒ Activity removals; Unlocking 1,000-year High Durability claims (Method 2).
Measurement and updating frequency	Track 3: Required during baseline calibration, when switching feedstock, or crossing continuous lot thresholds.
Measurement methods and procedures:	Optical white light microscopy (e.g., ISO 7404-5:2009 or ASTM D2798) conducted by an independent accredited laboratory.

Entity/person responsible for the measurement:	Independent Laboratory that is accredited by relevant accreditation board.	
Measuring instrument(s):	Type of instrument	N/A
	Accuracy class	N/A
	Calibration requirements	N/A
	Location	N/A
QA/QC procedures:	A minimum of 500 point-counts shall be made per sample.	
Treatment of uncertainty		
Comments:		

15.4 | QA/QC and Data Management

15.4.1 | Composite Sampling Protocol (Track 1 Specific): To ensure cost-effectiveness for LDCs, Biochar Hubs are permitted to use Composite Sampling for laboratory analysis (*Corg* and *H:Corg*):

15.4.1.1 | **Protocol:** A physical subsample (approx. 100g) is taken from every batch delivered to the Hub.

15.4.1.2 | **Composite Sampling Protocol (Track 1 & 2):** Subsamples thoroughly mixed to create a single Master Sample.

a. Track 1: The Master Sample shall represent a maximum of 50 metric tonnes of production, OR 1 calendar month (whichever occurs first) to prevent staleness.

b. Track 2: The Master Sample shall represent a maximum of **100 metric tonnes**, OR 1 calendar month (whichever occurs first).

15.4.1.3 | **Homogeneity Condition:** Only biochar from identical feedstock modules (e.g., purely woody vs. purely herbaceous) may be mixed. Mixed feedstocks require separate compositing samples.

15.4.2 | **"Missing Data" (Conservative Replacement):** In the event of a failure of monitoring equipment (e.g., CEMS downtime, broken weighbridge, corrupt data logs) exceeding 24 hours, the Activity Developer may not exclude the period nor use average values. The Developer shall apply the Most Conservative Value recorded during the previous 12 months to the missing period:

- a. For Emissions (e.g., Stack Methane): Apply the Maximum recorded concentration.
- b. For Removals (e.g., Biochar Mass): The Activity Developer shall mathematically back-calculate the volume strictly utilizing the recorded biomass input multiplied by the lowest theoretical default yield factor for that feedstock (e.g., 15%), ensuring a highly conservative estimate.

15.4.3 | **Pre-Monitoring End-Use QA/QC:** To strictly mitigate reversal risks, the VVB shall audit the End-Use application evidence prior to verification:

- a. **Module A1 (Soil):** Verify that geo-tagged photographic evidence (Proof_{App}) demonstrates physical incorporation (e.g., tilling, planting pits) rather than biochar merely sitting in unapplied bags. Check that aggregate tonnage claimed does not exceed documented agronomic carrying capacity (e.g., 50 t/ha).
- b. **Module A2 (Materials):** Audit the B2B sales contracts to verify the inclusion of clauses expressly prohibiting the use of the biochar in combustible polymers and assigning the CDR rights solely to the Activity Developer.
- c. **Module A3 (Earth Vaults):** Verify the receipt of the formal engineering As-Built survey confirming the impermeable cap installation prior to crediting.

15.5 | Correlated Proxy Protocol (Ash Proxy)

15.5.1 | To reduce laboratory costs for Track 1, the aggregator may establish a site-specific Correlation Curve between Ash Content and Organic Carbon (C_{org}), where

15.5.1.1 | **Calibration:** Analyse 10 samples at an ISO 17025 lab to establish the regression ($R^2 > 0.90$).

15.5.1.2 | **Routine monitoring:** Measure Ash Content onsite for every batch using a muffle furnace (ASTM D1762). Apply the curve to derive C_{org} .

15.5.1.3 | **Audit:** Send every 50th sample to the ISO lab to re-validate the curve.

15.5.1.4 | **Annual Calibration Campaign:** Track 1 Aggregator may opt to run an annual "Calibration Campaign" (testing 30 consecutive batches at an ISO lab) to establish Hub-Specific Default Factors for Yield and Carbon Content. If the Hub-Specific factors derived from the calibration campaign demonstrate lower statistical variability than the Global Defaults (Annex 5), the Hub may formally adopt these verified site-specific constants in lieu of Annex 5 defaults to securely claim higher creditable volumes.

16| MONITORING REQUIREMENTS FOR ACTIVITIES WITH REVERSAL RISKS

16.1 | General Requirements.

16.1.1 | The objective of this monitoring component is to detect and quantify **Event-Based Reversals**—defined as the unintentional or intentional release of sequestered carbon due to disturbance events (e.g., severe wildfire, topsoil stripping, fuel diversion, demolition, vault cap failure)—that occur within the Activity Boundary.

16.1.1.1 | **Monitoring Period:** Reversal monitoring shall be conducted during active crediting period - annually, concurrent with the standard verification cycle.

16.1.1.2 | **Post-Crediting Exemption:** Active physical monitoring naturally ceases at the end of the final Crediting Period (maximum 15 years). The 200-year or 1,000-year permanence claim is secured *ex-ante* by the physical chemistry of the biochar (e.g., Inertinite petrography, *H:Corg* ratio), the buffer pool, and legal Covenants, not by infinite human observation. Upon project closure, no further physical monitoring reports are required, provided all Legal Safeguards (e.g., Vault Deed Restrictions) have been verified as active.

16.2 | Responsibility

16.2.1 | **Track 1:** The Aggregator assumes strict liability for monitoring the distributed network of application sites and conducting Sentinel Site inspections.

16.2.2 | **Track 2 & 3:** The Activity Developer is responsible for monitoring the defined Application Boundary via Remote Sensing, ground truthing, or downstream engineering inspection.

16.3 | Monitoring Methods by End-Use Module

16.3.1 | The Activity Developer shall implement the monitoring approach corresponding to the End-Use Module and Compliance Track.

16.3.2 | **Module A1: Soil Application (Track 1 - Distributed):** Due to the fragmented nature of smallholder application, continuous monitoring of every farm is not feasible. Furthermore, Track 1 activities utilize the 10% Fixed Risk Deduction (Mechanism B, Section 12), which pre-pays for standard statistical losses. Therefore, Sentinel Site monitoring functions as a Systemic Breach Check to ensure Aggregator compliance with the "No-Burn" rule, rather than calculating individual reversal tonnages.

A. Sentinel Site Inspections: The Aggregator shall inspect a representative sample of Sentinel Sites annually. The sample size shall be determined in strict accordance with the *GS4GG Sampling and Estimation Requirements* to achieve a minimum **90/10 confidence/precision level**, rounded up.

B. Visual Assessment: The field monitor shall visually assess the field for:

- a. **Fuel Diversion:** Evidence of biochar being excavated for use as charcoal (e.g., pits, stockpiles near kitchens).
- b. **Soil Displacement/Conversion:** Evidence of topsoil stripping (e.g., surface mining) or land-use conversion (e.g., paving over the field). *(Note: Standard agricultural deep-ploughing or tilling is an agronomic norm that protects pyrogenic carbon and does NOT constitute a reversal).*
- c. **Fire:** Evidence of recent scorching or burning of crop residues on the treated field.

C. Trigger: If >5 of sampled Sentinel Sites show verified evidence of Avoidable Reversals (e.g., intentional fuel diversion), it indicates systemic negligence or fraud. This triggers the Aggregator Liability Clause (Section 12.5), resulting in a full audit, potential activity suspension, and the doubling of the Buffer Contribution for future issuances.

16.3.3 | **Module A1: Soil Application (Track 2 & 3 - Mechanized):** For large-scale contiguous application areas (or Track 2 activities with defined commercial partners), monitoring relies on remote sensing.

A. Remote Sensing Analysis: The Activity Developer shall analyse satellite imagery (e.g., Sentinel-2, Landsat, or VIIRS Active Fire data) covering the Application Boundary annually to identify "Burn Scars" overlapping with registered land parcels or Conversion of agricultural/forestry land to settlements or infrastructure (impervious surfaces).

B. Ground Truthing: If remote sensing detects a disturbance event (e.g., High Severity Fire) overlapping with >5% of the total application area, a ground survey is mandatory to quantify the depth of biochar loss (e.g., distinguishing surface ash from intact sub-soil carbon) and applying the relevant Damage Factor (Table 15)..Note: For Track 2 activities involving distributed smallholder application, the Track 1 Sentinel Site protocol shall be used.

16.3.4 | **Module A2: Engineered Materials (All Tracks):** For biochar encapsulated in concrete, asphalt, or composites, monitoring on the physical existence of the infrastructure is practically unenforceable.

16.3.4.1 | **Fixed Risk Deduction:** Module A2 activities rely entirely on the 5% Fixed Risk Deduction (Mechanism B, Section 12). This effectively pre-pays for long-term statistical demolition losses.

16.3.4.2 | **Monitoring Status: Deemed Compliance.** The Developer is permanently exempt from maintaining a "100-year Asset Registry" or tracking the lifespan of individual infrastructure projects ex-post, provided they furnish the executed B2B Non-Combustion Encapsulation Contracts at the time of issuance.

16.3.5 | **Module A3: Dedicated Earth Vaults (Track 2 & 3):** Monitoring focuses on the integrity of the engineering controls and legal status.

A. Cap Integrity Inspection: Annual visual inspection of the site surface for signs of erosion, subsidence, or unauthorized excavation, or deep-rooting tree establishment that could breach the anoxic liner.

Breach Penalty: If the cap is breached and not repaired within 30 days, the vault loses its Anoxic status. The affected volume reverts to the standard Soil Decay Model (F_{perm}) based on local temperature, and the difference is quantified as an Avoidable Reversal.

B. Legal Status Check: Every 5 years, the Developer shall confirm via the Land Registry that the Restrictive Covenant remains active and registered on the land title.

16.4 | Reversal Reporting and Quantification

16.4.1 | **Notification Requirement** In the event of a confirmed Reversal (whether detected via monitoring or reported by stakeholders), the Activity Developer shall:

- a. **Notify:** The Gold Standard Secretariat within 30 days of detection.
- b. **Report:** Submit a Reversal Event Report detailing the cause (Avoidable vs. Unavoidable), affected area, and estimated carbon loss, utilizing Equation 29 and the Damage Factors established in Section 12.
- c. **Compensate:** Proceed with Buffer Pool cancellation (Unavoidable) or the direct purchase and retirement of replacement GSVERs (Avoidable), in strict accordance with Section 12.5.

16.5 | Data and Parameters Monitored

16.5.1 | The following parameters are specific to Reversal Monitoring and shall be recorded in addition to the parameters in Section 15.

Parameter	Status Sentinel
Description	Verification status of a Sentinel Site during annual inspection (Track 1).
Data Unit	Categorical (Intact / Disturbed / Excavated)
Purpose of data	Systemic Breach Check (Enforcement of Section 12.5 Aggregator Liability)
Monitoring Method	Visual field inspection utilizing mobile application with geo-tagged/timestamped photographs.
Frequency	Annual (Statistical Sample Basis).
QA/QC	Aggregator shall provide photos for 100% of inspected Sentinel Sites in the selected sample cohort. If >5% of sites fail, systemic check is triggered.

Parameter	Index Fire
Description	Remote sensing indicator of fire disturbance (Track 2/3).
Unit	Burned Area Index (BAI) or Active Fire Confidence.
Purpose of data	Reversal Quantification (Module A1 / Track 2 & 3)
Monitoring Method	Satellite Imagery (e.g., NASA FIRMS, Copernicus) mapped against project application polygons.
Frequency	Annual.
QA/QC	Cross-reference with local meteorological data to rule out false positives. Any overlap >5% area triggers mandatory ground-truthing to apply Table 15 Damage Factors.

Parameter	<i>Cap_{integrity}</i>
Description	Integrity status of the engineered cap sealing the Anoxic Storage vault.
Unit	Boolean (Intact / Breached)
Purpose of data	Verification of 0.95 Permanence Factor (Module A3)
Monitoring Method	Visual Site Inspection Report confirming the absence of subsidence, excavation, or deep-rooting vegetation penetrating the liner.
Frequency	Annually (during active Crediting Period).
QA/QC	Inspection report shall be signed by the Site Manager or a qualified Civil Engineer. If breached and unrepaired >30 days, F_{perm} reverts to local soil decay model.

17| APPLICATION TO PROGRAMME OF ACTIVITIES

17.1 | General Requirements

17.1.1 | The methodology is applicable to a **Programme of Activities (PoA)**. The Coordinating/Managing Entity (CME) shall demonstrate that the PoA complies with the *GS4GG Programme of Activities Requirements* and the specific constraints defined below.

17.1.2 | **VPA Consistency (Homogeneity):** A PoA may comprise multiple Voluntary Project Activities (VPAs). To ensure rigorous quantification and simplified verification, each VPA inclusion request shall be restricted to a single Compliance Track. A single VPA shall not mix Compliance Tracks (e.g., a VPA cannot combine "Track 1 Artisanal Kilns" and a "Track 3 Industrial Plant").

These shall be registered as separate VPAs via real case VPAs and corresponding regular VPAs within the PoA.

- 17.1.2.1 | **Geographical Constraint:** Due to the country-specific nature of the Downward Adjustment Factor (DAF), a single VPA shall not span across national borders. Separate VPAs shall be registered for each Host Country.
- 17.1.2.2 | **Scale Management (Track 1 VPAs):** To maintain auditability, and strictly prevent the debundling of large-scale commercial operations, the **60,000 tCO₂e/yr** small-scale threshold applies cumulatively to the Entire PoA. The total sum of all Track 1 VPAs under a single PoA shall not exceed 60,000 tCO₂e/yr. The CME shall define distinct VPAs based on geographic clusters or administrative zones to facilitate the Cross-VPA Sampling approach.
- 17.1.3 | **The CME Role (Aggregator):** For Track 1 and Track 2 VPAs, the CME assumes the role and liabilities of the Aggregator defined in Section 2. The CME is strictly liable for:
 - 17.1.3.1 | **Centralized Data Management:** Operation of the Digital Monitoring System (DMS) to track biomass sourcing and biochar distribution across all VPAs.
 - 17.1.3.2 | **Safety Compliance:** Ensuring all units within Track 1 VPAs adhere to the "No-Burn" and air quality safeguards (Section 3).
 - 17.1.3.3 | **Benefit Sharing Execution:** Holding the strict financial liability for executing, logging, and reporting the mandatory Benefit Sharing Plan (Section 14.2) across all participating smallholder farmers.

17.2 | Baseline and Additionality Demonstration

- 17.2.1 | **Additionality:** Additionality shall be demonstrated at the level appropriate to the Track:
 - 17.2.1.1 | **Track 1 & 2:** Additionality may be demonstrated at the PoA Level if the CME defines a distinct eligibility class (e.g., "All Track 1 units in LDCs") that meets the Deemed Additionality criteria (Section 6.2) or passes the Barrier Analysis (Section 6.7).
 - 17.2.1.2 | **Track 3:** Additionality shall be demonstrated at the VPA Level. Each Track 3 VPA inclusion shall include a specific Financial Viability Analysis (Section 6.6) for the specific industrial facility.
- 17.2.2 | **Biomass Supply Shed (Leakage Prevention)** To prevent multiple VPAs from competing for the same biomass resource (violating the Surplus Test in Section 10), the CME shall define a "Supply Shed" for each VPA.
 - 17.2.2.1 | **Requirement:** The CME shall maintain a "Supply Shed Registry" defining as the maximum geographical procurement radius around a biochar production hub, and maintain a "Supply Shed Registry" mapping these radii.
 - 17.2.2.2 | **Overlap Check:** New VPA inclusions shall not overlap with the Supply Shed of existing VPAs unless the CME demonstrates (via the Surplus Test) that

the combined aggregate biomass demand of all overlapping VPAs does not exceed the total verifiable regional surplus.

17.3 | Monitoring and Sampling in PoAs

17.3.1 | Cross-VPA Sampling (Track 1 & Small Scale Track 2): For VPAs utilizing Distributed or Mechanized units with homogenous technology and feedstock, the CME may utilize Two-Stage Sampling (Cross-VPA Sampling) as defined in the GS4GG Sampling and Estimation Requirements. This is subject to strict bifurcation rules:

17.3.1.1 | Hierarchy:

- a. Primary Stage: Random selection of VPAs.
- b. Secondary Stage: Random selection of Production Units or Sentinel Sites within the selected VPAs.

17.3.1.2 | Condition: Cross-VPA sampling is Prohibited if the VPAs operate in different climatic zones (affecting baseline decay/soil temp) or use different feedstocks (affecting biochar yield).

17.3.2 | **Track 3 Exclusion** Cross-VPA sampling is **Strictly Prohibited** for Track 3. Every Track 3 facility included in a PoA shall undergo individual verification (100% check) of its CEMS data, Weighbridge logs, and Lab reports.

18 | RENEWAL OF CREDITING PERIOD

18.1 | Crediting Period Renewal Requirements

18.1.1 | The crediting period for activities under this methodology is 5 years. It may be renewed for a maximum of two additional periods (Total 15 years), subject to the successful reassessment of the baseline and adherence to the Technology Graduation requirements defined below.

18.1.2 | Exception: Activities utilizing Module F3 (Restorative Biomass) or Module F5 (Purpose-Grown) are limited to one renewal (Total 10 years) to prevent the perverse incentive of maintaining invasive species or degraded land solely for carbon revenue. (Note: The physical production facility may renew for a third period if the Activity Developer formally transitions the feedstock supply to an eligible waste/residue module [e.g., F1 or F2] and updates the project boundary accordingly).

18.2 | Reassessment of the Baseline Scenario

18.2.1 | At the time of renewal, the Activity Developer shall update the baseline parameters to reflect regulatory and economic changes in the Host Country.

18.2.2 | Regulatory Surplus Update: Because this methodology issues pure Carbon Dioxide Removal (CDR) credits, bans on baseline emissions (e.g., "No Open Burning" laws) do not affect the removals baseline. The Activity Developer shall conduct a new Regulatory Surplus Analysis (Section 6.3) to verify if the

Host Country has legally mandated the specific production and durable application of biochar. If biochar sequestration has become legally mandated and enforced (Common Practice compliance >50%), the Crediting Baseline Removals shall be updated to strictly deduct the mandated volume.

- 18.2.3 | Standardized Factors Update: For Track 1 and 2 activities utilizing Annex 5 (Default Factors), the activity shall update all factors (Yield, Methane, Carbon Content) to the Latest Version of the methodology available at the time of renewal.

18.3 | Reassessment of Additionality

- 18.3.1 | The Activity Developer shall demonstrate Ongoing Financial Need (OFN) for the renewal period in accordance with the *GS4GG Additionality Standard*.

- 18.3.1.1 | **Long-Term Offtakes:** Binding, long-term carbon credit off-take agreements established prior to or during the first crediting period serve as proof of the project's carbon-dependent financial structure. Carbon credit revenues are strictly excluded from the renewal IRR baseline calculation and do not retroactively void additionality.

- 18.3.1.2 | **Track 1 & 2 OPEX Barriers:** For distributed and mechanized activities, the Activity Developer may demonstrate OFN by proving that carbon revenues remain essential to fund the continuous Aggregator MRV requirements, hardware replacement, and the active Benefit Sharing Plan payments to smallholders.

- 18.3.1.3 | **Commercial Viability Test (Track 3 & Large-Scale Track 2):** For all Track 3 Industrial facilities, and any Track 2 activities exceeding the 60,000 tCO₂e/yr large-scale threshold, the developer shall provide an updated Financial Viability Analysis (Section 6.6) using actual operational costs and revenues from the previous period.

- 18.3.1.4 | **Graduation:** A project will not be penalized for temporary commodity price spikes. However, if the ex-post analysis demonstrates that the baseline market has fundamentally shifted and revenue strictly from physical Biochar Sales and Energy/By-products (excluding carbon credits) is sufficient to comfortably achieve the project's Benchmark IRR over a sustained multi-year trailing average, the activity is deemed Commercially Viable, loses its OFN, and is ineligible for renewal.

18.4 | Technology Graduation (Track 1 Sunset Clause)

- 18.4.1 | To ensure the biochar sector matures from artisanal poverty alleviation to robust industrial removal, Track 1 (Distributed) activities are subject to a Mandatory Graduation Requirement at renewal.

- 18.4.2 | **Requirement:** Track 1 activities utilizing manual/artisanal kilns (e.g., basic Flame Curtain) without digital verification shall not be renewed for a second crediting period under the same technical specifications.

18.4.3 | **Graduation Pathways:** To be eligible for renewal, the Activity Developer shall demonstrate a Structural Upgrade to one of the following:

18.4.3.1 | **Pathway A: Mechanization (Move to Track 2):** Transition production to mechanized retorts with controlled residence time and secondary combustion. Adoption of Track 2 MRV (Direct Weighing, no Yield-Back).

18.4.3.2 | **Pathway B: Digitalization ("Smart Kiln" Upgrade):** Retain artisanal kilns but equip the Aggregator Hubs/Units with **IoT Monitoring**. Installation of temperature loggers on a statistical sample (min 10%) of units to continuously verify combustion quality.

18.4.4 | To prevent creating an uneven playing field for early adopters in developing nations, the mandatory enforcement of the "Sunset Clause" (which would render non-upgraded projects ineligible for renewal) is suspended for Version 1.0. A formal evaluation regarding the mandatory phase-out of purely manual kilns will occur during the 2028 methodology revision.

Annex -1 | FEEDSTOCK MODULES & SUSTAINABILITY CRITERIA

A 1.1| Normative References and Applicability

- A 1.1.1| This Annex defines the eligible sources of biomass for biochar production. It establishes the mandatory sustainability criteria that the Activity Developer shall meet to ensure that the sourcing of biomass does not result in deforestation, ecosystem degradation, toxic contamination, or negative leakage impacts. All feedstocks shall strictly comply with the overarching GS4GG Biomass Sustainability Requirements.
- A 1.1.2| **Applicability:** The Activity Developer shall categorize all biomass inputs into one of the six Feedstock Modules (F1–F6). The activity developer shall strictly adhere to the Compliance Track Restrictions defined in Section 3. The VVB shall utilize a standardized feedstock eligibility checklist to explicitly verify compliance with the Negative List during every audit.

Table 17. Feedstock Module Applicability Matrix

Module	Description	Track 1 (Distributed)	Track 2 (Mechanized)	Track 3 (Industrial)
F1	Field Residues	Eligible	Eligible	Eligible
F2	Processing Residues	Eligible	Eligible	Eligible
F3	Restorative (Invasive)	Eligible	Eligible	Eligible
F4	Disaster/Sanitary	Restricted (Wildfire Only)*	Eligible (Temp >500°C)	Eligible
F5	Purpose-Grown	Ineligible	Ineligible	Eligible
F6	Organic Waste	Ineligible	Ineligible	Eligible

Note: Track 1 activities may utilize Module F4 only for wildfire fuel-load reduction consists of small diameter thinning (<10cm) coordinated by a local forestry or emergency authority. The processing of pest-infected sanitary timber is prohibited for Track 1 due to the lack of continuous thermal data-logging required to prove phytosanitary sterilization. Mobile, in-field pyrolysis systems (e.g., mechanized field rovers processing F1 residues) are fully eligible provided they comply with Track 2 or Track 3 hardware and digital MRV requirements.

A 1.2| General Eligibility Criteria (Negative List)

- A 1.2.1| Regardless of the Feedstock Module selected, the following feedstocks are Strictly Prohibited across all tracks:
- Fossil Carbon: Any feedstock containing non-biogenic carbon, including waste tires, rubber, plastics, synthetic textiles, or electronic waste. Waste tires are entirely ineligible under all Tracks as the fossil elements are chemically bound.

- i. *Track 3 Exception:* Municipal Solid Waste (MSW) containing fossil fractions is permitted under Module 6 only the waste is strictly physically segregated such that solely the verifiable biogenic fraction is utilized.
- b. Peat: Biomass sourced from peatlands, histosols, or involving the drainage of wetlands.
- c. Deforestation: Biomass obtained from the conversion of primary forests, High Conservation Value (HCV) areas, or land converted from forest to non-forest use after 31 December 2020 (aligning with EUDR).
- d. Treated Timber: Waste wood treated with copper chrome arsenate (CCA), creosote, or paint containing lead/heavy metals, unless processed in a Track 3 facility with advanced flue gas cleaning complying with national industrial emissions regulations. However, because heavy metals concentrate in the char matrix, the resulting biochar is Strictly Prohibited from Module A1 (Soil Application) and shall be legally diverted exclusively to durable encapsulation (Module A2) or anoxic earth vaults (Module A3).

A 1.3| Feedstock Module Requirements:

A 1.3.1| The Activity Developer shall demonstrate compliance with the specific definitions and safeguards for the selected module.

A 1.3.2| **Module F1: Agriculture & Forestry Residues**

- a. **Definition:** Biogenic residues generated during the harvesting of agricultural crops or forestry logging operations (e.g., straw, stover, stalks, logging slash, tops, branches) that are traditionally left on the field.
- b. **Sustainability Safeguard (Soil Health):** To prevent soil erosion and nutrient depletion, the activity developer shall not harvest 100% of the residues. A minimum of 10–30% (depending on slope and soil type) shall remain on the field to maintain soil organic matter. Total removal of crop residues accelerates erosion and depletes baseline Soil Organic Carbon (SOC) ².
- c. **Exception:** If the developer proves via historical evidence that 100% removal of the residue (e.g., the complete uprooting of cassava or peanuts, or systematic open burning) is the established baseline practice, the Ecological Leakage retention penalty is waived. However, because open burning leaves nutrient-rich ash on the field, the *Nutrient Displacement penalty* (N-P-K) shall still be quantified under

² Removing 100% of crop residues can accelerate erosion and deplete baseline Soil Organic Carbon (SOC) stocks, negating the project benefit (Blanco-Canqui & Lal, 2009)

Ecological Leakage (Section 10.6), unless the biochar is physically returned to the specific source field.

A 1.3.3| Module F2: Processing Residues

- a. **Definition:** Biogenic residues generated at a centralized processing facility. Examples: Rice husks, bagasse, nut shells, sawdust, fruit pits, olive pomace.
- b. **Surplus Test:** The developer shall mathematically demonstrate via the GS4GG Biomass Tool that the residues are entirely surplus and not currently utilized for high-value applications, thermal energy, controlled composting, or field mulching.

A 1.3.4| Module F3: Restorative Biomass (Invasive Species)³

- a. **Definition:** Biomass harvested from the removal of Invasive Alien Species (IAS) or bush encroachment vegetation to restore ecosystem function and water tables.
- b. **Safeguard (Perverse Incentives):** The target species shall be listed on a National or Regional "Invasive/Weed List" (e.g., *Prosopis juliflora*, *Acacia mearnsii*, *Lantana camara*). Harvesting shall be part of a documented ecosystem restoration plan. The cleared land shall not be replanted with the invasive species unless the land independently passes the strict F5 "Degraded Land" tests, permanently removing the incentive to farm invasives.

A 1.3.5| Module F4: Disaster Prevention & Sanitary Biomass

- a. **Definition:** Biomass removed to mitigate verified risks of wildfire (fuel load reduction) or to control the spread of pests/disease (sanitary felling).
- b. **Safeguard (Verification):** Thinning operations shall be authorized by the relevant National Forestry or Emergency Management Authority via a "Fire Risk Assessment" or "Sanitary Felling Order." For pest-infected biomass, Track 2 and 3 production units shall provide continuous thermal logs proving the reactor maintained $> 500^{\circ}\text{C}$ to ensure complete phytosanitary sterilization.

A 1.3.6| Module F5: Purpose-Grown Biomass (Track 3 Only)

- a. **Definition:** Crops cultivated specifically for biochar production (e.g., *Miscanthus*, Bamboo, Short Rotation Coppice).
- b. **Degraded Land Safeguard:** Cultivation shall occur exclusively on land classified as "Degraded," "Marginal," or "Contaminated" (e.g., saline soils, brownfields) (Wicke et al., 2011). In data-scarce rural areas lacking official soil surveys, developers may prove abandonment (>10 years) using open-source remote sensing (e.g., NDVI Land Use

³ Strategic Alignment: Activities under this module are aligned with Target 6 of the Kunming-Montreal Global Biodiversity Framework (Minimize impact of invasive alien species).

Change analysis) or formally documented Participatory Rural Appraisals (PRA). All upstream fertilizer emissions shall be fully quantified.

A 1.3.7| Module F6: Organic Waste Streams (Track 3 only)

- a. **Definition:** Biogenic waste streams requiring pathogen control, including animal manure, anaerobic digestate, sewage sludge (biosolids), and the organic fraction of Municipal Solid Waste (MSW). Restricted to Track 3 (Industrial Precision) equipped with Continuous Emissions Monitoring Systems (CEMS) and Advanced Flue Gas Cleaning (e.g., scrubbers, electrostatic precipitators) compliant with national industrial incineration standards.
- b. **Safeguard:** The pyrolysis process shall maintain a minimum temperature of 600°C for at least 15 minutes to ensure sterilization. This high-temperature threshold is mandatory to guarantee the total destruction of biological pathogens and effectively volatilize/degrade Per- and Polyfluoroalkyl Substances (PFAS), pharmaceutical residues, and emerging organic contaminants commonly found in sludge.
- c. **Safeguard: (14C Fossil Deduction for MSW):** Because mechanical sorting of MSW cannot achieve 100% biogenic purity, Track 3 facilities processing MSW shall conduct periodic Radiocarbon Isotope Testing ¹⁴C (e.g., via ASTM D6866 or EN 16640) on the final biochar product. Issuance of CDR credits shall be strictly pro-rated to match the verified biogenic carbon fraction; the fossil carbon fraction is fundamentally ineligible for crediting.

A 1.4| The Positive List (Deemed Compliance)

- A 1.4.1| To simplify MRV for Track 1 and Track 2 activities, biomass categories listed in the European Biochar Certificate (EBC) Positive List or the World Biochar Certificate (WBC) Positive List are Deemed Eligible under Module F1 or F2, provided they meet the definition of "Biogenic Residue." The Activity Developer shall cite the specific EBC/WBC ID code for the feedstock in the PDD (e.g., EBC ID 11: "Grain Husks").

A 1.5| Evidence Requirements

- A 1.5.1| The activity developer shall collect and archive the following evidence to verify feedstock eligibility during the annual audit

Table 18. Evidence Requirements

Module	Required Evidence	Frequency
F1 (Field)	Geo-tagged photos of harvest area; Agronomic calculation of retention rate or open-burning baseline evidence.	Annual Sample
F2 (Process)	Letter of Origin from the facility; Weighbridge tickets; Surplus Test justification.	Monthly Aggregated

F3 (Invasive)	Botanical ID of species; Reference to National Invasive List; Restoration Plan.	Design Certification/ / Ex-Ante
F4 (Disaster)	Written authorization/order from Forestry/Fire Authority.	Per Harvest Event
F5 (Crops)	Soil survey, Land Classification, or Yield records proving "Degraded" or Abandoned status.	Design Certification/ / Ex-Ante
F6 (Waste)	Waste transfer notes; Lab analysis of input (if MSW/Sludge); Temperature logs (>600°C).	Per Continuous Lot / Batch

A 1.6| References

- A 1.6.1| Blanco-Canqui, H., & Lal, R. (2009). Crop residue removal impacts on soil productivity and environmental quality. *Critical Reviews in Plant Sciences*, 28(3), 139-163.
- A 1.6.2| European Biochar Certificate (EBC). (2023). EBC Guidelines for the Certification of Biochar Based Carbon Sinks. Version 3.4. Ithaka Institute.
- A 1.6.3| European Parliament. (2023). Regulation (EU) 2023/1115 on the making available on the Union market and the export from the Union of certain commodities and products associated with deforestation and forest degradation (EUDR).
- A 1.6.4| Gold Standard. (2021). Land Use & Forests Activity Requirements. Version 1.2. Gold Standard Foundation.
- A 1.6.5| Wicke, B., Smeets, E., Dornburg, V., Vashev, B., Gaiser, T., Turkenburg, W., & Faaij, A. (2011). The global technical and economic potential of bioenergy from salt-affected soils. *Energy & Environmental Science*, 4(8), 2669–2681. <https://doi.org/10.1039/C1EE01029H>
- A 1.6.6| World Biochar Certificate (WBC). (2022). Guidelines for the Production of Biochar. Carbon Standards International.

Annex -2| REQUIREMENTS FOR TRAINING, CAPACITY BUILDING & OPERATIONS

A 2.1| Normative References and Applicability

- A 2.1.1| This Annex defines the minimum operational standards, health and safety protocols, and capacity-building requirements for Activity Developers to ensure occupational safety, environmental protection, and accurate MRV data collection.
- A 2.1.2| **Applicability:** The activity developer shall submit a Training Plan at the time of design certification. The implementation of this plan is mandatory, with requirements differentiated by Compliance Track:
- Track 1 (Distributed):** Mandatory implementation of a "Train-the-Trainer" model focusing on artisanal safety, manual process control (e.g., Flame Curtain), Benefit Sharing, and digital literacy for decentralized monitoring.
 - Track 2 (Mechanized):** Mandatory operator certification focusing on semi-automated machinery operation, maintenance of thermal proxies, and industrial safety.
 - Track 3 (Industrial):** Deemed Compliance. Facilities operating under valid, internationally recognized occupational health and safety licenses (e.g., ISO 45001) or strict national industrial safety audits (e.g., OSHA) are deemed compliant with the Health & Safety requirements of this Annex. However, Track 3 facilities remain strictly mandated to complete and document training on Module T3 (Digital MRV & Compliance) to ensure carbon accounting integrity.

A 2.2| Standard Operating Procedures (SOPs)

- A 2.2.1| Prior to the start of the Crediting Period, the Activity Developer shall develop and document comprehensive Standard Operating Procedures (SOPs).
- A 2.2.2| **Language & Visual Accessibility:** For manual and semi-mechanized systems (Track 1 & 2), SOPs and training materials shall be translated into the local dialect and rely heavily on highly visual/pictographic guides to accommodate varying literacy levels. Waterproof safety placards utilizing universally recognized hazard symbols shall be available at every production site.

A 2.3| Training Curriculum

- A 2.3.1| **Training Curriculum:** The activity developer (or the Aggregator for Track 1) shall implement a training program ensuring all operators possess the necessary competency.
- A 2.3.2| **Module T1: Health, Safety & Environment (HSE):** Mandatory for Track 1 & 2.

- a. Fire Safety: Establishment of "Exclusion Zones" (min. 3 meters) around hot kilns, maintenance of firebreaks, and use of fire extinguishers/water buckets.
- b. Respiratory Protection (Dust vs. Smoke):
 - i. Dust Hazard: Proper use of N95/P2 particulate respirators exclusively during the unloading, crushing, screening, and bagging phases to prevent fine particulate and silica inhalation.
 - ii. Smoke Hazard: Education that N95 masks do not filter Carbon Monoxide (CO) or toxic pyrolysis gases. Smoke inhalation shall be prevented via strict "Windward Operation" (training operators to continuously work upwind of the smoke plume) and proper thermal process control.
- c. CO and smoke Exposure: Awareness of Carbon Monoxide risks; Indoor operation of unvented units is Strictly Prohibited.
- d. PPE Usage: Proper use of Personal Protective Equipment (PPE) including heat-resistant gloves, N95/P2 particulate masks (to prevent smoke inhalation), and closed-toe footwear.
- e. First Aid: Basic treatment protocols for thermal burns and smoke inhalation.

A 2.3.3| **Module T2: Production Technology**

- a. **Track 1 (Artisanal):**
 - i. Visual identification of the "Ash Layer" (indicating complete carbonization).
 - ii. Management of the "Pyrolysis Front" to prevent smoke events.
 - iii. Quench Point: Identification of the correct moment to quench to maximize stability.
- b. **Track 2 (Mechanized):**
 - i. Machine loading rates to prevent jamming.
 - ii. Thermal Proxy Management: Monitoring temperature gauges and procedures for manual recording during "Data Logger" failures.
 - iii. Routine maintenance (e.g., cleaning air injection nozzles).

A 2.3.4| **Module T3: Digital MRV & Compliance:** Mandatory for All Tracks.

- a. Device Training: Operation of the mobile tracking applications, weighbridge software, or facility dashboards.
- b. Evidence Collection: Protocol for taking clear, fraud-proof photographs (e.g., incorporating a timestamp or reference object).
- c. Weighing Protocol: Correct procedure for taring scales and recording "Net Weight." and adhering to the strict Composite Sampling limits defined in Annex 4 without cross-contaminating feedstocks.

A 2.3.5| **Module T4: Social Safeguards:** ("No-Burn" Rule) Mandatory for Track 1.

- a. Education: Clear instruction that biochar produced for carbon crediting shall never be diverted for use as heating or cooking fuel.
- b. Economic Logic: Training shall demonstrate the agronomic value proposition (Yield Increase + Carbon Payment > Charcoal Price) to reinforce "Social Permanence".

A 2.4| Capacity Building and Competency Assessment

- A 2.4.1| The "Train-the-Trainer" Model (Track 1) To scale distributed networks effectively, the Activity Developer shall utilize a hierarchical training structure:
- a. Master Trainers: Technical experts employed by the Developer.
 - b. Community Trainers: Local leaders trained by Master Trainers to oversee clusters of producers.
 - c. Producers: Individual farmers operating the kilns.
- A 2.4.2| Competency Verification: Training effectiveness shall be verified prior to the authorization of any operator to generate credits.
- a. Test: Operators shall pass a practical exam (demonstrating safe ignition and quenching) and a theoretical check (safety rules).
 - b. Refresher: Training shall be repeated Annually or whenever a significant change in SOPs occurs.
- A 2.4.3| Gender and Social Inclusion: In accordance with GS4GG Gender Equality Requirements:
- a. Access: Training sessions shall be scheduled at times and locations accessible to women and marginalized groups, accounting for local agricultural labour cycles and domestic responsibilities.
 - b. Content: Training materials shall rely on visual aids to accommodate varying literacy levels.
 - c. Safety: PPE provided shall include sizes appropriate for all workers, including women.

A 2.5| Operational Equipment Requirements

- A 2.5.1| Personal Protective Equipment (PPE): The activity developer shall provide (or verify the possession of) the following minimum PPE for all workers:
- a. Respiratory Protection: Masks rated for fine particulate matter (e.g., N95) during reactor unloading, crushing, and bagging.
 - b. Thermal Protection: Heat-resistant gloves for handling hot equipment.
 - c. Eye Protection: Safety goggles to prevent ash/spark injury.
- A 2.5.2| **Safety Infrastructure**
- a. Fire Breaks: A cleared perimeter of at least 3 meters around open-air kilns (Track 1) cleared of flammable vegetation.
 - b. Water Access: Immediate availability of at least 200 liters of water (or sand equivalent) per unit for emergency suppression or **0.5 cubic**

meters of loose mineral sand/soil (for arid contexts or enclosed retorts where introducing water presents an extreme steam-expansion explosion hazard) per active unit for emergency smothering.

A 2.6| References

- A 2.6.1| Cornelissen, G., Pandit, N. R., Taylor, P., Pandit, B. H., Sparrevik, M., & Schmidt, H.-P. (2016). Emissions and char quality of flame curtain kilns for low-emission biochar production. PLOS ONE, 11(5), e0154617. <https://doi.org/10.1371/journal.pone.0154617>
- A 2.6.2| Gold Standard Foundation. (2022). Gender equality guidelines and requirements (Version 1.2). Geneva, Switzerland.
- A 2.6.3| International Biochar Initiative (IBI). (2014). Biochar safety sheets: Guidelines for health and safety in biochar production and application.
- A 2.6.4| International Labour Organization (ILO). (2011). Safety and health in agriculture: Code of practice. ILO Office.
- A 2.6.5| Roth, C., Schmidt, H.-P., & Hagemann, N. (2021). Biochar production with the flame curtain kiln: A user manual. Ithaka Institute.

Annex -3| ELIGIBLE END-USE APPLICATION MODULES

A 3.1| Normative References and Applicability

- A 3.1.1| This Annex defines the eligible sinks for the durable storage of biochar. It establishes the specific quality standards, operational application restrictions, and chain of custody evidence requirements that the activity developer shall meet to generate Verified Removals (CDR).
- A 3.1.2| **Module Selection** The activity developer shall select the applicable module(s) at the time of Design Certification. The selection shall adhere to the Compliance Track Restrictions defined in Table 19.

Table 19. Module Applicability Matrix

Module	Description	Track 1 (Distributed)	Track 2 (Mechanized)	Track 3 (Industrial)
A1	Soil Application	Eligible	Eligible	Eligible
A2	Engineered Materials	Ineligible	Eligible	Eligible
A3	Dedicated Earth Vaults	Ineligible	Eligible	Eligible

A 3.2| Module A1: Soil and Land Application

- A 3.2.1| **Scope:** This module covers the application of biochar to soil systems to durably enhance soil organic carbon stocks, improve agronomic fertility, or remediate contamination.
- Eligible Sinks:** Agricultural cropland, pasture/rangeland, agroforestry systems, commercial forestry, urban green infrastructure (e.g., parks, bioswales), and remediation sites (e.g., mine tailings, brownfields).
 - Ineligible Sinks:** Application to sensitive ecosystems (e.g., native peatlands, histosols, protected wetlands, undisturbed native grasslands) where mechanical disturbance could result in net loss of baseline soil carbon is strictly prohibited.
- A 3.2.2| **Technical & Safety Requirements:** To prevent heavy metal accumulation and soil pollution, the biochar applied shall comply with the toxicity thresholds (e.g., Pb, Cd, Hg, As, PAHs, Dioxins) defined by the European Biochar Certificate (EBC) "Agro" class, the International Biochar Initiative (IBI) standard, or national fertilizer regulations, whichever is strictest. Testing requirements are tiered by feedstock risk:
- Track 1 & 2 (Clean Biomass):** Activities exclusively utilizing clean, untreated residues (Modules F1, F2, F3, F5) are exempt from complex Polycyclic Aromatic Hydrocarbon (PAH) and Dioxin/Furan testing. Compliance for heavy metals shall be demonstrated via Composite Sampling.

- b. **Track 3 (High-Risk Waste):** Activities utilizing Organic Waste (Module F6, e.g., MSW, biosolids) or treated/sanitary timber (Module F4) are strictly mandated to conduct full, batch-specific ISO 17025 laboratory screening for Heavy Metals, PAHs, and Dioxins/Furans prior to land application. .

A 3.2.3| Application Protocols & Safeguards

- c. **Incorporation vs. Surface Application:** Biochar should ideally be physically incorporated into the root zone (top 10–30 cm) via ploughing, harrowing, or precision planting pits to minimize wind erosion and surface oxidation. Surface application (top-dressing) without physical incorporation is fully permitted for no-till agriculture and broad-acre forestry; however, the Activity Developer shall apply the correspondingly higher Reversal Risk Damage Factor for surface-exposed biochar as defined in Section 12.
- d. **Agronomic Volume Caps:** To protect smallholder food security from sudden pH shocks or nutrient immobilization, the maximum application rate on active food-producing land shall not exceed 50 metric tonnes (dry matter) per hectare, calculated as a field-level broadcast average. Precision agriculture techniques (e.g., root-zone spot dosing, banded rows, or planting pits) that result in highly localized concentrations exceeding this limit are fully permitted, provided the total volume applied does not exceed the equivalent 50 t/ha average across the defined field polygon.
- e. **Remediation Exemption:** Certified brownfield or mine-tailing remediation sites are explicitly exempt from the 50 t/ha agronomic cap, provided the elevated application rate is verified by a qualified environmental engineer or agronomist to safely immobilize toxicants.

A 3.2.4| Evidence of Application

- a. **Track 1:** Geo-tagged photographs of the application event (e.g., mixing into pits) for the statistical sample of farms defined in the monitoring plan.
- b. **Track 2 & 3:** Weighbridge tickets signed by the land manager/farmer, citing the location (GPS coordinates) and quantity delivered, by spatial polygon data (KML/Shapefiles) of the treated boundaries and a signed "Attestation of Incorporation" confirming the biochar was physically applied to the field and not stockpiled.

A 3.3| Module A2: Engineered Materials (Built Environment)

A 3.3.1| **Scope:** This module covers the encapsulation of biochar into long-lived, non-soil construction or industrial materials. The mineral matrix protects the carbon from oxidative decay, offering high durability.

- a. **Eligible Sinks:** Encapsulation is strictly restricted to inert **mineral, cementitious, or bituminous matrices** (e.g., structural and non-

structural concrete, asphalt, plaster/mortar, and fired masonry bricks)..

- b. **Ineligible Sinks:** To permanently eliminate the risk of end-of-life Waste-to-Energy (WtE) incineration, biochar shall not be integrated into combustible matrices, including plastic-wood composites, polymers, resins, or drywall/gypsum paper boards. Single-use packaging and fuel pellets are strictly prohibited.
- c. **Structural Integrity:** The biochar inclusion shall not compromise the structural safety of the host material. The Activity Developer shall ensure the downstream manufacturer complies with relevant structural performance standards (e.g., ASTM C1919-22 for biochar in cementitious composites).
- a. **Prohibition of Kiln Fuel:** In B2B concrete or asphalt applications, biochar shall strictly be utilized as an aggregate/filler in the final mixing phase. The diversion of biochar into cement kilns to be burned as an alternative fuel for Scope 1 emissions reduction is strictly prohibited and constitutes an immediate reversal.

A 3.3.2| **Safeguards (Reversal & Double Counting)**

- a. **End-of-Life:** Because the eligible matrices (e.g., concrete, asphalt) are non-combustible, the biochar will survive even if the infrastructure is demolished and sent to a municipal incinerator. Therefore, developers relying on the 5% Fixed Risk Deduction established in Section 12 are permanently exempt from 100-year end-of-life tracking and Asset Registries.
- b. **Assignment of Rights:** To prevent double-counting, the activity developer shall obtain a contractual assignment of rights from the material manufacturer, confirming that the carbon removal attribute is retained by the activity and shall not be claimed in the manufacturer's Environmental Product Declaration (EPD) or Corporate GHG Inventory.

A 3.3.3| **Evidence of Application**

- a. **Chain of Custody:** Signed B2B sales invoices linking the specific biochar batch IDs to the material manufacturer, including the executed Assignment of Rights.

A 3.4| **Module A3: Geologic and Anoxic Storage**

A 3.4.1| This module covers the permanent storage of biochar in engineered, oxygen-limited environments where oxidative decay is physically prevented.

- a. **Eligible Sinks:** Dedicated Earth Vaults (DEVs), Sealed Geologic Trenches. Active or capped methanogenic Municipal Solid Waste (MSW) landfills are strictly excluded.

A 3.4.2| **Technical Requirements**

- a. Storage is strictly limited to **Dedicated Earth Vaults**. These shall be subterranean (buried at least 2 meters below grade), strictly isolated

from the seasonal high-water table (1.5 meters clearance), dedicated purely to biochar (no mixed organic waste), and permanently sealed with an impermeable cap.

A 3.4.3| Safeguards:

- a. To secure the multi-century permanence of the vault, the developer shall implement at least one of the following safeguards:
- b. Denaturing (Economic Safeguard): Prior to or during burial, the biochar shall be physically mixed with low-value native soil, heavy clay, or raw manure. Denaturing destroys the biochar's commercial value as a clean heating fuel, permanently removing the economic incentive for future actors to excavate it.
- c. Legal Restrictive Covenant: The storage site footprint shall be geofenced. The land title shall be subject to a Legal Restrictive Covenant (or equivalent land-title notation) prohibiting future excavation for a minimum of 100 years. Where fee-simple deed restrictions are legally unavailable (e.g., customary or state-owned land), long-term state land-use concessions specifically designating the site as a permanent carbon repository are acceptable.

A 3.4.4| Evidence Requirements

- a. **Geotechnical Proof:** A Geotechnical Bore Log or certified hydrological survey submitted prior to construction proving the 1.5-meter water table clearance.
- b. As-Built Survey: Surveyor report confirming the GPS boundaries, depth, and volume of the burial cell.
- c. Engineering Certification: Validation of the cap integrity and liner installation by a qualified civil engineer.

A 3.5| References

- A 3.5.1| ASTM International. (2022). ASTM C1919-22 Standard Specification for Biochar for Use in Concrete and other Cementitious Composites. West Conshohocken, PA.
- A 3.5.2| European Biochar Certificate (EBC). (2023). EBC Guidelines for the Certification of Biochar Based Carbon Sinks. Version 3.4. Ithaka Institute.
- A 3.5.3| International Biochar Initiative (IBI). (2015). Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soil. Version 2.1. International Biochar Initiative.
- A 3.5.4| IPCC. (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. Intergovernmental Panel on Climate Change.

Annex -4| LABORATORY TESTING & ANALYTICAL METHODS

A 4.1| Optimization for Track 1 & 2 (Composite Sampling)

- A 4.1.1| To ensure financial viability for decentralized operations, Track 1 and Track 2 activities are permitted to systematically aggregate physical sub-samples across production units into representative, homogenous Composite Master Samples prior to laboratory submission.
- Homogeneity Constraint: Compositing is strictly limited to biochar produced from the exact same parent feedstock category. Mixed feedstocks shall be separated into distinct composite samples.
 - Track 1 Limit: A Master Sample shall represent a maximum of 50 metric tonnes of production, or 1 calendar month (whichever occurs first). (Note: Track 1 activities utilizing the Conservative Default Factors in Annex 5 are exempt from *C_{org}* and *H:C_{org}* laboratory testing requirements).
 - Track 2 Limit: A Master Sample shall represent a maximum of 100 metric tonnes of production, or 1 calendar month (whichever occurs first) to mitigate the commercial risk of broad lot invalidation.

A 4.2| Laboratory Accreditation Equivalency

- A 4.2.1| All formal laboratory analysis shall generally be conducted by an independent ISO 17025 accredited laboratory.
- A 4.2.2| Exemption (LDC): If no ISO 17025 accredited laboratory capable of advanced biochar analysis exists within the Host Country, the Activity developer may utilize a national university laboratory or a government-certified agricultural testing facility, provided the VVB formally audits their internal QA/QC calibration logs during verification to ensure Standard Reference Materials (SRMs) were utilized with a machine calibration error of $\leq 2\%$.

A 4.3| Analytical Standards for Stability

- A 4.3.1| To accurately calculate the molar *H:C_{org}* ratio, laboratories shall explicitly adhere to the following bifurcated protocol to prevent the chemical corruption of hydrogen bounds:
- Moisture Content (MC):** Determined via standard gravimetric oven drying (e.g., 105°C to constant weight per ASTM D1762 or ISO 18134). Thermogravimetric Analysis (TGA) is not required.
 - Total Hydrogen (H):** Shall be analyzed via Ultimate Elemental Analysis (CHNO-S) on a rigorously dried, untreated (non-acid washed) raw biochar sample.
 - Organic Carbon (C_{org}):** Total Carbon (C_{tot}) shall not be used to calculate sequestration unless the biochar is verified to contain negligible carbonates (<2% mass). C_{org} shall be determined either by

quantifying and subtracting Total Inorganic Carbon (TIC) from the C_{tot} measurement (e.g., via calcimetry), or by performing an acid wash (HCl treatment) on a secondary, separate sample to completely dissolve and remove inorganic carbonates prior to elemental carbon analysis

A 4.4| Method 2: Inertinite Petrography (1,000-Year High Durability)

A 4.4.1| This analytical method is strictly Mandatory for Track 2 and Track 3 activities aiming to unlock geological-scale High Durability (1,000+ years) via Section 8.5.

- a. **Protocol:** Laboratories shall use optical white light microscopy (following ASTM D2798 or ISO 7404-5:2009 petrographic standards) to visually determine the fraction of the carbon matrix that has thermo-chemically transitioned to highly recalcitrant inertinite. A minimum of 500 point-counts shall be made per sample.
- b. **Quantification:** Because inertinite is fundamentally insensitive to soil temperature variations, the laboratory shall report the exact fraction (%) of point-counted pyrogenic organic carbon particles that exhibit a Random Reflectance (R_o) of $\geq 2.0\%$. This reported percentage shall be applied directly to Equation 7 in Section 8.5, formally superseding the temperature-dependent decay model.

A 4.5| Tiered Testing Framework (Track 3 Cost Optimization)

A 4.5.1| To optimize operational costs for Track 3 continuous facilities, developers may utilize operational proxies:

- a. **Baseline Calibration Phase:** Full, high precision Ultimate Analysis (CHNO-S) is required during initial baseline calibration.
- b. **Routine Monitoring Phase:** For ongoing, steady-state continuous production utilizing the exact same feedstock and temperature profile, the facility may rely on high-frequency, low-cost Proximate Analysis (Fixed Carbon via ASTM D1762) as a daily/weekly QA/QC proxy to calculate continuous C_{org} .
- c. **Rigour Safeguards:** The proxy correlation curve between Fixed Carbon and C_{org} shall demonstrate a Coefficient of Determination (R^2) of ≥ 0.90 . The proxy shall be cross-calibrated against a full Ultimate Analysis at an external ISO 17025 lab at least annually, and a new baseline calibration shall be triggered immediately if the facility switches feedstock types or alters core reactor operating temperatures by $>50^\circ\text{C}$.

A 4.6| Toxicity Testing Standards (Module A1)

A 4.6.1| To ensure global consistency in assessing Module A1 agricultural safety, laboratories shall utilize internationally recognized digestion and detection protocols:

- a. Heavy Metals: Acid Digestion (EPA 3050B, EN 13650, or ISO equivalent) prior to ICP-MS or ICP-OES detection.
- b. Polycyclic Aromatic Hydrocarbons (PAHs): Aggressive non-polar solvent extraction is mandatory. Laboratories shall utilize **100% Toluene Soxhlet extraction** (e.g., EPA 3540C for 36 hours) or DIN EN 16181 protocols, followed by GC-MS detection (e.g., EPA 8270) for the 16 EPA Priority PAHs. Weak solvent extractions (e.g., acetone/hexane) are strictly prohibited.

Annex -5| CONSERVATIVE STANDARDIZATION FACTORS FOR TRACK 1 & 2

A 5.1| Normative References and Applicability

A 5.1.1| This Annex provides standardized, conservative default factors to simplify Monitoring, Reporting, and Verification (MRV) for Track 1 (Distributed) activities and specific excursion scenarios for Track 2 (Mechanized) activities.

Because this methodology strictly issues pure CDR, all historical defaults related to baseline avoided emissions (decay/burning) have been permanently deleted. All factors listed below are statistically calibrated to the conservative "tails" (10th or 90th percentiles) of peer-reviewed scientific literature.

A 5.2| Biochar Production Parameters (Track 1)

A 5.2.1| Default Yield Factors ($Y_{default}$): Used in Section 8.3 to calculate back-calculate dry biomass input from weighed biochar output when direct weighing of raw inputs is unfeasible.

Table 20. Conservative Biochar Yield Factors

Feedstock Category	Default Yield ($t_{char}/t_{dryfeed}$)	Justification (Lower Bound)
Woody Biomass (Branches, Shells, Pits, Lignin > 25%)	0.20 (20%)	Captures the lower thermodynamic bound of mass yield in open-draft flame curtain kilns (Cornelissen et al., 2016).
Herbaceous / Crop Residues (Straw, Stover, Husks, Grass)	0.15 (15%)	Herbaceous biomass exhibits lower lignin and higher volatile content, resulting in diminished fixed carbon retention post-volatilization (IPCC, 2019).

A 5.3| Default Organic Carbon Content (C_{org})

A 5.3.1| Used in in Section 8.4 to quantify sequestration potential when continuous when continuous laboratory analysis is not feasible (Track 1 Exemption). The factors systematically account for the stoichiometric dilution of carbon by inorganic ash and biogenic silica.

Table 21. Conservative Organic Carbon Content

Feedstock Category	Default C_{org} (Decimal)	Justification (Lower Bound)
Woody Biomass	0.65 (65%)	Discounted from typical 75-85% mean range for high-temp temperature woody

		char to establish a conservative lower bound (Schmidt et al., 2021).
Standard Herbaceous / Crop Residues (Wheat straw, Corn stover)	0.40 (40%)	Discounted to account for structurally lower lignin content and moderate ash fractions.
High-Ash / High-Silica Herbaceous (Rice husks, Grasses)	0.35 (35%)	Establishes the stoichiometric lower bound for feedstocks where biogenic silica heavily dilutes the organic carbon mass.

A 5.4| Activity Methane Emission Factors ($EF_{CH_4,tech}$)

A 5.4.1| These factors are used to quantify process methane slip. The standard factors are applied continuously to Track 1 activities, while the Excursion Penalty is applied to Track 2 activities only when thermal destruction proxies fail..

Table 22. Technology Methane Slip Factors

Technology Class	Emission Factor (tCH ₄ /tchar)	Justification (Upper Bound)
Flame Curtain Kilns	0.018	Track 1 Default: Based on 90 th percentile emissions observed in field-observed emissions for open-cavity flame pyrolysis, ensuring conservative modelling of sub-optimal field operations (Cornelissen et al., 2016).
TLUD Gasifiers	0.010	Track 1 Default: Based on life cycle emission profiles for micro-scale top-lit updraft gasifiers, reflecting high combustion efficiency due to the physical separation of the primary gasification and secondary oxidation zones (Sparrevik et al., 2013).
Thermal Excursion Penalty	0.150	Track 2 Penalty: Applies exclusively to production batches where the secondary combustion chamber drops below 850°C. Represents the stoichiometric worst-case scenario of venting raw syngas.

A 5.5| Standardized Deductions & Application Losses

A 5.5.1| This section standardizes lifecycle operational deductions, particularly resolving the thermodynamic reality of biochar moisture capacity resulting from kiln quenching operations..

Table 23. Standardized Deduction Factors

Parameter	Description	Value	Unit	Application
$EF_{embodied}$	Infrastructure Emissions (Track 1)	0.01	tCO ₂ e/tchar	Covers steel/concrete of kilns (amortized).
$EF_{embodied}$	Infrastructure Emissions (Track2)	0.05	tCO ₂ e/tchar	
$MC_{deduct,dry}$	Moisture Deduction (Air/Snuff Quenched)	0.15	Fraction	15% water weight assumed if not measured.
$MC_{deduct,water}$	Moisture Deduction (Water Quenched)	0.35	Fraction	35% water weight assumed if not measured.
$L_{app,manual}$	Application Loss (Precision Manual))	0.02	Fraction	2% loss during manual transport/spreading.
$L_{app,surface}$	App loss Mechanized	0.05	Fraction	5% loss during mechanized surface spreading / tilling.
$L_{app,material}$	App Loss (Module A2 / A3)	0.01	Fraction	1% transit/spillage loss before encapsulation or burial.

A 5.6| References

- A 5.6.1| Cornelissen, G., Pandit, N. R., Taylor, P., Pandit, B. H., Sparrevik, M., & Schmidt, H. P. (2016). Emissions and Char Quality of Flame Curtain Kilns for Low-Emission Biochar Production. *PLoS ONE*, 11(5), e0154617. <https://doi.org/10.1371/journal.pone.0154617> (Scientific Context: Establishes the empirical 90th percentile upper-bound for Methane Slip [0.018] and the conservative thermodynamic mass yield [20%] for open-cavity flame curtain kilns).
- A 5.6.2| Intergovernmental Panel on Climate Change. (2019). *2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories*. (E. Calvo Buendia, K. Tanabe, A. Kranjc, J. Baasansuren, M. Fukuda, S. Ngarize, A. Osako, Y. Pyrozhenko, P. Shermanau, & T. Y. Troxler, Eds.). Institute for Global Environmental Strategies. (Scientific Context: Validates the thermodynamic constraints requiring a lower biochar mass yield [15%] for herbaceous crop residues compared to woody biomass).
- A 5.6.3| Schmidt, H.-P., Kammann, C., Hagemann, N., Leifeld, J., Bucheli, T. D., Sánchez Monedero, M. A., & Cayuela, M. L. (2021). Biochar in agriculture – A systematic review of 26 global meta-analyses. *GCB Bioenergy*, 13(11), 1708–1730. <https://doi.org/10.1111/gcbb.12889> (Scientific Context: Provides the global statistical basis for the conservative 10th percentile

Organic Carbon [*C_{org}*] content constraints for both woody and herbaceous feedstocks).

- A 5.6.4| Sparrevik, M., Field, J. L., Martinsen, V., Breedveld, G. D., & Cornelissen, G. (2013). Life cycle assessment to evaluate the environmental impact of biochar implementation in conservation agriculture in Zambia. *Environmental Science & Technology*, 47(3), 1206–1215.
<https://doi.org/10.1021/es302720k> (Scientific Context: Resolves the TLUD scale mismatch by providing empirically measured emission profiles for micro-scale TLUD gasifiers in developing contexts. Additionally provides the LCA data justifying the ultra-low embodied infrastructure emissions [$EF_{\text{embodied, T1}}$] for Track 1).

Annex -6| BIOCHAR PERMANENCE FACTORS (200-Year)

A 6.1.1| **Normative Reference:** Values are derived from the Arrhenius double-exponential decay models presented in Woolf et al. (2021), calibrated for a 200-year time horizon at a reference temperature of 14.9°C with an Activation Energy (E_a) of 108 kJ/mol.

A 6.1.2| Instructions for Use:

- Identify the Molar H:Corg Ratio of the biochar batch (Columns).
- Identify the Mean Annual Soil Temperature (MAST) of the application site (Rows).
- Select the intersecting Permanence Factor (F_{perm}).
- For temperatures falling between integers (e.g., 23.5°C), round UP to the next whole degree (e.g., 24°C) to ensure conservativeness.
- Module A2 / A3 Exemption: Biochar permanently encapsulated in non-porous engineered materials (Module A2) or sealed underground anoxic earth vaults (Module A3) is physically isolated from biological soil oxidation. These modules shall bypass this table and apply a fixed F_{perm} of 0.95, provided the physical integrity safeguards in Section 12 are met.

Table 24. Permanence Factors (F_{perm}) for 200-Year Durability

Mean Annual Soil Temp (°C)	H:C < 0.4(Highly Stable)	H:C 0.4 – 0.5(Stable)	H:C 0.5 – 0.6(Moderate)	H:C 0.6 – 0.7(Minimal)
0	0.887	0.788	0.582	0.481
1	0.884	0.785	0.578	0.478
2	0.881	0.783	0.574	0.474
3	0.878	0.779	0.569	0.469
4	0.874	0.776	0.564	0.464
5	0.869	0.771	0.558	0.457
6	0.864	0.766	0.550	0.450
7	0.857	0.760	0.542	0.441
8	0.850	0.753	0.532	0.431
9	0.841	0.745	0.521	0.420
10	0.831	0.736	0.508	0.408
11	0.819	0.725	0.493	0.393
12	0.806	0.713	0.476	0.377
13	0.791	0.698	0.458	0.359
14	0.774	0.682	0.437	0.339
15	0.754	0.664	0.414	0.318

16	0.732	0.644	0.389	0.294
17	0.707	0.621	0.362	0.269
18	0.679	0.595	0.333	0.243
19	0.649	0.567	0.302	0.216
20	0.615	0.536	0.270	0.188
21	0.578	0.502	0.237	0.160
22	0.538	0.465	0.204	0.133
23	0.495	0.427	0.172	0.108
24	0.450	0.386	0.141	0.085
25	0.404	0.344	0.112	0.064
26	0.356	0.301	0.086	0.046
27	0.308	0.259	0.063	0.032
28	0.261	0.218	0.045	0.021
29	0.216	0.178	0.030	0.013
30	0.174	0.142	0.019	0.007
31	0.135	0.109	0.011	0.004
32	0.102	0.081	0.006	0.002
33	0.074	0.057	0.003	0.001
34	0.051	0.039	0.001	0.000
35	0.033	0.025	0.001	0.000
36	0.021	0.015	0.000	0.000
37	0.012	0.008	0.000	0.000
38	0.006	0.004	0.000	0.000
39	0.003	0.002	0.000	0.000
40	0.001	0.001	0.000	0.000

A 6.1.3| Mathematical Derivation of Permanence Factors

To ensure complete transparency and reproducibility, the values in Table 26 were calculated using the double-exponential decay model defined by *Woolf et al. (2021)*. Because the highly labile (degradable) fraction of biochar (f_{lab}) mineralizes rapidly within the first few years, the remaining carbon fraction at year 200 ($t=200$) is dictated exclusively by the recalcitrant carbon pool, calculated as:

$$F_{perm}(t) = f_{rec} \times \exp(-k_T \times t)$$

Where the temperature-adjusted decay rate (k_T) is derived using the Arrhenius equation to scale the reference decay rate based on the application site's specific temperature:

$$k_T = k_{ref} \times \exp \left[\frac{E_a}{R} \times \left(\frac{1}{T_{ref}} - \frac{1}{T_{soil}} \right) \right]$$

Parameters Applied:

t (Time): 200 years.

f_{rec} (Recalcitrant Fraction) & k_{ref} (Reference Decay Rate): The empirical baseline stable fractions and reference decay rates derived from Woolf et al. (2021) for the respective molar $H:Corg$ structural classes.

E_a (Activation Energy): 108,000 J/mol (The verified activation energy required to break down highly recalcitrant pyrogenic carbon).

R (Ideal Gas Constant): 8.314 J K⁻¹ mol⁻¹.

T_{ref} (Reference Temperature): 288.05 K (14.9°C, the global mean cropland soil temperature).

T_{soil} (Target Soil Temp): The applicable row's Mean Annual Soil Temperature (MAST) converted to Kelvin (°C + 273.15).

A 6.1.4| **Justification for Track 1 Default MAST (25°C):**

To eliminate the financial burden of deploying meteorological soil sensors for artisanal smallholders in Least Developed Countries (LDCs), Track 1 activities are permitted to use a conservative default Mean Annual Soil Temperature (MAST). This default is established at **25°C**. This value is scientifically justified, and acts as a strict, conservative upper-bound for the following reasons:

- a. MAST: Mean Annual Soil Temperature is the mathematical average of the soil profile across all 365 days of the year (encompassing winter and monsoon seasons) and across all day/night diurnal cycles, measured at a sub-surface depth of 30 cm. While tropical surface soils exposed to direct equatorial sunlight may briefly spike above 35°C on a summer afternoon, night-time cooling and the insulating thermal mass of the soil buffer this heat. The continuous annual average at 30 cm rarely exceeds 24°C–26°C, even in the hottest tropical agricultural zones in Sub-Saharan Africa, the Amazon Basin, and Southeast Asia.
- b. Agronomic Cooling Effects: In active agricultural settings (Module A1), the topsoil is subject to crop canopy shading and evaporative cooling from seasonal rainfall and irrigation. These agronomic realities actively depress the sub-surface MAST compared to bare, exposed soils.
- c. Prevention of Desertification Proxies: A continuous MAST of 30°C at a 30 cm depth occurs almost exclusively in hyper-arid, non-vegetated desert biomes (e.g., the deep Sahara or Death Valley) where biomass cultivation is physically impossible. Furthermore, viable rainfed agriculture—where Track 1 crop residues are generated—requires seasonal precipitation, which systematically cools the soil profile through evapotranspiration. Therefore, 25°C represents the true upper-bound for viable agriculture.

- d. Actuarial Conservativeness: By defaulting to 25°C, the methodology forces data-poor Track 1 projects to assume a 90th-percentile global decay rate. Because biological decay accelerates exponentially with heat under the Arrhenius model, applying a 25°C baseline drops the 200-year Permanence Factor to 40.4% (compared to ~83% in temperate 10°C climates). This enforces a severe, highly conservative mathematical adjustment that guarantees environmental integrity.

Annex -7| REVERSAL RISK ASSESSMENT TOOL

A 7.1.1| **Applicability:**

- This tool is applicable to Track 2 (Mechanized Transition) and Track 3 (Industrial Precision) activities to determine the project-specific Buffer Pool Contribution Rate ($Rate_{Buffer}$).
- It is Not Applicable to Track 1 activities, which shall apply the Standardized Default Buffer (10%) due to the administrative complexity of site-specific assessment. This rate is statistically calibrated to cover the 95th percentile of reversal risks in artisanal settings, including potential fuel diversion (Social Risk) and lack of precise geotechnical data (World Bank, 2014).

A 7.1.2| **Methodology:** The activity developer shall calculate the Buffer Rate by summing using the following equation.

$$Rate_{buffer} = \max(Floor_{Track,mod}, [R_{base} + \sum R_{Add} - \sum R_{Mit}])$$

Parameter	Description
R_{base}	Base Risk Score determined by the End-Use Module.
R_{Add}	Risk Additions based on site-specific hazards.
R_{Mit}	Risk Mitigations based on verified safeguards.
$Floor_{Track,mod,}$	The minimum allowable buffer rating (Safety Net).

A 7.1.3| **Step 1: Determine Base Risk (R_{base}):** The Base Risk reflects the inherent exposure of the storage medium to oxidation and disturbance.

Table 25:

Module	Base Risk	Primary Risk Driver	Justification
A1: Soil	10.0%	Open system; exposed to erosion, fire, and biotic decay.	Aligns with baseline Land Use & Forestry (LUF) non-permanence risk thresholds for open agricultural systems. Set lower than standard Soil Organic Carbon (SOC) baseline risks (which routinely approach 15-20%) to appropriately reflect biochar's superior physical recalcitrance to standard tilling, while adequately capitalizing the buffer pool against stochastic surface displacement (erosion/land-use change) over a multi-century timeframe

A3: Burial	1.0%	Closed system; engineered anoxia eliminates oxidation pathway.	Closed system; engineered anoxia eliminates oxidation pathways (Sanei et al., 2024).
-------------------	------	--	--

A 7.1.4| Step 2: Assess Specific Risk Factors (R_{Add}): Add the percentages below if the criteria are met. Evidence shall be provided in the PDD.

Table 26:

Category	Risk Factor	Criteria	Add	Evidence Required
Natural	Fire Exposure <i>(Modules A1)</i>	Site in "High Fire Risk" zone (FRI 30 yrs).	+ 4.0%	National Fire Map / NASA FIRMS
		Site in "Moderate Fire Risk" zone (FRI 30–100 yrs).	+ 2.0%	
Social	Diversion	Local Charcoal Price > Biochar Production Cost.	+ 5.0%	Local Market Survey
Legal	Land Tenure	Lease duration < Crediting Period.	+ 3.0%	Lease Agreement/ Title deed
	Enforcement	No legal covenant recording carbon storage on deed.	+ 2.0%	Legal opinion or Registry Search.

Step 3: Apply Mitigation Discounts (R_{Mit}): Subtract these percentages if the safeguard is verified.

Category	Safeguard	Criteria	Deduct	Evidence Required	Scientific Justification
Physical	Deep Incorporation	Biochar injected >20 cm depth (Module A1).	- 1.5%	Field Audit / SOPs	Prevents surface oxidation and erosion (Woolf et al., 2021).
	Irrigation	Site is permanently irrigated.	- 2.0%	Irrigation Plan	Water saturation limits oxygen availability, reducing decay.

	Engineered Cap	(Module A3) Double composite liner (HDPE + Clay).	- 0.5%	As-Built Engineering Report	Ensures permanent anoxia.
Chemical	Denaturing	Mixed with manure/compost (Non-combustible).	- 4.0%	Product Formulation Log	Physical prevention of fuel use (Module A1).
Legal	Ownership	Land Owned by Activity Developer (Freehold).	- 1.0%	Title Deed	Removes tenure risk.
Financial	Insurance	Valid Policy covering Reversal Events.	- 2.0%	Insurance Certificate	Transfers financial liability.

Step 4: Minimum Floors ($Floor_{Track,mod}$)

Compliance Track	Module A1 (Soil)	Module A2 (Materials)	Module A3 (Burial)
Track 2 (Mechanized)	5.0%	3.0%	2.0%
Track 3 (Industrial)	2.0%	1.0%	0.5%

Note: The lower floors for Track 3 reflect the higher precision of monitoring (CEMS, industrial weighing) and the generally more secure legal/tenure arrangements associated with industrial facilities.

A 7.2| References

- ASTM International. (2022). Standard Specification for Biochar for Use in Concrete and other Cementitious Composites. ASTM C1919-22.
- Sanei, H., et al. (2024). Assessing biochar's permanence: An inertinite benchmark. International Journal of Coal Geology. <https://doi.org/10.1016/j.coal.2023.104409>
- Woolf, D., et al. (2021). Greenhouse Gas Inventory Model for Biochar Additions to Soil. Environmental Science & Technology, 2021, 55, 21, 14795–14805, <https://doi.org/10.1021/acs.est.1c02425>
- World Bank. (2014). [Biochar Systems for Smallholders in Developing Countries](#). Washington, D.C.

Annex -8| REFERENCES

A 8.1| Key Methodological Standards

- A 8.1.1| Gold Standard Foundation. (2021). Land Use & Forests Activity Requirements. Version 1.2. Geneva, Switzerland.
- A 8.1.2| Gold Standard Foundation. (2022). Gender Equality Guidelines and Requirements. Version 1.2. Geneva, Switzerland.
- A 8.1.3| Gold Standard Foundation. (2022). Programme of Activities (PoA) Requirements. Version 2.0. Geneva, Switzerland.
- A 8.1.4| Gold Standard Foundation. (2023). GHG Emissions Reduction & Sequestration Product Requirements. Version 2.1. Geneva, Switzerland.
- A 8.1.5| Gold Standard Foundation. (2025). Engineered Carbon Removal Activity Requirements. Version 1.0. Geneva, Switzerland.
- A 8.1.6| Gold Standard Foundation. (2025). Methodology Standard: Requirements for Additionality Demonstration. Version 1.0. Geneva, Switzerland.
- A 8.1.7| Gold Standard Foundation. (2025). Methodology Standard: Requirements for Addressing Leakage in Methodologies (MS400-05). Version 1.0. Geneva, Switzerland.
- A 8.1.8| Gold Standard Foundation. (2025). Methodology Standard: Requirements for Baseline Determination in Methodologies (MS400-04). Version 1.0. Geneva, Switzerland.
- A 8.1.9| Gold Standard Foundation. (2025). Methodology Tool: Common Practice Analysis (MT400-06). Version 1.0. Geneva, Switzerland.
- A 8.1.10| Gold Standard Foundation. (2025). Methodology Tool: Downward Adjustment Factor Determination (MT400-05). Version 1.0. Geneva, Switzerland.
- A 8.1.11| Gold Standard Foundation. (2025). Renewal of Crediting Period Requirements. Version 2.0. Geneva, Switzerland.

A 8.2| External Standards and Methodological Tools

- A 8.2.1| ASTM International. (2022). ASTM C1919-22 Standard Specification for Biochar for Use in Concrete and other Cementitious Composites. West Conshohocken, PA: ASTM International.
- A 8.2.2| Clean Development Mechanism (CDM). (2013). Tool 16: Project and leakage emissions from biomass. Version 05.0. Bonn, Germany: UNFCCC.
- A 8.2.3| Clean Development Mechanism (CDM). (2017). Tool 04: Emissions from solid waste disposal sites. Version 08.0. Bonn, Germany: UNFCCC.
- A 8.2.4| European Biochar Certificate (EBC). (2023). EBC Guidelines for the Certification of Biochar Based Carbon Sinks. Version 3.4. Ithaka Institute.
- A 8.2.5| European Parliament. (2023). Regulation (EU) 2023/1115 on the making available on the Union market and the export from the Union of certain

commodities and products associated with deforestation and forest degradation (EUDR). Brussels: European Union.

- A 8.2.6| International Biochar Initiative (IBI). (2014). Biochar Safety Sheets: Guidelines for Health and Safety in Biochar Production and Application. International Biochar Initiative.
- A 8.2.7| International Biochar Initiative (IBI). (2015). [Standardized Product Definition and Product Testing Guidelines for Biochar That Is Used in Soil. Version 2.1](#). International Biochar Initiative.
- A 8.2.8| International Labour Organization (ILO). (2011). Safety and Health in Agriculture: Code of Practice. Geneva: ILO Office.
- A 8.2.9| World Biochar Certificate (WBC). (2022). [Guidelines for the Production of Biochar. Carbon Standards International](#).

A 8.3| Scientific Literature

- A 8.3.1| Blanco-Canqui, H., & Lal, R. (2009). Crop residue removal impacts on soil productivity and environmental quality. *Critical Reviews in Plant Sciences*, 28(3), 139-163. <https://doi.org/10.1080/07352680902776507>
- A 8.3.2| Cornelissen, G., Pandit, N. R., Taylor, P., Pandit, B. H., Sparrevik, M., & Schmidt, H. P. (2016). Emissions and Char Quality of Flame Curtain Kilns for Low-Emission Biochar Production. *PLoS ONE*, 11(5), e0154617. <https://doi.org/10.1371/journal.pone.0154617>
- A 8.3.3| Sanei, H., Rudra, A., Przyswitt, Z. M. M., Kousted, S., Sindlev, M. B., Zheng, X., Nielsen, S. B., & Petersen, H. I. (2024). Assessing biochar's permanence: An inertinite benchmark. *International Journal of Coal Geology*, 281, 104409. <https://doi.org/10.1016/j.coal.2023.104409>
- A 8.3.4| Intergovernmental Panel on Climate Change (IPCC). (2006). 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 2: Energy & Volume 4: AFOLU. Hayama, Japan: IGES.
- A 8.3.5| Intergovernmental Panel on Climate Change (IPCC). (2019). 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Volume 4: Agriculture, Forestry and Other Land Use. Hayama, Japan: IGES.
- A 8.3.6| Obernberger, I., & Thek, G. (2008). Status and Development of Pyrolysis and Gasification of Biomass in Europe. *Bioenergy 2020+*.
- A 8.3.7| Roth, C., Schmidt, H., & Hagemann, N. (2021). Biochar Production with the Flame Curtain Kiln: A User Manual. Ithaka Institute.
- A 8.3.8| Sanei, H., Rudra, A., Przyswitt, Z. M. M., Kousted, S., Sindlev, M. B., Zheng, X., Nielsen, S. B., & Petersen, H. I. (2024). Assessing biochar's permanence: An inertinite benchmark. *International Journal of Coal Geology*, 281, 104409. <https://doi.org/10.1016/j.coal.2023.104409>
- A 8.3.9| Schmidt, H.-P., Kammann, C., Hagemann, N., Leifeld, J., Bucheli, T. D., Sánchez Monedero, M. A., & Cayuela, M. L. (2021). Biochar in agriculture – A systematic review of 26 global meta-analyses. *GCB Bioenergy*, 13(11), 1708–1730. <https://doi.org/10.1111/gcbb.12889>

- A 8.3.10| Sparrevik, M., Field, J. L., Martinsen, V., Breedveld, G. D., & Cornelissen, G. (2015). Life Cycle Assessment to Evaluate the Environmental Performance of Biochar Implementation in Conservation Agriculture in Zambia. *Environmental Science & Technology*, 49(2), 756–764. <https://doi.org/10.1021/es302720k>
- A 8.3.11| Wicke, B., Smeets, E., Dornburg, V., Vashev, B., Gaiser, T., Turkenburg, W., & Faaij, A. (2011). The global technical and economic potential of bioenergy from salt-affected soils. *Energy & Environmental Science*, 4(8), 2669–2681. <https://doi.org/10.1039/C1EE01029H>
- A 8.3.12| Woolf, D., Lehmann, J., Ogle, S., Kishimoto-Mo, A. W., McConkey, B., & Baldock, J. (2021). Greenhouse Gas Inventory Model for Biochar Additions to Soil. *Environmental Science & Technology*, 55(21), 14795–14805. <https://doi.org/10.1021/acs.est.1c02425>

DOCUMENT INFORMATION

VERSION	DATE	DESCRIPTION
-	-	Public consultation

Published by Gold Standard

Contact Details

The Gold Standard Foundation
International Environment House 2
Chemin de Balxert 7-9
1219 Châtelaine Geneva, Switzerland
Tel +41 22 788 70 80
Email help@goldstandard.org