

Biochar Production and Storage



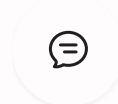
BiCRS
Protocol

This protocol outlines the MRV and best practices for high-quality carbon removal via biochar production and storage via a durable storage pathway.

 v1.1 

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1.0 ↑ ↻

Summary

This Protocol provides the requirements and procedures for the calculation of net carbon dioxide equivalent (CO_2e) Removal from the atmosphere via the production of biochar and its durable Storage.

Biochar is a durable carbon-rich solid material produced from the pyrolysis of biomass. Pyrolysis is a thermochemical conversion process, where biomass is heated in an oxygen

free environment to produce a mixture of solid biochar and condensable and non-condensable gasses. There are several storage options for biochar produced by pyrolysis, such as application to surface soil in agricultural settings, burial in the shallow subsurface, and incorporation into building materials. In each of these settings, a substantial fraction of the organic carbon content can be stored durably. The amount of carbon stored within biochar may decrease over time if the biochar is exposed to oxidizing conditions. Several physical and chemical properties of the biochar, as well as environmental factors associated with the application site, affect the rate at which organic carbon in the biochar can be potentially released back into the atmosphere. This Protocol adopts a conservative approach to crediting, with only the highly durable fraction of the organic carbon content in the biochar being eligible for the generation of Credits.

This Protocol accounts for the quantification of the gross amount of CO₂ removed via the production and durable storage of biochar and all cradle-to-grave life-cycle Greenhouse Gas (GHG) emissions associated with the process, to determine the net carbon dioxide equivalent (CO₂e) removal.

This Protocol is developed to adhere to the requirements of ISO 14064-2: 2019 – Greenhouse Gases – Part 2: Specification with guidance at the Project level for quantification, monitoring, and reporting of greenhouse gas emission reductions or removal enhancements. This Protocol ensures:

- Consistent, accurate procedures are used to measure and monitor all aspects of biochar production and storage to enable accurate accounting of net CO₂e removals;

- Consistent system boundaries and calculations are utilized to quantify net CO₂e removals;
- Requirements are met to ensure the CO₂e removals are additional; and
- Evidence is provided and verified by independent third parties to support all net CO₂e removal claims.

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Sources and Reference Standards & Methodologies

This Protocol mainly utilizes and is intended to be compliant with the following standards and protocols:

- Isometric Standard
- ISO, 14064-2: 2019 - Greenhouse Gases - Part 2: Specification with guidance at the Project level for quantification, monitoring, and reporting of greenhouse gas emission reductions or removal enhancements

Additional reference standards that inform the requirements and overall practices incorporated in this Protocol include:

- ISO 14064-3: 2019 - Greenhouse Gases - Part 3: Specification with Guidance for the verification and validation of greenhouse gas statements
- ISO 14040: 2006 - Environmental Management - Lifecycle Assessment - Principles & Framework
- ISO 14044: 2006 - Environmental Management - Lifecycle Assessment - Requirements & Guidelines

Additional standards, methodologies and protocols that

were reviewed, referenced or for which attempts were made to align with or leverage during development of this Protocol include:

- Criteria for High-Quality Carbon Dioxide Removal, Carbon Direct, Microsoft, 2023
- BS EN 15978:2011 Sustainability of construction works - Assessment of environmental performance of buildings - Calculation method
- Support to the development of methodologies for the certification of industrial carbon removals with permanent storage - Review of carbon removals through biochar, European Commission, 2024
- European Biochar Certificate Guidelines for a Sustainable Production of Biochar, Version 10.3E
- Guidelines of the World Biochar Certificate, Version 1.0B
- International Biochar Initiative - IBI Biochar Standards Version 2.1
- A Manual for Biochar Carbon Removal: Comparative guide for the certification of biochar production as a carbon sink (2024) [IBI in cooperation with HAMERKOP Climate Change & Finance]
- Global Biochar C-Cink Version 3.0

3.0 [↑](#) [↗](#)

Future Versions

This Protocol was developed based on the current state of the art, publicly available science regarding biochar production and storage. The Protocol will be updated in future versions as the science underlying biochar production and storage evolves and the overall body of knowledge and data across all processes is increased, for examples

regarding Feedstock supply, thermochemical conversion,
and durable storage.

This Protocol will be reviewed at a minimum every 2 years and/or when there is an update to scientific published literature which would affect net CO₂e removal quantification or the monitoring guidelines outlined in this Protocol. Because biochar production and storage is a novel Carbon Dioxide Removal (CDR) approach, this Protocol incorporates requirements that may be more stringent than some current relevant regulations or other protocols related to biochar for CDR. In particular, requirements for demonstrating Durability of biochar will be updated as the stability of CO₂ captured by biochar becomes well demonstrated and documented, and biochar degradation is proven to be limited.

4.0 ↑ ↗

Applicability

This Protocol applies to projects and associated operations that meet all of the following project conditions:

- The Project provides a net-negative CO₂e impact (net CO₂e removal) as calculated in the GHG Statement, in compliance with [Sections 7 and 8](#) of this Protocol;
- The Project does not disproportionately harm underserved or marginalized communities, in compliance with [Section 3.7 of the Isometric Standard](#) and [Section 5](#) of this Protocol;
- The Project is considered additional, in accordance with the requirements of [Section 6.4](#) of this Protocol; and
- The Project provides long duration storage of CO₂ (>200 years).

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Environmental & Social Safeguarding

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Overarching Principles

Following the Isometric Standard, Credits issued under this Protocol are contingent on the implementation, transparent reporting and independent Verification of comprehensive safeguards. These safeguards encompass a wide range of considerations, including environmental protection, social equity, community engagement and respect for cultural values. The process mandates that safeguard plans be incorporated into all major project phases, with detailed reports made accessible to Stakeholders. Adherence to and verification of environmental and social safeguards is a condition for all Crediting Projects.

5.1.1 ↑ ↗

Governance and Legal Framework

Project Proponents must comply with all national and local laws, regulations and policies, and receive a permit for any project activities undertaken from the relevant authority. Where relevant, projects must comply with international conventions and standards governing human rights and uses of the environment, when conducted within or foreseeably impacting party jurisdictions.

Project Proponents must document activities conducted under The Project that would require it to obtain

environmental permits.

5.2

Risk Mitigation Strategies

The Project must consider environmental and social impacts at all project locations, including the biomass sourcing, pyrolysis and biochar deployment sites as well as during biomass/biochar transportation. Appropriate measures must be implemented to identify and eliminate potential risks to terrestrial and aquatic ecosystems and biodiversity. Where risks cannot be eliminated, the Project Design Document (PDD) must identify measures to monitor ecosystem health and mitigate adverse effects through a project-specific mitigation plan. Mitigation plans must be carried out by subject matter experts, in consultation with Isometric. Refer to [Section 3.7 of the Isometric Standard](#) for further guidelines on environmental and social impacts.

Environmental and social risk assessment in adherence with [Section 3.7 of the Isometric Standard](#) must be completed to identify potential risks, followed by the development of tailored mitigation plans. These plans must encompass specific actions to avoid, minimize or rectify identified impacts. Effective implementation of these measures must also be accompanied by a robust monitoring plan to detect negative impacts and stop projects when necessary.

The severity of these risks vary based on site specifics and the intensity and duration of activities. Environmental and social risk identification, assessment, avoidance, and mitigation planning will be unique to each Project's technical, environmental, and social contexts. The risks identified in this Protocol are a minimum set to which Isometric and the Project Proponent can add risks on a case

by case basis, which would be included in the PDD.

5.2.1

Environmental Safeguards

The Project Proponent must conduct an environmental risk assessment which adheres to Section 3.7.1 of the Isometric Standard. Potential additional environmental risks associated with biochar production and storage are listed below.

Polycyclic Aromatic Hydrocarbons (PAHs) and heavy metals are pollutants of concern that may be found in biochar^{1,2}:

- PAHs are organic molecules containing fused aromatic rings and are formed in biochar as a result of incomplete combustion or pyrolysis reactions. The type and concentration of PAHs may be dependent on feedstock type, pyrolysis temperature, and carrier gas¹. PAHs are known carcinogens and exposure to PAHs may be associated with other adverse health effects³. Project Proponents must consider environmental risks that PAHs may pose to an ecosystem as a result of biochar application and demonstrate how this risk has been mitigated in the PDD. Mitigation techniques may include altering biomass feedstock source, altering pyrolysis conditions, or pretreatment of biochar to control PAH concentration¹.
- Total heavy metals concentration in soil following biochar application must not exceed the limits established by the local authority where the Project is located. In the absence of local regulations, the Project Proponent must adhere to standards set by the European Union (EU), the World Health Organization (WHO) or the United States Environmental Protection

Agency (US EPA). Justification behind the regulatory body selection must be provided in the PDD.

- If pre-existing heavy metal concentrations exceed applicable regulatory limits or guidance the Project may still be considered for crediting against this Protocol. To qualify, the Project Proponent must provide evidence of existing elevated metal concentrations and undertake specific remediation strategies to mitigate the contamination. These strategies could include altering the variety or quantity of biochar applied, implementing soil amendments or introducing phytoremediation practices using plants adept at absorbing heavy metals. These practices should only be undertaken where they do not contradict applicability criteria in the relevant storage Module. Any Project with pre-existing elevated heavy metal concentrations which further aggravates soil contamination, will not meet the safeguarding criteria of this Protocol.
- Other pollutants of concern that may be found in biochar as a result of pyrolysis include Polychlorinated biphenyls (PCBs), Dioxins, and Furans. Project Proponents must also include how environmental risks due to these pollutants are being screened and mitigated. Please refer to the relevant storage Module for further guidance on application thresholds to adhere to for these parameters.

5.2.2

Social Safeguards

The Project Proponent must conduct a social risk assessment which adheres to Section 3.7.2 of the Isometric Standard on social impacts. In particular, this should include specific risks to human health that may be associated with biochar production, application and/or storage during the

Project, for example during transport and application due to dust.

5.2.2.1

Stakeholder Engagement

In accordance with Section 3.5 of the Isometric Standard, Project Proponents must demonstrate active stakeholder engagement through a Stakeholder Input Process throughout project planning and operation, ensuring that all risk mitigation strategies contribute to sustainable project outcomes. Local stakeholders situated in the vicinity of the Project site may contribute an in-depth understanding of the local system and provide invaluable insights and recommendations on the potential risks, necessary safeguards and specific monitoring needs. The Stakeholder Input Process must adhere to requirements outlined in Section 3.5 of the Isometric Standard, and evidence of these meetings must be submitted in the PDD.

5.2.3

Adaptive Management

Project Proponents must include in the PDD a plan for information sharing, emergency response and conditions for stopping or pausing a deployment. Plans for pausing or stopping a deployment must be in place in instances where there may be:

- Instrument malfunctions leading to data-gaps in required monitoring;
- Pollutants/metals of concern exceed thresholds outlined in the PDD;

- Regulatory non-compliance, e.g. danger to ecosystem health detected (such as by the local community or a government agency); or
 - Compromised health and/or safety of workers and/or local stakeholders.
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6.0 ↑ ↗

Relation to Isometric Standard

The following topics are covered briefly in this Protocol due to their inclusion in the [Isometric Standard](#), which governs all Isometric Protocols. See in-text references to the [Isometric Standard](#) for further guidance.

6.1 ↑ ↗

Project Design Document

For each specific project to be evaluated under this Protocol, the Project Proponent must document project characteristics in a Project Design Document (PDD) as outlined in [Section 3.2 of the Isometric Standard](#). The PDD will form the basis for [Project Validation](#) and evaluation in accordance with this Protocol, and must include consideration of processes unique to biomass such as:

- Location information for biomass production, biomass pyrolysis, and the storage area, including project boundaries of the Project area;
- Conditions of biomass use prior to Project initiation;
- Details on technologies, products, and services relevant to biochar production, including production rates, process parameters, and volumes;
- Detailed biochar characterization (see [Biochar Storage](#)

in Agricultural Soils Module 1.1, Section 3)

- Description of any models used to quantify processes relevant to the calculation of CO₂ removal that are not directly measurable; and
- Description of measurement methods for all required analyses, cross-referenced with relevant standards where applicable.

6.2 ↑ ↻

Verification and Validation

Projects must be validated and net CO₂e removals verified by an independent third party, consistent with the requirements described in this Protocol and in [Section 4 of the Isometric Standard](#).

The Validation and Verification Body (VVB) must consider the following requisite components:

1. Validate that feedstock adheres to the requirements listed in the [Biomass Feedstock Accounting Module v1.2](#).
2. Verify that storage sites adhere to the requirements listed in the relevant storage [Module](#).
3. Verify that the quantification approach adheres to requirements of [Section 8](#) of this Protocol and the relevant storage [Module](#), including provision of required records.
4. Verify that the Environmental & Social Safeguards outlined in [Section 5](#) of this Protocol are met.
5. Verify that the Project is compliant with requirements outlined in the [Isometric Standard](#).

6.2.1

Verification Materiality

The threshold for Materiality, considering the totality of all omissions, errors and mis-statements is 5%, in accordance with Section 4.3 of the Isometric Standard.

Verifiers must also verify the documentation of Uncertainty of the GHG Statement as required by Section 2.5.7 of the Isometric Standard. Qualitative Materiality issues may also be identified and documented, such as:

- Control issues that erode the verifier's confidence in the reported data;
- Poorly managed documented information;
- Difficulty in locating requested information; and
- Noncompliance with regulations indirectly related to GHG emissions removals or storage.

6.2.2

Site Visits

Project validation and verification must incorporate site visits to project facilities in accordance with the requirements of ISO 14064-3, 6.1.4.2, including site visits during validation and initial verification to the biomass pyrolysis site and the biochar application site. In the instance of multiple application sites under a single verification event, a representative number of application sites can be selected for the site visits. Validators should, whenever possible, observe operation of the biochar processing and deployment to ensure full documentation of process inputs and outputs through visual observation. Guidance on the number of sites to be taken as a

"representative" number here should be outlined in the PDD and agreed upon with Isometric prior to verification. In cases where it is not possible to line up site visits to the pyrolysis site and application site, alternative arrangements may be agreed in advance with Isometric, for example using photo and video evidence of activities at the application site, and/or introducing spot check site visits for ongoing operations.

6.2.3

Verifier Qualifications & Requirements

Verifiers and validators must comply with the requirements defined in Section 4 of the Isometric Standard. In addition, teams must maintain and demonstrate expertise associated with the specific technologies of interest, including biomass growth or production, biomass processing and pyrolysis, sampling, analysis, and data processing.

Competency must be demonstrated in accordance with Isometric's VVB policy, for example based on the relevant sectoral scope accreditations in IAF MD 14, or another demonstration of relevant expertise for this protocol and the selected storage module(s).

6.3

Ownership

CDR via biochar is often a result of a multi-step process (such as biomass growth, harvesting, transport, pyrolysis, processing, and storage), with activities in each step potentially managed and operated by a different operator, company, or owner. When there are multiple parties involved in the process, and to avoid Double Counting of net CO₂e

removals, a single Project Proponent must be specified contractually as the sole owner of the Credits. Contracts must comply with all requirements defined in [Section 3.1 of the Isometric Standard](#).

6.4 ↑ 🔗

Additionality

The Project Proponent must be able to demonstrate [Additionality](#) through compliance with [Section 2.5.3 of the Isometric Standard](#). The [baseline scenario](#) and [counterfactual](#) utilized to assess additionality must be project-specific, and are described in [Section 7.2](#) of this Protocol.

Additionality determinations should be reviewed and completed at the time of initial verification or whenever project operating conditions change significantly, such as the following:

- Regulatory requirements or other legal obligations for project implementation change or new requirements are implemented; or
- Project financials indicate [Carbon Finance](#) is no longer required to incentivize the use of biochar for carbon removal, potentially due to, for example:
 - Increased tipping fees for waste feedstocks;
 - Increased revenues from farmers paying for agronomic services;
 - Reduced rates for capital access; or
 - Decreases in the effective cost of producing biochar due to increased revenue from co-product sales.

Any review and change in the determination of additionality shall not affect the availability of Carbon Finance and Credits for the current or past Crediting Periods. If the review indicates the Project has become non-additional, this shall make The Project ineligible for future Credits⁴.

6.5

Uncertainty

The uncertainty in the overall estimate of the net CO₂e removal as a result of the Project must be accounted for. The total net CO₂e removed for a specific Reporting Period, *RP*, CO₂e_{Removal, RP}, must be conservatively determined in accordance with the requirements outlined in Section 2.5.7 of the Isometric Standard.

6.5.1

Reporting of Uncertainty

Projects must report a list of all input variables used in the net CO₂e removal calculation and their uncertainties, including:

- Emission factors utilized, as published in public and other databases used;
- Values of measured parameters from process instrumentation, such as truck weights from weigh scales, flow rates from flow meters, electricity usage from utility power meters, and other similar equipment;
- Laboratory analyses, including analysis of carbon content of biochar; and
- Data used to model and estimate biochar degradation.

The uncertainty information should at least include the minimum and maximum values of a variable. More detailed uncertainty information should be provided if available, as outlined in [Section 2.5.7 of the Isometric Standard](#).

In addition, a [sensitivity analysis](#) that demonstrates the impact of each input parameter's uncertainty on the final net CO₂e uncertainty must be provided. Details of the sensitivity analysis method must be provided such that a third party can reproduce the results. Input variables may be omitted from an uncertainty analysis if they contribute to a < 1% change in the net CO₂e removal. For all other parameters, information about uncertainty must be specified.

6.6 [↑](#) [🔗](#)

Data Sharing

In accordance with the [Isometric Standard](#), all evidence and data related to the underlying quantification of the net CO₂e removal and environmental and social safeguards monitoring will be available to the public through Isometric's platform. This includes:

- Project Design Document;
- GHG Statement;
- Measurements taken and supporting documentation, such as calibration certificates;
- Emission factors used
- Scientific literature used; and
- Proof of necessary permits.

The Project Proponent can request certain information to be restricted (only available to authorized [Buyers](#), the [Registry](#) and [Validation and Verification Bodies \(VVBs\)](#)) where it is

subject to confidentiality. This includes emissions factors from licensed databases. However, all other numerical data produced or used as part of the quantification of net CO₂e removal will be made available.

7.0 [↑](#) [🔗](#)

System Boundary & Project Baseline

7.1 [↑](#) [🔗](#)

System Boundary & GHG Emissions Scope

The scope of this Protocol includes GHG sources, sinks and reservoirs (SSRs) associated with a biochar CDR project. A cradle-to-grave GHG Statement must be prepared encompassing the GHG emissions relating to the activities outlined within the system boundary.

GHG emissions associated with The Project may be as direct emissions from a process or storage system or as indirect emissions from combustion of fuels, electricity generation, or other sources. Emissions for processes within the system boundary must include all GHG SSRs from the construction or manufacturing of any project-specific physical site and associated equipment; closure and disposal of each site and associated equipment; and operation of each process (including biochar production, processing, characterization, transport and spreading) to include Embodied Emissions of consumables in the process.

Any emissions from sub-processes or process changes that would not have taken place without the CDR project, such as subsequent transportation and refining, must be fully

[illegible]

ACTIVITY	GHG SOURCE, SINK OR RESERVOIR	GHG	SCOPE	TIMESCALE OF EMISSIONS AND ACCOUNTING ALLOCATION
Project Establishment	Equipment and materials manufacture	All GHGs	Embodied emissions associated with equipment and materials manufacture for project establishment (lifecycle modules A1-3 ⁵). To include product manufacture emissions for equipment, buildings, infrastructure and temporary structures.	Before project operations start - must be accounted for in the first Reporting Period or amortized in line with allocation rules (See Section 8.5.1)
	Equipment and materials transport to site	All GHGs	Transport emissions associated with transporting materials and equipment to the Project site(s) (lifecycle module A4 ⁵).	
	Construction and installation	All GHGs	Emissions related to construction and installation of the project site(s) (lifecycle module A5 ⁵). To include energy use for construction, installation and groundworks, as well as waste processing activities and emissions associated with land use change.	
	Initial surveys and feasibility studies	All GHGs	Any embodied, energy and transport emissions associated with surveys or feasibility studies required for establishment of the project site.	
	Misc.	All GHGs	Any SSRs not captured by categories above, for example staff transport.	
	Biomass feedstock sourcing	All GHGs	Any embodied, energy and transport emissions associated with biomass cultivation and harvesting.	
	Biomass feedstock transport	All GHGs	Transport of biomass including to biomass processing site and all other transport of biomass ahead of biochar production.	
	Biomass feedstock processing	All GHGs	Any embodied, energy and transport emissions associated with biomass feedstock processing.	
			Emissions associated with pyrolysis including: energy use	

ACTIVITY	GHG SOURCE, SINK OR RESERVOIR	GHG	SCOPE	TIMESCALE OF EMISSIONS AND ACCOUNTING ALLOCATION
Operations	Pyrolysis	All GHGs	• maintenance of the project site(s), equipment, vehicles, buildings and infrastructure including activities associated with maintenance (lifecycle module B2⁵), repair (B3), replacement (B4) and refurbishment (B5) • use of consumables • waste processing, including the environmentally responsible disposal of non-solid residues	Over each Reporting Period - must be accounted for in the relevant Reporting Period (See Section 8.5.2)
	Direct emissions	All GHGs	Direct emissions released during pyrolysis. See Section 9.2.1 for calculation details.	
	Biochar processing	All GHGs	Emissions associated with biochar processing and characterization including: • energy use • maintenance of the project site(s), equipment, vehicles, buildings and infrastructure including activities associated with maintenance (lifecycle module B2⁵), repair (B3), replacement (B4) and refurbishment (B5) • use of consumables • waste processing	
	Biochar storage	All GHGs	Emissions associated with biochar storage including: • energy use through electricity or fuel consumption • maintenance of the project site(s), equipment, vehicles, buildings and infrastructure including activities associated with maintenance (lifecycle module B2⁵), repair (B3), replacement (B4) and refurbishment (B5) • use of consumables • waste processing • land use change emissions associated with application	

ACTIVITY	GHG SOURCE, SINK OR RESERVOIR		SCOPE	TIMESCALE OF EMISSIONS AND ACCOUNTING ALLOCATION
	GHG			
			requiring burial	
	Biochar transport	All GHGs	All transport of biochar including to biochar processing site and to the biochar storage site.	
	CO ₂ Stored	CO ₂ only	The gross amount of CO ₂ removed and durably stored from a biochar project over a Reporting Period.	
	Sampling required for MRV	All GHGs	Any embodied, energy and transport emissions associated with sampling for MRV purposes, including transportation to collect samples, shipping of samples for laboratory analysis and sample processing.	
	Staff travel	All GHGs	Flight, car, train or other travel required for the project operations, including contractors and suppliers required on site.	
	Surveys	All GHGs	Equipment, energy use and transport associated with surveys e.g. ecological surveys.	
	Misc.	All GHGs	Any SSRs not captured by categories above.	
End-of-Life	End-of-life of project facilities	All GHGs	Anticipated end-of-life emissions (lifecycle modules C1-4 ⁵). To include deconstruction and disposal of the project site(s), equipment, vehicles, buildings or infrastructure.	After Reporting Period - must be accounted for in the first Reporting Period or amortized in line with allocation rules (See Section 8.5.3)
	Misc.	All GHGs	Any emissions SSR not captured by categories above.	

The Project Proponent must consider all GHGs associated with SSRs, in alignment with the United States Environmental Protection Agency's definition of GHGs, which includes: carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and fluorinated gasses such as hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF₆) and

nitrogen trifluoride (NF₃). For CO₂ stored, only CO₂ shall be included as part of the quantification. For all other activities all GHGs must be considered. For example, the release of CO₂, CH₄, and N₂O is expected during diesel consumption.

All GHGs must be quantified and converted to CO₂e in the GHG Statement using the 100-year Global Warming Potential (GWP) for the GHG of interest, based on the most recent volume of the IPCC Assessment Report (currently the Sixth Assessment Report).

Miscellaneous GHG emissions are those that cannot be categorized by the GHG SSR categories provided in **Table 1**. The Project Proponent is responsible for identifying all sources of emissions directly or indirectly related to project activities and must report any outside of the SSR categories identified as miscellaneous emissions.

Emissions associated with a project's impact on activities that fall outside of the system boundary of a project must also be considered. This is covered under Leakage in Section 8.5.4.

7.1.1

System boundary considerations

7.1.1.1

Ancillary activities

Ancillary activities (such as supplementary research and development activities and corporate administrative activities) that are associated with a project but are not directly or indirectly related to the issuance of Credits can be excluded from the system boundary.

7.1.1.2

Secondary Impacts on GHG emissions

Biochar may have additional impacts on GHG emissions beyond the scope of this Protocol. For example, there may be potential for increased Soil Organic Carbon (SOC) as a result of biochar application to soil. These potential secondary climate effects are uncertain at this time and are not covered by this Protocol.

7.1.1.3

Considerations for Waste Input Emissions

Embodied emissions associated with system inputs considered to be waste products can be excluded from the accounting of the GHG Statement system boundary provided the appropriate eligibility criteria are met.

For waste energy inputs, for example the use of waste heat, refer to the Energy Use Accounting Module v1.2.



Energy Use Accounting



Refer to Energy Use Accounting Module for the calculation guidelines.

For waste biomass feedstocks, refer to the Biomass Feedstock Accounting Module v1.2. All eligibility criteria described in the Biomass Feedstock Accounting Module must be satisfied in order to exclude biomass sourcing emissions from the system boundary. Emissions relating to any processing and transport of biomass feedstock must be

included in the system boundary.

 Biomass Feedstock Accounting 

See Biomass Feedstock Accounting Module for eligibility criteria.

For all other waste inputs, the following criteria shall be considered. If EC1 in Table 2 is satisfied, embodied emissions associated with the waste product input can be excluded from the system boundary. Market leakage emissions associated with waste inputs may also be excluded from the system boundary, as compliance with EC1 would result in no change to the waste producer behavior (i.e. no market leakage) and indicates there are no alternative users of the waste product (i.e. no replacement emissions).

Table 2. Waste input emissions exclusion criteria, EC1

CRITERIA	DESCRIPTION	DOCUMENTATION REQUIRED
EC1	No payment was made for the material, or only a “tipping fee” is paid.	Feedstock purchase or removal records between Project Proponent and feedstock supplier demonstrating price paid, amount, buyer, seller and date. Additionally, a signed affidavit from the Project Proponent stating that no in-kind compensation was made to the feedstock supplier must be provided.

If EC2 and EC3 in Table 3 are both satisfied, embodied emissions associated with the waste product input can be excluded from the system boundary. Market leakage emissions associated with waste inputs may also be excluded from the system boundary, as compliance with EC2 and EC3 would result in no significant change to the waste producer behavior (i.e. no market leakage) and there are no alternative use cases for the waste product (i.e. no

replacement emissions).

Table 3. Waste input emissions exclusion criteria, EC2 and EC3

CRITERIA	DESCRIPTION	DOCUMENTATION REQUIRED
EC2	The amount of the waste product used by the CDR project was not already being utilized as a valuable product by another party for non-CDR uses. Therefore, the producer of the waste product has no alternative use case for the waste product.	Feedstock purchase or removal records between Project Proponent and feedstock supplier demonstrating price paid, amount, buyer, seller and date. Additionally, an affidavit from the waste supplier identifying that there are no alternative use cases for the waste product.
EC3	Payments for the waste product do not constitute a significant share of upstream operations revenue for the waste producer.	Feedstock purchase or removal records between Project Proponent and feedstock supplier demonstrating price paid, amount, buyer, seller and date. Additionally, an affidavit from the waste supplier that documents that payments from the project do not constitute a significant share of upstream operations revenue.

7.1.1.4

Considerations for Project Activities Integrated into Existing Practices

In some instances, the project activities may be integrated into existing activities, such as biochar spreading while tilling. Activities that were already occurring, and would continue to occur in the absence of The Project, may be omitted from the system boundary of the GHG accounting if evidence of this is provided.

7.1.1.5

Co-product allocation

The biomass pyrolysis process may result in the production of co-products, such as bio-oil, pyrolysis gas (bio-gas), electricity and heat. To allocate project emissions associated with CDR and co-product(s), the Project

Proponent may use one or a combination of, where relevant, the following co-product allocation procedures outlined below.

Procedure 1: Allocate all emissions to CDR

Projects may opt to allocate all project emissions to CDR. The co-product(s) must still comply with all relevant emission accounting regulations and requirements, which may mean emissions are double counted. Removals must not be double counted. This is the most conservative approach to take.

Procedure 2: Divide the process into sub-processes

Where possible, the process may be divided into sub-processes. For example it may be possible to isolate processes relating to processing of the co-product, or the biochar process may be a retrofit to an existing process.

Eligibility criteria, evidence requirements and GHG system boundary considerations are set out in Table 4. One of EC4 or EC5 must be satisfied in order to divide the process into sub-processes.

Table 4. Procedure 2 Eligibility Criteria, EC4 and EC5

CRITERIA	DESCRIPTION	DOCUMENTATION REQUIRED
EC4	The biochar production process is a retrofit to an existing facility that was operable prior to the introduction of the CDR process. The purpose of the existing facility must not have been CDR prior to retrofit.	Records of existing facility activities dating back 3 years must be provided for a major infrastructure projects where a planning application was required. For all other projects, records of the existing facility activities dating back 6 months is required. The distinction between major infrastructure projects and other projects is to ensure that the biochar process is a retrofit, as major infrastructure project construction may be staged over many years. The GHG system boundary in this case is limited to materials and processes necessary for the retrofit and processes that directly contribute to the biochar CDR process, including existing processes at the facility that are operated at increased capacity to provide for biochar production and additional load bearing structures. Evidence of fractional

CRITERIA	DESCRIPTION	DOCUMENTATION REQUIRED
		differences in inputs, for example the step-change in energy requirements for the addition of a biochar process as a retrofit to an existing facility, must be evidenced in full. Any reduction in efficiency of energy production as a result of the biochar production process must be included in the system boundary.
EC5	The process has components and operations that are physically separate from one another.	Evidence of separation, for example engineering diagrams showing separate equipment or electricity metering systems for separate components of the process. Sub-processes that can be isolated from the CDR process and do not contribute to CDR may be excluded from the system boundary.

Procedure 3: Substituting emissions

Project Proponents may use the substitution method to incorporate emissions associated with a substitute co-product into the system boundary as an avoided burden. This is referred to as "expanding the system boundary" in ISO 14044:2006. In practice, the co-product emissions are substitutes with emissions for an equivalent product and subtracted from total project GHG emissions.

The calculation approach to be followed is set out below:

1. Report the quantity and type for all marketed co-products produced within the Project system boundary.
2. Identify the use of the co-product and the appropriate alternative product (the "substitute product") considering the product qualities and specific use case.
3. Determine the emissions intensity associated with the substitute product, in line with the following requirements:
 - Where multiple similar substitute products with variable emissions intensities are available, the most conservative substitute product must be selected. This is the substitute product with the lowest emissions intensity.
 - If the use of the product is electricity generation which is supplied to the grid, then the emissions

intensity associated with the substitute product will be the average grid intensity of the region for the most recent year.

- The emissions intensity associated with the substitute product must be conservative, from a reputable source and approved by Isometric ahead of verification.
 - Where the product will be subject to policy or regulatory requirements, for example in relation to tax credits or to satisfy specific marketing claims, the most conservative threshold for emissions intensity shall be selected.
4. The quantity of merchantable co-products sold should be multiplied by the approved substitute product emissions intensity factor to determine the total substituted emissions.
 5. The total substituted emissions should be subtracted from $CO_2e_{Emissions,RP}$ (see [Section 8.2](#)). Both the total project emissions, and the project emissions following substitution must be documented.

Procedure 4: Carbon mass balance if the co-product leads to crediting

Physical allocation based on carbon mass balance shall be used in instances where the co-product leads to crediting for CDR with Isometric, for example if the process produces both biochar and bio-oil. This is so that emissions are distributed according to the CO₂ balance output of the system. The requirement for crediting to be with an Isometric project ensures that co-product allocation can be traced and verified appropriately and according to the same set of allocation and emissions accounting requirements. The co-product allocation between CDR products can be made after process subdivision and substitution has taken place,

however EC1 for subdivision is not viable where there is more than one CDR product.

7.2 [↑](#) [↗](#)

Baseline

The baseline scenario for biochar projects assumes that the activities associated with the biochar Project do not take place and that any infrastructure associated with the biochar Project is not built.

The counterfactual is the CO_2 stored in the biomass feedstock that would have remained durably stored in the biomass in the absence of the Project. This is called ineligible biomass in the [Biomass Feedstock Accounting Module v1.2](#). The Biomass Feedstock Accounting Module sets out requirements for establishing ineligible biomass as part of the Counterfactual Storage Eligibility criteria. The Biomass Feedstock Accounting Module includes details for quantification of $\text{CO}_2e_{\text{Counterfactual},RP}$.



Biomass Feedstock Accounting



See [Section 3](#) of the Biomass Feedstock Accounting Module for requirements.

8.0 [↑](#) [↗](#)

Net CDR Calculation

8.1 [↑](#) [↗](#)

Calculation Approach and Reporting Period

The Reporting Period, RP, for biochar projects represents an interval of time over which removals are calculated and reported for verification. The equations used to calculate net CO₂e removals will pertain to all GHG emissions and CO₂ removals occurring over a Reporting Period. In most cases, the Reporting Period will be an interval of time bounded by a batch of biomass feedstock sourcing, pyrolysis, biochar processing and biochar storage activities, for example a spreading event.

For all storage pathways associated with biochar, it is necessary to calculate the carbon content of the biochar, $C_{biochar}$. Guidelines for determining biochar carbon content are outlined below, and should be used in conjunction with the relevant storage Module.

In addition to biochar quantification, upfront characterization is required to assess CO₂ removed via the production of biochar and biochar durability. The requirements for this are set out in [Biochar Storage in Agricultural Soils Module 1.1, Section 3](#)).

GHG emission calculations must include all emissions related to the project activities that occur within the Reporting Period. This includes: (a) any emissions associated with project establishment allocated to the Reporting Period (See [Section 8.5.1](#)) (b) any emissions that occur within the Reporting Period (See [Section 8.5.2](#)), (c) any anticipated emissions that would occur after the Reporting Period that have been allocated to the Reporting Period (See [Section 8.5.3](#)) and (d) leakage emissions that occur outside of the system boundary that are associated with the Reporting Period (See [Section 8.5.4](#)).

Total net CO₂e removal is calculated for each Reporting Period, and is written hereafter as $CO_2e_{Removal,RP}$. The final net CO₂e removal quantification must be conservatively determined, giving high confidence that at a minimum, the estimated amount of CO₂e was removed.

In line with the Isometric Standard, this Protocol requires that Removal Credits are issued ex-post. Credits may be issued once CO₂ has been durably stored in the identified storage reservoir.

8.2 [↑](#) [↗](#)

Calculation of CO₂eRemoval, RP

Net CO₂e removal for the production of biochar and its durable storage for each Reporting Period, RP , can be calculated by Equation 1.

$$CO_2e_{Removal,RP} = CO_2e_{Stored,RP} - CO_2e_{Counterfactual,RP} - CO_2e_{Emission,RP}$$

(Equation 1)

Where:

- $CO_2e_{Removal,RP}$ - the total net CO₂e removal for the Reporting Period, RP, in tonnes of CO₂e.
- $CO_2e_{Stored,RP}$ - the total CO₂ removed from the atmosphere and stored as organic carbon in the biochar for the RP, in tonnes of CO₂e.
- $CO_2e_{Counterfactual,RP}$ - the total counterfactual CO₂

removed from the atmosphere and stored as organic carbon in the absence of the Project for the RP, in tonnes of CO₂e.

- $CO_2e_{Emissions,RP}$ - the total GHG emissions for the RP, in tonnes of CO₂e.

Reversals which occur after Credits have been issued are separately accounted for by the Buffer Pool, and are therefore not included in Equation 1. Risk of reversal information is given in [Appendix 1: Risk of Reversal Questionnaire](#), with further information provided in [Section 5 of the Biochar Storage in Agricultural Soils Module](#)

8.3

Calculation of CO₂e_{Stored, RP}

The method of calculation for $CO_2e_{Stored,RP}$ will depend on the method of storage. Refer to the relevant storage Module for requirements (see [Section 10](#)).

8.3.1

Calculation of C_{biochar}

$C_{biochar}$ can be calculated for either a blend of biochars (Storage Batch), or for individual Production Batches.

A 'Production Batch', p , typically consists of utilizing a single type of biomass feedstock, often of a single source of origin, converting the biomass to biochar via pyrolysis, and transporting that biochar to the storage site for storage. The unique characteristics of the biomass used, the pyrolysis process, the produced biochar characteristics, transportation distances, and storage site characteristics will be the same for all of the biochar within a Production

Batch. The process leading to the formation of a 'Production Batch' is a 'Production Process'.

The total amount of CO₂ contained in the stored biochar can be calculated as follows.

Where all biochar Production Batches are blended prior to storage:

$$CO_2e_{Stored, n} = \frac{C_{biochar, n} \cdot m_{biochar, n}}{C_{CO_2}}$$

(Equation 2)

Where biochar Production Batches are not blended prior to storage:

$$CO_2e_{Stored, n} = \sum_{p=1}^k \left(\frac{C_{biochar, p} \cdot m_{biochar, p}}{C_{CO_2}} \right)$$

(Equation 3)

Where:

- n - Storage Batch
- p - Production Batch
- k - number of Production Batches, p , blended in the Storage batch, n
- $CO_2e_{Stored, n}$ - the total CO₂ removed for batch n , in tonnes of CO₂e

- $C_{biochar, n(p)}$ - the concentration of C in the biochar stored for Storage Batch n OR for each production batch p included in storage Batch n , as weight percent
- $m_{biochar, n(p)}$ - the total mass of biochar emplaced for Storage Batch n OR for each production batch p included in Storage Batch n , in tonnes
- C_{CO_2} - the content of C in CO_2 , as a mass percent

The total carbon content in biochar must be assessed following ASTM D5373: Standard Test Methods for Determination of Carbon, Hydrogen and Nitrogen in Analysis Samples of Coal and Carbon in Analysis Samples of Coal and Coke, or an equivalent procedure that yields the percent weight of carbon (%wt of C) in the biochar. Alternative methods or analytical equipment which determine total carbon content may be utilized if justified and documented to be equivalent to ASTM D5373. For example, EPA 9060A can be used for analysis of liquid samples, in the case where a biochar may be applied as a slurry.

This Protocol provides two alternative methods for the frequency with which carbon content must be measured and quantified. The first method (A) involves measuring every batch, the second method (B) involves only sampling a proportion of all batches, and conservatively estimating the carbon content of unsampled batches.

Method A: Measure every Batch

Using this method, the carbon content of the Production Batch must be quantified through direct measurement, either by:

1. Sampling the Biochar. Note that in the case of unblended biochar, the Biochar originates from only a single Production Batch, by definition, and no

calculation is required; or

2. Sampling all constituent Production Batches which comprise the Storage Batches, and calculating the carbon content of the Storage Batch through a linear weighted combination of the carbon contents of these Production Batches, as given in Equation 3.

For details regarding the acceptable minimum number of samples to be taken for each sampled Batch, see minimum number of samples per Batch below. If multiple samples are taken per Batch, the average $C_{biochar}$ content of these samples must be used. Data used to calculate the average should be reported.

Method B: Sampling a Production Process

For a given Production Process of a feedstock, samples must be taken directly for an agreed upon number of Production Batches, to ensure there is enough data to estimate carbon content for future Production Batches with appropriate statistical significance. This should be agreed with Isometric. Until the time at which this threshold is reached, Method A must be used.

Subsequently, samples must be taken at least every 10 Production Batches. The frequency of sampling Production Batches can alternatively be agreed upon with Isometric prior to verification, provided the production process conditions can be proven to be stable over the course of the Project.

For the acceptable minimum number of samples to take per Batch, see minimum number of samples per Batch below.

For batches which are not sampled, carbon content must be conservatively estimated, as follows:

$$C_{Biochar} = \mu_{CC} - \sigma_{\overline{CC}}$$

(Equation 4)

$$\sigma_{\overline{CC}} = \frac{\sigma_{CC}}{\sqrt{n_{samples}}}$$

(Equation 5)

Where:

- $\sigma_{\overline{CC}}$ - the standard error of the mean of carbon content, across all eligible samples for this Production Process
- σ_{CC} - the standard deviation of carbon content, across all eligible samples for this Production Process
- $n_{samples}$ - the number of eligible samples for this Production Process
- μ_{CC} - the mean carbon content of all eligible samples for this Production Process

Eligible samples are those taken in the previous 6 months before a specific Production Batch was produced. Older samples may not be used.

Additionally, batches must be subject to random sampling, to alleviate the risk of any given batch containing substantially different carbon contents.

A random sampling approach must be agreed upon with

Isometric and documented in the Project Design Document, whereby Isometric will contact the Project Proponent on randomly selected days, at an agreed cadence, which must be no less frequent than once per month, on average. Once contacted, the Project Proponent must sample the carbon content of the subsequent batches processed.

If the Project Proponent is unable to carry this random sampling out on 3 occasions within a 6 month period, or if within a 6 month period more than 3 measurements are below 3 standard deviations from the mean, this will trigger a project review by Isometric.

If there is a significant change to a Production Process for a feedstock, which is likely to alter the average carbon content of the feedstock, or if significant deviations in carbon content are detected (as described below), the feedstock should be considered as a new Production Process. This means that sampling must be restarted, with all prior samples no longer able to be used for estimating carbon content.

Minimum number of samples per Batch

For all measurements taken, samples must be from a well mixed and representative aliquot of the biochar. To account for the possibility of variation within a single Production Batch either of the following approaches must be adopted:

1. A minimum of 3 samples must be taken for each measured Production Batch. These samples must be representative of the full range of physical characteristics (eg. particle size, color) available in the batch.
2. Justification and evidence must be provided to demonstrate that the “within batch” variation is likely to

be minimal. For example, this could be justified due to the physical details of the Production Process used, or alternatively by providing data examining the “within batch” carbon content variation.

Process for handling carbon content measurement outliers

This process applies only if method B is used to calculate carbon content and should be used whether a batch was sampled or not. For a given Production Process, an Outlier is defined as any individual sample which lies more than 3 standard deviations, σ_{CC} , above or below the mean. To minimize the potential overall impact of outlier measurements, all carbon content measurement outliers must be handled via applying the technique of "winsorization", as follows.

For a given measurement, m , the winsorized measurement m_w is defined as follows:

- For a measurement m where $m > \mu + 3\sigma_{CC}$, $m_w = \mu + 3\sigma_{CC}$
- For a measurement m where $m < \mu - 3\sigma_{CC}$, $m_w = \mu - 3\sigma_{CC}$

Where μ and σ_{CC} are calculated from all carbon content samples from the same Production Process taken within 6 months of the removal for which the carbon content is being calculated. For estimating the carbon content from sampled batches, only historical samples should be used to calculate μ and σ_{CC} and not samples from the batch being calculated. The standard deviation, σ_{CC} , should be calculated with the formula for sample standard deviation.

The winsorized measurement, m_w , must be used for the determination of carbon content.

This winsorization process must only be applied once a minimum number of 30 measurements have been taken, to ensure statistical significance.

The Project Proponent must monitor occurrences of outliers, and investigate if significantly more than the statistically expected number occurs, as it may be indicative of a systematic issue. This may be checked at verification, at the discretion of the verifying VVB.

Ensuring representative sampling

Samples must accurately represent materials designated for the storage pathway that will form the basis for credit quantification. Biochar should be sampled in its final pre-storage condition, i.e., post-processing and at typical moisture levels. For storage in agricultural soils involving co-application with other substances (such as compost), sampling should occur before the blending process is performed.

8.3.1.1

Measurement of Mass of Biochar Applied

The mass of biochar applied is measured via determination of weight of delivered biochar to the application site using a calibrated scale. This serves as proof of delivery to site for storage, as well as providing a weight measurement. The total mass of applied biochar may be determined by the difference in biochar delivery truck weight measured upon arrival at the application site and at departure, after offloading of biochar, either into storage or directly applied.

Any truck scale used must have a current certification in accordance with applicable local, state, or federal

regulations for legal-for-trade weights and measures. Testing and calibration of scales must utilize certified weights in accordance with local, state, or other regulations. Calibration weights must meet NIST Handbook 44⁶ specifications, and scale testing and calibration must be performed by a state certified entity.

In the event that truck scales are not available at the delivery site, for this purpose, prior to verification, it can be agreed with Isometric to instead provide a signed document for record of receipt, bill of lading and/or photograph of delivery, for each completed delivery. This serves as alternative proof of delivery to the delivery site for storage. In this case, all details of weight measurements carried out at the production site, including all precautions taken to prevent mass loss during transportation, must be outlined in the PDD.

8.3.1.2

Required Records & Documentation - CO₂e_{Stored, n}

The Project Proponent must maintain the following records as evidence of gross CO₂e stored in applied biochar:

- Weigh scale tickets for each delivery of biochar (arrival and departure weights) or other equivalent records;
- Analytical results for each ASTM D5291, or equivalent, analysis for carbon content of biochar from each batch, as required; and
- Documentation of any spills during application operations and estimates of quantity released.

Records of all C analyses and application masses (e.g. weigh scale tickets) must be maintained by the Project

Proponent for verification purposes for a period of at least five years.

Other Considerations - $\text{CO}_2\text{e}_{\text{Stored}, n}$

Biochar application processes should be monitored to ensure that any process upsets or equipment failures and resulting spills of biochar are monitored, documented, quantified, and accounted for in the GHG Statement of The Project batch. For each batch, where a process upset results in loss of biochar, that amount must be deducted from the delivered amount of biochar based on delivery weigh tickets. Such amounts must be allocated directly to the specific biochar application.

8.4  

Calculation of $\text{CO}_2\text{e}_{\text{Counterfactual}, \text{RP}}$

Type: Counterfactual

$\text{CO}_2\text{e}_{\text{Counterfactual}, \text{RP}}$ describes the CO_2 that would have been removed from the atmosphere and stored beyond 15 years in the baseline scenario.

The calculation of $\text{CO}_2\text{e}_{\text{Counterfactual}, \text{RP}}$ is determined by the requirements outlined in Section 2 of the Biomass Feedstock Accounting Module.



Biomass Feedstock Accounting



See Biomass Feedstock Accounting Module for calculation of $\text{CO}_2\text{e}_{\text{Counterfactual}, \text{RP}}$.

Calculation of CO₂eEmissions, RP

Type: Emissions

$CO_2e_{Emissions, RP}$ is the total quantity of GHG emissions from operations and allocated embodied emissions for each Reporting Period RP . This can be calculated as:

$$CO_2e_{Emissions, RP} = CO_2e_{Establishment, RP} + CO_2e_{Operations, RP} + CO_2e_{End-of-life, RP} + CO_2e_{Leakage, RP}$$

(Equation 6)

Where:

- $CO_2e_{Emissions, RP}$ - the total GHG emissions for a Reporting Period, RP, in tonnes of CO₂e.
- $CO_2e_{Establishment, RP}$ - the total GHG emissions associated with project establishment for a RP, in tonnes of CO₂e, see [Section 8.5.1](#).
- $CO_2e_{Operations, RP}$ - the total GHG emissions associated with operational processes for a RP, in tonnes of CO₂e, see [Section 8.5.2](#).
- $CO_2e_{End-of-life, RP}$ - the total GHG emissions that occur after the RP and are allocated to the RP, in tonnes of CO₂e, see [Section 8.5.3](#).
- $CO_2e_{Leakage, RP}$ - the GHG emissions associated with the Project's impact on activities that fall outside of the system boundary of a Project, over a given RP, in tonnes of CO₂e, see [Section 8.5.4](#).

The following sections set out specific quantification requirements for each variable.

8.5.1

Calculation of $CO_2e_{Establishment, RP}$

GHG emissions associated with $CO_2e_{Establishment, RP}$ should include all historic emissions incurred as a result of project establishment, including but not limited to the SSRs set out in Table 1.

Project establishment emissions occur from the point of project inception through to before the first removal activity takes place. GHG emissions associated with project establishment may be allocated in one of the following ways, with the allocation method selected and justified by the Project Proponent in the PDD:

- As a one time deduction from the first Reporting Period;
- Allocated to removals as annual emissions over the anticipated project lifetime; or
- Allocated per output of product (i.e., per tonne CO_2 removed) based on estimated total production over project lifetime.

The anticipated lifetime of The Project should be based on reasonable justification and should be included in the PDD to be assessed as part of project validation.

Allocation of $CO_2e_{Emissions, RP}$ emissions to removals must be reviewed at each Crediting Period renewal and any necessary adjustments made. If the Project Proponent is not able to comply with the allocation schedule described in the PDD (e.g., due to changes in delivered volume or anticipated

project lifetime), the Project Proponent should notify Isometric as early as possible in order to adjust the allocation schedule for future removals. If that is not possible, the Reversal process will be triggered in accordance with the Isometric Standard, to account for any remaining emissions.

8.5.2

Calculation of $CO_2e_{Operations, RP}$

GHG emissions associated with $CO_2e_{Operations, RP}$ should include all emissions associated with operational activities including but not limited to the SSRs set out in **Table 1**. This includes direct emissions from pyrolysis, $CO_2e_{Direct, RP}$, for which calculation and measurement details are set out in Section 9.2.

For biochar projects, the Reporting Period begins when the activity associated with a batch of Removals begins, and ends upon application of biochar from that batch at the storage site. As an example, for Projects storing biochar in agricultural soils, the Reporting Period begins with biomass feedstock sourcing and ends with biochar application to agricultural soils. The Reporting Period may cover a set period of time, for example a one month period of activity, inclusive of biomass sourcing through to application on agricultural soils for batches of Removals that fall into that month.

$CO_2e_{Operations, RP}$ emissions must be attributed to the Reporting Period in which they occur. Allocation may be permitted in certain instances, on a case by case basis, in agreement with Isometric.

8.5.3

Calculation of $CO_2e_{End-of-life, RP}$

$CO_2e_{End-of-life, RP}$ includes all emissions associated with activities that are anticipated to occur after the Reporting Period, but are directly or indirectly related to the Reporting Period. For example this could include end-of-life emissions for project facilities (indirectly related to all deployments).

GHG emissions associated with $CO_2e_{End-of-life, RP}$ may occur from the end of the Reporting Period onward, and typically through to completion of project site deconstruction and any other end-of-life activities.

GHG emissions associated with activities that are directly related to each deployment must be quantified as part of that Reporting Period. GHG emissions associated with activities that are indirectly related to all deployments may be allocated in the same ways as set out in $CO_2e_{End-of-life, RP}$.

Given the uncertain nature of $CO_2e_{End-of-life, RP}$ emissions, assumptions must be revisited at each Crediting Period and any necessary adjustments made. Furthermore, if there are unexpected $CO_2e_{End-of-life, RP}$ emissions associated with a Reporting Period, or The Project as a whole, that occur after The Project has ended, then the Reversal process will be triggered to compensate for any emissions not accounted for.

8.5.4

Calculation of $CO_2e_{Leakage, RP}$

$CO_2e_{Leakage, RP}$ includes emissions associated with a Project's impact on activities that fall outside of the system

boundary of a Project.

It includes increases in GHG emissions as a result of The Project displacing emissions or causing a knock on effect that increases emissions elsewhere. This includes emissions associated with activity-shifting, market leakage and ecological leakage.

It is the Project Proponent's responsibility to identify potential sources of leakage emissions. At a minimum, biochar Projects must account for market leakage emissions associated with biomass feedstocks in accordance with the Biomass Feedstock Accounting Module v1.2.

$CO_2e_{Leakage, RP}$ emissions must be attributed to the Reporting Period in which they occur. Allocation may be permitted in certain instances, on a case by case basis in agreement with Isometric.

8.6

Emissions Accounting

This section of the Protocol outlines requirements for emissions accounting relating to energy use, transportation, and embodied emissions associated with a Project.

8.6.1

Energy Use Accounting

This section sets out specific requirements relating to quantification of energy use as part of the GHG Statement. Emissions associated with energy usage result from the consumption of electricity or fuel.

Examples of electricity usage may include, but are not

limited to:

- Electricity consumption for pyrolysis activities;
- Processing equipment, motors, drives and instrumentation;
- Biomass pre-treatment, drying, densification or particle size reduction;
- Facility operations;
- Pyrolysis system start up;
- Electricity for building operation & management; and
- Electricity consumption for any biochar processing activities at the pyrolysis site or application site.

Examples of fuel consumption may include, but are not limited to:

- Pyrolysis system start up;
- Pyrolysis reactor heating;
- Emission control (e.g. propane for flare co-firing or pilot)
- Handling equipment, such as fork trucks or loaders; and
- Fuel consumption of agricultural machinery for spreading.

The Energy Use Accounting Module v1.2 provides requirements on how energy-related emissions must be calculated in a CDR Project. It sets out the calculation approach to be followed and acceptable emissions factors.



Energy Use Accounting



Refer to Energy Use Accounting Module for the calculation guidelines.

8.6.2

Transport Emissions Accounting

This section sets out specific requirements relating to quantification of emissions related to transportation.

Emissions associated with transportation include transportation of products and equipment as part of a Reporting Period process. Examples may include, but are not limited to:

- Transportation of biomass to pyrolysis facility;
- Transportation of pyrolyzed biochar to storage site; and
- Transportation and shipping related to collecting samples for characterization.

The Transportation Emissions Accounting Module v1.1 provides requirements on how transportation-related emissions must be calculated in a CDR Project so that they can be subtracted in the net CO₂e removal calculation. It sets out the calculation approach to be followed and acceptable emissions factors.



Transportation Emissions Accounting



Refer to Transportation Emissions Accounting Module for the calculation guidelines.

8.6.3

Embodied Emissions Accounting

This section sets out specific requirements relating to quantification of embodied emissions as part of the GHG Statement. Embodied emissions are those related to the life cycle impact of equipment and consumables.

Examples of project-specific materials and equipment that must be considered as part of the embodied emission calculation include but are not limited to:

- Process inputs or consumables:
 - Catalysts;
 - Water (for biomass pre-treatment or reactor cooling, not to be used during pyrolysis);
 - Thermal oils used for heat transfer;
 - Coolants used for biochar quench; and
 - Gasses such as nitrogen used for process or instrumentation purges.
- Gasses, reagents or other materials used for operation of monitoring equipment and on-site analyzers; and
- Equipment:
 - Pyrolysis reactor;
 - Feedstock conveyors, augers, feed bins, and related equipment;
 - Biochar quench or condenser units, including any heat transfer equipment, such as glycol chillers and pumps;
 - Offgas emissions control systems, such as flares or oxidizers;
 - Preparation or mixing equipment;
 - Pumps, piping, and related equipment;
 - Storage tanks;
 - All support structures, facilities, and infrastructure,

including steel platforms, framing, supports, concrete footings and building structures; and

- On-line analyzers, measurement equipment, or other such devices.

The Embodied Emissions Accounting Module v1.0 sets out the calculation approach to be followed including allocation of embodied emissions, life cycle stages to be considered, data sources and emission factors.



Embodied Emissions Accounting



Refer to Embodied Emissions Accounting Module for the calculation guidelines.

9.0 ↑ 🔗

Biomass Feedstock Pyrolysis Requirements & Emissions Calculations

Pyrolysis is the process of thermochemical conversion of a solid biomass feedstock. The biomass is heated to a temperature greater than 300°C without addition of an oxidizing atmosphere. Pyrolysis of biomass results in a product mixture containing solid biochar, liquid bio-oil, and gasses.

There are a wide range of technologies for achieving pyrolysis of solid biomass, which can generally be categorized into "slow pyrolysis" and "fast pyrolysis" based on the heating rate and residence time of biomass in the pyrolysis chamber. Slow pyrolysis processes are ideal to

maximize the yield of pyrolysis towards the solid biochar product, and minimize the production of bio-oil and pyrolysis gasses, however both "slow" and "fast" pyrolysis processes may be eligible under this Protocol. Several reactor configurations can be used to achieve slow pyrolysis of biomass to produce biochar, including both batch reactors and semi-batch reactors (e.g. fixed-beds, fluidized-beds, etc.). Any type of reactor configuration is eligible under this Protocol, provided that the reactor design requirements set out in [Section 9.1](#) below are satisfied. A brief overview of common reactor configurations covered under this Protocol are provided in the **Table 5** below. However, novel reactor configurations not belonging to any of the categories listed here will be acceptable provided that the appropriate reactor design documentation according to [Section 9.1](#) is supplied in the PDD. All reactor designs, including the reactor type, engineering design diagrams and materials selection must be described in the PDD.

Table 5: Overview of common reactor types

REACTOR	
TYPE	DESCRIPTION
Fixed-bed reactor	Solid biomass is loaded into a vessel. Heat is applied to the vessel to increase the temperature of the biomass. Once the target pyrolysis temperature is reached, and potentially sustained for some period of time, the solid biochar product is collected in a batch-mode. Gaseous and solid products self-separate within the reactor.
Auger reactor	Solid biomass is continuously fed to and transported through a cylindrical vessel using a screw-type fitting. Heat is applied to the exterior of the vessel. As biomass is transported along the length of the reactor, its temperature is increased. The target pyrolysis temperature is reached at the product exit point from the reactor. Gaseous and solid products are collected and separated at the reactor outlet. The biochar product is collected continuously.
Rotary kiln reactor	Solid biomass is continuously loaded at the top of an inclined rotating drum. As more biomass is added to the vessel, biomass inside the vessel is transported downwards. Heat is applied to the exterior of the vessel. As biomass is transported along the length of the reactor, its temperature is increased. The target pyrolysis temperature is reached at the product exit point from the reactor. Gaseous and solid products self-separate at the reactor outlet. The biochar product is collected continuously.

Maximum pyrolysis temperature may be manipulated in order to increase the yield of solid biochar products and their relative carbon stability. For example, pyrolysis at higher temperatures may lower the yield of the solid biochar. However, thermal breakdown of biochar is positively correlated with increasing temperatures - yielding biochar with lower volatile content that is more stable. The optimum range for pyrolysis temperature is 500–800°C to maximise the production of highly stable biochar⁷.

9.1 [↑](#) [🔗](#)

Reactor design requirements

9.1.1 [↑](#) [🔗](#)

Design diagram requirements

An engineering design diagram of the chemical reactor used to achieve pyrolysis must be included in the PDD. The design diagram must include details of the dimensions of the reactor, the locations of material inflows/outflows, the positioning of sensors for the monitoring of temperature/pressure, details of any internal equipment such as agitators or heating/cooling coils and details of any external heat transfer equipment (including heat exchange fluid entry/exit points and corresponding sensors for flow rate and temperature). A sufficient number of viewpoints must be included in the engineering design diagram to show the positioning of all of the key components listed above. Any other process equipment essential to the safe and effective operation of the pyrolyzer not listed above should be included and highlighted in the engineering design diagram.

In instances where Project Proponents wish to expand an

existing Project, or to submit a new Project for validation, where the reactor vessels used to achieve pyrolysis of biomass are manufactured according to the same design diagrams as those submitted for initial project validation, it is not necessary to resubmit a new design diagram at each subsequent validation event. In cases where the design of the reactor vessel differs to that from the original project validation, submission of updated design diagram documentation is required.

9.1.2

Pyrolysis gas loss

The reactor design must include sensors to quantify leakage due to loss of pyrolysis gasses during operation of the reactor. This should include, at minimum, sensors to determine the outflow of pyrolysis gasses from the flue gas outlet, which can be used in conjunction with a suitable reactor model to determine the amount of pyrolysis gasses produced and to estimate any loss of these gasses by unmonitored and unintentional leakage to the environment. The chemical reactor model used to characterize reactor performance and estimate pyrolysis gas losses should consider all physical and chemical mechanisms relevant to the operation of the chosen reactor type. The chemical reactor model should incorporate a chemical kinetics model which is based on the latest scientific understanding for the chosen reactor configuration. The model should be demonstrated to be validated using empirical data and should include a process mass balance accounting for the product yields. Details of the validation of the chemical reactor model should be provided in the PDD.

Alternatively, in situations where it is not possible to develop a high-quality mathematical reactor model to represent

pyrolyzer operations, it is permissible to deploy one of the following alternative approaches to verify that there is no substantial unintended leakage of gaseous products from the system:

- Continuous measurement of system pressure, demonstrating the the pressure of the reactor vessel during project operations is consistently sub-atmospheric. System pressure should be measured using a calibrated sensor which satisfies the below requirements:
 - Must have an accuracy of 2% of full scale or better;
 - Recorded at a frequency of 1-minute intervals at minimum;
 - Must be calibrated in accordance with and at a frequency which meets or exceeds manufacturer calibration requirements, but which in any case must be no less than annual; and
 - Raw data must be made available upon request.
- Regular leakage testing of the system. Leakage testing should be conducted according to prevailing national/international standards, and/or by an accredited leakage testing authority, for example in compliance with ASTM E1003-13(2022), or an equivalent standard. Leakage testing should be conducted at least once every 12 months. Project Proponents are required to maintain proof and results of leakage tests for a period of at least five years.

9.1.3

Construction Considerations

It is anticipated that the operation of the pyrolyzer will occur at high temperature, and may occur at elevated pressure.

Appropriate considerations need to be made in the design of the reactor to mitigate potential adverse operational conditions. Details must be provided in the PDD to describe the selection of materials for each component of the reactor, including suitable justification of these choices from the perspectives of thermal and mechanical resilience. For reactors operating at high pressures (i.e. above atmospheric pressure), considerations should be made relating to the operating pressure, vessel shape/size, positioning of material inlets/outlets, and positioning of sensors to ensure mechanical integrity of the reaction vessel. Such considerations should be made in compliance with a suitable local standard which provides regulations for the design and fabrication of pressure vessels, such as 2014/68/EU (the "Pressure Equipment Directive") or an appropriate regional equivalent standard in the region of project operation. If no such regional standard exists in the region of operation, Project Proponents are required to use the 2014/68/EU standard.

9.1.4

Reactor Maintenance

An appropriate reactor maintenance plan should be in place, and must be detailed in the PDD. The maintenance plan should outline how the Project Proponent will ensure the structural integrity of the reactor vessel to mitigate against potential material loss events. This includes suitable monitoring and mitigation for mechanical and thermal degradation events which may lead to the failure of the vessel and subsequent release of materials into the environment. All maintenance plans should be in compliance with a suitable local standard which provides regulations for the maintenance of pressure vessels, such as 2014/68/EU or an appropriate regional equivalent standard in the region of

project operation.

9.2

Direct Emissions

The thermochemical conversion of solid biomass to produce biochar in a pyrolysis process also produces a gas as a significant co-product. The gas contains both volatile condensable components (bio-oil) and non-condensable components (pyrolysis gasses; predominantly CH₄, with H₂, CO, CO₂ and light hydrocarbons). Depending on the specific technologies deployed by the Project, there are various options for handling the gaseous co-product eluted from the pyrolyzer. Permissible options for handling the gaseous product and emissions accounting requirements associated requirements are detailed in this section.

The gasses eluted from the pyrolyzer are fed to a condenser, or any other suitable gas-liquid separation unit, to separate the condensable and non-condensable fractions of the gaseous product. The resulting (condensable) liquid-phase is bio-oil, and the (non-condensable) gas-phase is pyrolysis gasses. There are three permissible end-use emissions accounting approaches for the produced bio-oil:

- Storage of the produced bio-oil by injection into natural or engineered subsurface features or geologic storage formations which may include, but are not limited to, reservoirs, saline aquifers, caverns, or mines. Storage of produced bio-oil must be conducted in compliance with the requirements described in the Bio-Oil Geological Storage Protocol. In this case, the Project Proponent may claim Credits for the storage of bio-oil, in addition to the Credits claimed for storage via biochar (as detailed under this Protocol). Where Isometric Credits

are generated for both bio-oil injection and biochar resulting from the same thermochemical conversion process, emissions associated with the thermochemical conversion of solid biomass to produce biochar and bio-oil will be allocated proportionately to each storage pathway for the purposes of calculating net-CO₂e removal for each (see [Section 7.1.1](#) for allocation calculation details); or

- Provision of produced bio-oil to a downstream consumer for third-party use, such as combustion for heating. In this case, the Project Proponent may follow emission allocation procedures (see [Section 7.1.1](#) of this Protocol for allocation calculation details).
- Treatment of the produced bio-oil downstream and environmental disposal as a waste stream or hazardous waste, following methods compliant to relevant local legislative frameworks. In this case, the Project Proponent must account for all emissions relevant to treatment and disposal of the waste stream (see [Section 7.1](#) of this Protocol).

There are four permissible end-use emissions accounting approaches for the produced pyrolysis gasses:

- Venting of pyrolysis gasses directly to the atmosphere. The Project Proponent must measure the flow rate and composition of the vented gas stream to determine the emissions associated with the vented gasses. Composition measurements must account for at least CH₄, H₂, CO, and CO₂.
- Venting of pyrolysis gasses to the atmosphere via an emissions control unit, such as a flare stack. The Project Proponent must measure the flow rate and composition of the vented gas stream immediately upstream of the point of emission to the atmosphere to determine the

emissions associated with the vented gasses.

Composition measurements must account for at least CH_4 , H_2 , CO , and CO_2 .

- Combustion of pyrolysis gasses within the project gate to provide thermal energy for operation of the pyrolyzer. The Project Proponent must measure the flow rate and composition of the flue gas eluted from the heating source for the pyrolyzer. Composition measurements must account for at least CH_4 , H_2 , CO , and CO_2 . It should be noted that the flue gas from the pyrolyzer heating source may also partially result from co-firing with fuels obtained from outside sources. If the flue gas from the pyrolyzer heating source is directly monitored, it is not necessary to include fuel combustion for heating the pyrolyzer in the calculation of $\text{CO}_2e_{\text{Energy, RP}}$, to avoid double counting. However, the emissions associated with the production and transportation of such fuels must still be accounted for. Bio-oil produced during pyrolysis may also be co-fired using this approach, and can be accounted for in the same way as for the co-firing of pyrolysis gasses.
- Provision of pyrolysis gasses to a downstream consumer for third-party use. In this case, the Project Proponent may follow emission allocation procedures (see [Section 7.1.1](#) for allocation calculation details).

All non- CO_2 emissions to the atmosphere, via any of the approaches described above, must be converted to tonnes of CO_2e using the 100-year Global Warming Potential (GWP) for the relevant GHGs, based on the most recent volume of the IPCC Assessment Report (presently the Sixth Assessment Report).

9.2.1

Calculation of direct emissions - $\text{CO}_2e_{\text{Direct,RP}}$

Direct emissions from a pyrolysis process occur when pyrolysis gasses are emitted to the atmosphere, are combusted in an emissions control unit, or are combusted within the process for the provision of thermal energy for the process. Direct emissions should be calculated as follows:

$$CO_2e_{Direct,RP} = \sum_{n=1}^{n_c} \sum_{i=1}^N m_i \cdot C_{n,i} \cdot GWP_n \cdot \Delta t_i$$

(Equation 7)

Where:

- $CO_2e_{Direct,RP}$ - the total amount of non-CO₂ GHG emissions associated with the release of pyrolysis gasses directly to the atmosphere, via combustion in an emissions control unit, or via combustion for the provision of thermal energy within the process, during a Reporting Period, RP , in tonnes of CO₂e.
- m_i - the total mass flow rate of gas emitted to the atmosphere during time period i , in tonnes per hour. Measurement must be made immediately upstream of the point of emission to the atmosphere.
- $C_{n,i}$ - the concentration of species n in the emitted gas during time period i , expressed as a mass fraction. Measurement must be made immediately upstream of the point of emissions to the atmosphere.
- GWP_n - the 100-year global warming potential of species n .
- Δt_i - the duration of time period i , in hours.
- n_c - the total number of species in the emitted gas

stream.

- N - the total number of time periods comprising the Reporting Period, RP .

Direct CO₂e emissions, $CO_2e_{Direct,RP}$, consider non-CO₂ emissions only to avoid double counting, given that release of CO₂ emissions during pyrolysis will be realized in the reduction of carbon stored in the biochar after pyrolysis of biomass. Carbon stored is calculated as $CO_2e_{Stored,RP}$, which directly informs net CO₂e removal and Crediting. Consideration of non-CO₂ emissions during pyrolysis is important given the amount and composition of gasses emitted during pyrolysis may be substantially different to that emitted in the baseline scenario, for example as a result of biomass decay or combustion.

9.2.2

Measurements - CO₂eDirect,RP

Quantification of $CO_2e_{Direct,RP}$ requires two primary measurements, the measurement of gas flow and the analysis of gas composition for CH₄, H₂, CO, and CO₂ in the emitted gas stream.

Gas flow rate, m_i , must be:

- Measured immediately upstream of the point of emission to the atmosphere; and
- Measured using a continuous inline meter, such as a coriolis meter, thermal mass meter, or similar, which satisfies the below requirements:
 - Provided with a factory calibration for the specific gas composition range expected;
 - Meter accuracy specification of 2% full scale;

- Recorded at a minimum frequency of 1-minute intervals;
- Must be calibrated in accordance with and at a frequency which meets or exceeds manufacturer calibration requirements, but which in any case must be no less than annual;
- Calibration traceable to national standards;
- Meters are selected and installed for the expected and observed operating range of the emitted stream;
- Meters are installed in accordance with manufacture installation guidelines, including, for example, minimum distances up or downstream of piping disturbances required to ensure accurate flow measurement; and
- Raw data must be made available upon request.

The concentration of CH₄, H₂, CO, and CO₂ must be:

- Measured immediately upstream of the point of emission to the atmosphere; and
- Measured using a continuous inline analyzer, such as NDIR, TDL, or similar, which satisfies the below requirements:
 - Must have an accuracy of 2% of full scale or better;
 - Recorded at a frequency of 1-minute intervals at minimum
 - Must be calibrated in accordance with and at a frequency which meets or exceeds manufacturer calibration requirements, but which in any case must be no less than annual;
 - Calibration gasses must be traceable to national standards and a certificate of analysis indicating so; and

- Raw data must be made available upon request.

9.2.3

Required Records & Documentation - CO₂eDirect,RP

The Project Proponent must maintain the following records as evidence supporting calculation of direct emissions from the biomass conversion process for a period of at least five years:

- Raw data provided via emitted stream flow and concentration meters for the Reporting Period, *RP*;
- Calibration records for all measurement equipment, including, but not limited to, flow meters and composition measurements; and
- Manufacturer operating manuals indicating required calibration procedures and frequency, as well as maintenance procedures and frequency for any measurement equipment.

9.2.4

Emissions testing - CO₂eDirect,RP

For some projects, particularly those deploying pyrolyzers in a highly distributed manner or in remote locations, the measurement of direct emissions to the atmosphere using calibrated gas flow and concentration sensors may not be a practically feasible approach. As an alternative to the measurement requirements established in [Section 9.2.2](#), emissions testing data may be used to estimate m_i and $C_{n,i}$ for project operations. For both quantities, suitable measurements must be made during process operations to

substantiate that the conducted emissions tests are representative of actual project operations.

The gas flow rate, m_i , should be determined by using calibration curves from emissions testing in conjunction with measurements of the pressure drop in the direct emission stream. The concentration of CH₄, H₂, CO, and CO₂ should be determined using concentration data from emissions testing. Emissions testing data should be produced by a qualified emissions testing company, accredited to the Stack Testing Accreditation Council for ASTM D7036, ISO 17025, or approved by state regulatory authority to perform compliance emissions testing.

For emissions testing to be considered representative of actual project operations, the following criteria must be satisfied:

- The biomass feedstock used during project operations should be identical or similar to the feedstock used during emissions testing. Where the biomass feedstocks used during project operations and emissions testing are not the same, analytical testing should be used to demonstrate that they are similar. Analytical testing should correspond to ASTM D5291 ultimate analysis or proximate analysis for moisture, volatiles, fixed carbon and ash, and should show that for each feedstock characteristic the biomass feedstock used for actual project operations is within 10% of the corresponding characteristic of the biomass feedstock used for the emissions testing; and
- The temperature within the flue stack during project operations should be similar to that of the emissions test, defined as being within 10% of the measured value(s) during the corresponding emissions test.

Measurement of the temperature within the flue stack should be conducted using a calibrated sensor which satisfies the below requirements:

- Must have an accuracy of 2% of full scale or better;
- Recorded at a frequency of 1-minute intervals at minimum;
- Must be calibrated in accordance with and at a frequency which meets or exceeds manufacturer calibration requirements, but which in any case must be no less than annual; and
- Raw data must be made available upon request.

9.2.4.1

Required Records & Documentation - emissions testing

The Project Proponent must maintain the following records as evidence supporting calculation of direct emissions from the biomass conversion process for a period of at least five years:

- Results of emissions tests used to determine direct emissions from The Project, including a signed report from the accredited emissions testing entity;
- Raw data provided via pyrolyzer temperature measurements for the Reporting Period, *RP*;
- Calibration records for all temperature measurement equipment; and
- Manufacturer operating manuals indicating required calibration procedures and frequency, as well as maintenance procedures and frequency for any measurement equipment.

10.0 ↑ 🔗

Storage

For all information on what chemical and physical characterization of biochar must be carried out, and for calculation of CO_2e_{Stored} , please refer to the relevant storage Module.



Biochar Storage in Agricultural Soils



Durability and monitoring requirements for Biochar Storage in Agricultural Soils.



Biochar Storage in Low Oxygen Burial Environments



Durability and monitoring requirements for Biochar Storage in Low Oxygen Burial Environments.

11.0 ↑ 🔗

Appendix 1: Risk of Reversal Questionnaire

This risk assessment identifies the pathway specific risk factors relevant to a carbon removal project. The relevant risk factors identified as part of a risk assessment are included in the monitoring plan requirements for the project, with details included in the Project Design Document. Project specific risk factors inform the required duration of

monitoring along with the monitoring requirements set out in the Protocol and the requirements set out in the Monitoring Section of the Isometric Standard.

The risk score, as determined by the Risk of Reversal Questionnaire, will determine a project's buffer pool contribution. Projects must re-assess their reversal risk at the renewal of each crediting period, or if monitoring identifies a reversal-related risk, or if an actual reversal event takes place. In any event, projects should reassess their reversal risk at a minimum every 5 years.

The Risk of Reversal Questionnaire questions that pertain to this protocol, drawn from the programme-level Risk of Reversal Questionnaire defined in Appendix B: Risk Reversal Questionnaire of the Isometric Standard, include the following:

# IN ISOMETRIC STANDARD QUESTIONNAIRE	QUESTION	IF ANSWERED "YES"	IF ANSWERED "NO"
1	Is a reversal directly observable with a physical or chemical measurement as opposed to a modeled result?	Proceed to questions 2-9	Proceed to questions 8-9
2	Is the carbon being stored in an impermeable geologic system? (e.g., salt cavern)	Proceed to questions 8-9	Add 1 to Risk Score and proceed to questions 3-9
3	Is the carbon being stored organic?	Add 1 to Risk Score	
5	Does this approach have a material risk of reversal due to natural disasters including, but not limited to, floods, storms, earthquakes, fires, etc.?	Add 1 to Risk Score	

IN ISOMETRIC

STANDARD		IF ANSWERED	IF ANSWERED
QUESTIONNAIRE	QUESTION	"YES"	"NO"
6	Does this approach have a material risk of reversal due to human-induced events from outside actors, such as change in farming practices, change in ownership and management of project sites, or similar?	Add up to 2 to Risk Score	
8	Is there 10+ years of monitoring and/or lab data demonstrating low project risk?	Minus up to 2 to Risk Score	
9	Does this pathway have a documented history of reversals?	Add 2 to Risk Score	
10	Is there one or more project-specific factors that merit a high risk level?	Add up to 2 to Risk Score	

Risk Score Categories

- 0: Very Low Risk Level (2% buffer)
- 1-2: Low Risk Level (5% buffer)
- 3-4: Medium Risk Level (7% buffer)
- 5+: High Risk Level (10-20% buffer)

Project specific risk factors will depend on the form of carbon being stored (i.e., organic vs. inorganic), the method of storage (e.g., mineralization, encapsulation), the location of carbon storage (e.g., subsurface, ocean), and the proximity of that carbon to potential agents of reversal.

For projects with carbon storage as organic carbon, the presence of the following risk factors must be reflected in the risk score corresponding to question 10:

- High-potential oxidants
- Temperatures in excess of thermal stability
- Fires
- Microbial degradation

For projects with any form of subsurface carbon storage, the presence of the following risk factors must be reflected in the risk score corresponding to question 10:

- Seismicity
- Subsurface migration

12.0 [↑](#) [🔗](#)

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-

Definitions and Acronyms

Activity

The steps of a Project Proponent's Removal process that result in carbon fluxes. The carbon flux associated with an activity is a component of the Project Proponent's Protocol.

Additionality

An evaluation of the likelihood that an intervention—for example, a CDR Project—causes a climate benefit above and beyond what would have happened in a no-intervention Baseline scenario.

American Society for Testing and Materials (ASTM)

A standards organization that develops and publishes voluntary consensus international standards.

Baseline

A set of data describing pre-intervention or control conditions to be used as a reference scenario for comparison.

Bio-oil

A mixture of water, organic acids, aldehydes, ketones, sugars, phenols, and other organic compounds derived from the thermal breakdown of biomass. Thermal breakdown of biomass is achieved via thermochemical processes, such as pyrolysis, which heat biomass in low- or no-oxygen environments to high temperatures (~e.g. 350-650°C). Bio-oil is often also referred to as pyrolysis oil or bio-crude.

Biodiversity

The diversity of life across taxonomic and spatial scales. Biodiversity can be measured within species (i.e. genetic diversity and variations in allele frequencies across populations), between species (i.e. the total number and abundance of species within and across defined regions), within ecosystems (i.e. the variation in functional diversity, such as guilds, life-history traits, and food-webs), and

between ecosystems (variation in the services of abiotic and biotic communities across large, landscape-level scales) that support ecoregions and biomes.

Buffer Pool

A common and recognized insurance mechanism among Registries allowing Credits to be set aside (in this case by Isometric) to compensate for Reversals which may occur in the future.

Buyer

An entity that purchases Removals, often with the purpose of Retiring Credits to make a Removal claim.

Carbon Dioxide Equivalent Emissions (CO₂e)

The amount of CO₂ emissions that would cause the same integrated radiative forcing or temperature change, over a given time horizon, as an emitted amount of GHG or a mixture of GHGs. One common metric of CO₂e is the 100-year Global Warming Potential.

Carbon Dioxide Removal (CDR)

Activities that remove carbon dioxide (CO₂) from the atmosphere and store it in products or geological, terrestrial, and oceanic Reservoirs. CDR includes the enhancement of biological or geochemical sinks and direct air capture (DAC) and storage, but excludes natural CO₂ uptake not directly caused by human intervention.

Carbon Finance

Resources provided to projects that are generating, or are expected to generate, greenhouse gas (GHG) Emission Reductions or Removals.

Conservative

Purposefully erring on the side of caution under conditions of Uncertainty by choosing input parameter values that will result in a lower net CO₂ Removal than if using the median input values. This is done to increase the likelihood that a given Removal calculation is an underestimation rather than an overestimation.

Counterfactual

An assessment of what would have happened in the absence of a particular intervention – i.e., assuming the

Baseline scenario.

Cradle-to-Grave

Considering impacts at each stage of a product's life cycle, from the time natural resources are extracted from the ground and processed through each subsequent stage of manufacturing, transportation, product use, and ultimately, disposal.

Credit

A publicly visible uniquely identifiable Credit Certificate Issued by a Registry that gives the owner of the Credit the right to account for one net metric tonne of Verified CO₂e Removal. In the case of this Standard, the net tonne of CO₂e Removal comes from a Project Validated against a Certified Protocol.

Crediting Period

The period of time over which a Project Design Document is valid, and over which Removals may be Verified, resulting in Issued Credits.

Direct Emissions

Emissions that are produced by a specific CDR process and are directly controllable.

Double Counting

Improperly allocating the same Removal from a Project Proponent more than once to multiple Buyers.

Durability

The amount of time carbon removed from the atmosphere by an intervention – for example, a CDR project – is expected to reside in a given Reservoir, taking into account both physical risks and socioeconomic constructs (such as contracts) to protect the Reservoir in question.

Embodied Emissions

Life cycle GHG emissions associated with production of materials, transportation, and construction or other processes for goods or buildings.

Emission Factor

An estimate of the emissions intensity per unit of an

activity.

Ex-post Credits

Issuance of Credits after removal took place. This is the manner in which Isometric Delivers Credits.

Feedstock

Raw material which is used for CO₂ Removal.

GHG Statement

A document submitted alongside Claimed Removals that details the calculations associated with a Removal, including the Project's emissions, Removals and Leakages, presented together in net metric tonnes of CO₂e.

Global Warming Potential

A measure of how much energy the emissions of 1 tonne of a GHG will absorb over a given period of time, relative to the emissions of 1 ton of CO₂.

Greenhouse Gas (GHG)

Those gaseous constituents of the atmosphere, both natural and anthropogenic (human-caused), that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect, whereby heat is trapped in Earth's atmosphere (CDR Primer, 2022).

Leakage

The increase in GHG emissions outside the geographic or temporal boundary of a project that results from that project's activities.

Materiality

An acceptable difference between reported Removals/emissions and what an auditor determines is the actual Removal/emissions.

Model

A calculation, series of calculations or simulations that use input variables in order to generate values for variables of interest that are not directly measured.

Module

Independent components of Isometric Certified Protocols which are transferable between and applicable to different Protocols.

Monitoring, Reporting, and Verification (MRV)

The multi-step process to _monitor_ the Removals and impacts of a Project, report the findings to an accredited third party, and have this third party Verify the report so that the results can be Certified.

Project

An activity or process or group of activities or processes that alter the condition of a Baseline and leads to Removals.

Project Design Document (PDD)

The document that clearly outlines how a Project will generate rigorously quantifiable Additional high-quality Removals.

Project Proponent

The organization that develops and/or has overall legal ownership or control of a Removal Project.

Protocol

A document that describes how to quantitatively assess the net amount of CO₂ removed by a process. To Isometric, a Protocol is specific to a Project Proponent's process and comprised of Modules representing the Carbon Fluxes involved in the CDR process. A Protocol measures the full carbon impact of a process against the Baseline of it not occurring.

RP

Reporting Period

Registry

A database that holds information on Verified Removals based on Protocols. Registries Issue Credits, and track their ownership and Retirement.

Removal

The term used to represent the CO₂ taken out of the atmosphere as a result of a CDR process.

Replacement Emissions

Any emissions that occur to compensate for biomass that was previously serving another purpose and is now being used for carbon removal. For example, if agricultural waste was previously left on a field to decompose - fertilizer production to replace those nutrients need to be accounted for.

Reputable Source

A source that would be widely considered trustworthy based on the process undertaken (e.g., peer review) or origin of the information (e.g., government body).

Reservoir

A location where carbon is stored. This can be via physical barriers (such as geological formations) or through partitioning based on chemical or biological processes (such as mineralization or photosynthesis).

Reversal

The escape of CO₂ to the atmosphere after it has been stored, and after a Credit has been Issued. A Reversal is classified as avoidable if a Project Proponent has influence or control over it and it likely could have been averted through application of reasonable risk mitigation measures. Any other Reversals will be classified as unavoidable.

Sensitivity Analysis

An analysis of how much different components in a Model contribute to the overall Uncertainty.

Sink

Any process, activity, or mechanism that removes a greenhouse gas, a precursor to a greenhouse gas, or an aerosol from the atmosphere.

Source

Any process or activity that releases a greenhouse gas, an aerosol, or a precursor of a greenhouse gas into the atmosphere.

Stakeholder

Any person or entity who can potentially affect or be

affected by Isometric or an individual Project activity.

Storage

Describes the addition of carbon dioxide removed from the atmosphere to a reservoir, which serves as its ultimate destination. This is also referred to as “sequestration”.

Uncertainty

A lack of knowledge of the exact amount of CO₂ removed by a particular process, Uncertainty may be quantified using probability distributions, confidence intervals, or variance estimates.

Validation

A systematic and independent process for evaluating the reasonableness of the assumptions, limitations and methods that support a Project and assessing whether the Project conforms to the criteria set forth in the Isometric Standard and the Protocol by which the Project is governed. Validation must be completed by an Isometric approved third-party (VVB).

Validation and Verification Bodies (VVBs)

Third-party auditing organizations that are experts in their sector and used to determine if a project conforms to the rules, regulations, and standards set out by a governing body. A VVB must be approved by Isometric prior to conducting validation and verification.

Verification

A process for evaluating and confirming the net Removals for a Project, using data and information collected from the Project and assessing conformity with the criteria set forth in the Isometric Standard and the Protocol by which it is governed. Verification must be completed by an Isometric approved third-party (VVB).

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Changelog

> v1.1

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Updated site visit and sampling guidance, with reference added to new/updated storage modules.

> v1.0

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Initial Release



Isometric is the world's leading carbon removal registry. Our mission is to build the trust needed to scale the carbon removal market responsibly and fast. Founded in 2022, Isometric is based in London and New York.

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