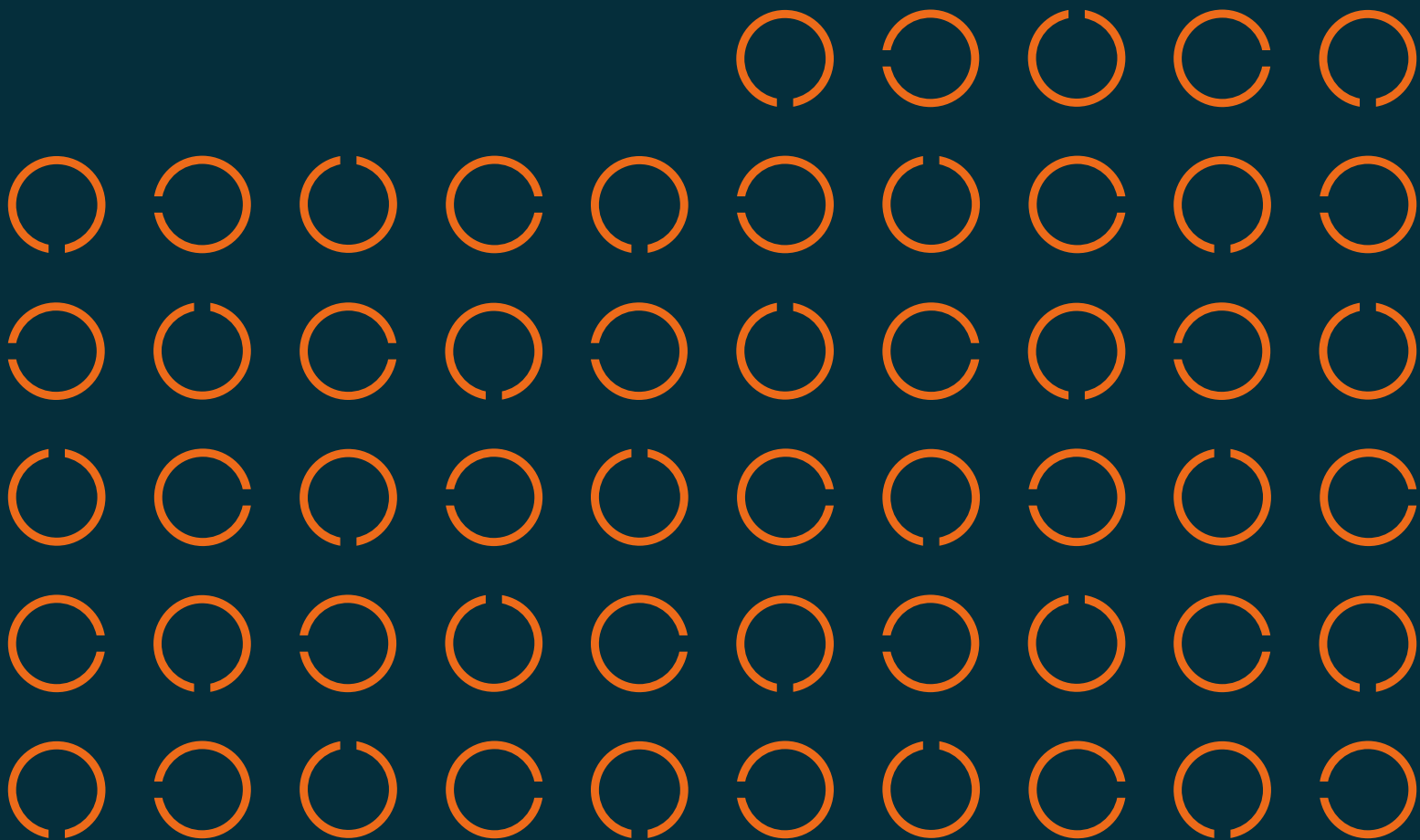


Biochar Carbon Removal Standards

A comparative assessment of the EU CRCF,
ICVCM and Article 6.4

June 2026



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Author contributions

Murali Thoppil: managed the review, led on additionality, quantification, carbon and nature markets, and scaling. Evangelos Mouchos: led on permanence. Natasha Martirosian: led on environmental sustainability. Carol Morris and Catherine Price: led on social sustainability. Nicoletta Brazzola: focus on integrity gaps in certification and MRV. Leo Mercer: focus on MRV costs and scaling. Colin Snape: academic leadership on permanence, sustainability and MRV. Jo House: overall academic leadership and research throughout. All: contributed to discussions on approach and implementation of RAG ratings and contributed text and editing across all sections.

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Acronyms

Acronym	Definition
A6.4	Article 6.4 of the Paris Agreement
A6.4ER	Article 6.4 Emission Reduction
AF	Assessment Framework for the Core Carbon Principles (CCPs) of the Integrity Council for the Voluntary Carbon Market (ICVCM)
BECCS	Biomass energy with carbon capture and storage – a sub-category of BioCCS, although the terms are often used interchangeably
BioCCS	Biomass with carbon capture and storage (includes BECCS but also non-power biomass CCS)
BSI	British Standards Institution
CCS	Carbon capture and storage
CCPs	Core Carbon Principles of the Integrity Council for the Voluntary Carbon Market (ICVCM)
CDR	Carbon dioxide removal – often used interchangeably with GGR
COP	Conference of the Parties – annual negotiations under the UNFCCC
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRCF	Carbon Removal and Carbon Farming Regulation (EU) 2024/3012
DACCS	Direct air carbon capture and storage
DESNZ	UK Government Department for Energy Security and Net Zero
DR PCR	Delegated Regulation for Permanent Carbon Removals (EU) 2026/285, adopted under the CRCF (EU) 2024/3012
EC	European Commission
ER	Emission reduction
ESMP	Environmental and social management plan
ESRA	Environmental and social risk assessment
EU	European Union
GGR	Greenhouse gas removal – often used interchangeably with CDR
GPC	Geological persistent carbon
H/Corg	Hydrogen to organic carbon ratio
HyPy	Hydropyrolysis
ICVCM	Integrity Council for the Voluntary Carbon Market
iLUC	Indirect land-use change
MRV	Monitoring, reporting and verification/validation
MS	Member States of the European Union
NDC	Nationally determined contribution
PAC	Persistent aromatic carbon
PACM	Paris Agreement Crediting Mechanism
RAG	Red-Amber-Green (rating scale)
RED	Renewable Energy Directive
Ro	Random reflectance
RRBp	Reversal risk buffer pool
SD	Sustainable development
SDG	Sustainable Development Goal
SDI	Sustainable development impact
SEC	Solid-state electric conductivity
SPC	Semi-persistent carbon
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary carbon market

Technical definitions

Additionality: “Mitigation projects, mitigation policies, or climate finance are additional if they go beyond a ‘business as usual’ level, or baseline. Additionality is required to guarantee the environmental integrity of project-based offset mechanisms, but difficult to establish in practice due to the counterfactual nature of the baseline” (Allwood et al, 2014, p.1252).

Baseline scenario: A description of the situation and the outcome that is predicted or assumed to occur in the absence of the incentives created by the carbon credits and their associated mitigation activities, while holding all other factors constant (ICVCM, 2024).

Leakage: When the removal, relative to the baseline, in a project is offset by an increase outside the project boundary through displacement of resources, changes in consumption, production, land use, indirect land-use change (iLUC) or trade across other sectors (ibid, p.1265).

Permanence: Refers to the length of time for long-term carbon storage (Schulte, 2024).

Reversal risk: A project’s susceptibility of releasing stored GHGs back into the atmosphere (Axelsson et al, 2024).

Project operators: Those implementing the CDR activity and applying for credits. Sometimes referred to in standards as, e.g., project proponents or activity proponents.

Executive summary

Context and purpose

Following the rapid growth of the voluntary carbon removal market, and the need to scale high-integrity, internationally recognised standards, the EU has developed a Carbon Removal and Carbon Farming Regulation (CRCF) (2024/3012) for DACCS (direct air carbon capture and storage), BioCCS (biomass with carbon capture and storage) and biochar. The UK Government has signalled its intention to align British Standards Institution (BSI) greenhouse gas removal (GGR) standards with the EU Carbon Removal and Carbon Farming Regulation (CRCF), including for biochar carbon removal, to avoid duplication and divergence as both markets develop. This report provides a timely assessment of whether the CRCF biochar methodology meets the requirements of internationally recognised, high-integrity carbon crediting frameworks and informs considerations around potential UK–EU carbon market compatibility.

Scope

This report assesses the alignment of the EU CRCF biochar methodology, as set out in the Delegated Regulation on Permanent Carbon Removals (DR PCR (EU) 2026/285), against two internationally recognised benchmarks for carbon credit quality: the Integrity Council for the Voluntary Carbon Market (ICVCM) Core Carbon Principles (CCPs) Assessment Framework, and the Article 6.4 Paris Agreement Crediting Mechanism (A6.4). The assessment examines four pillars that determine carbon credit integrity: additionality, quantification of removals, permanence and sustainability (environmental and social). The European Biochar Certificate (EBC) and the Global Biochar C-Sink Standard are incorporated for sectoral context, particularly on permanence methodology. A detailed review of all EU regulations referenced by the CRCF, and an assessment of individual voluntary carbon market (VCM) standards bodies, falls outside the scope of this report.

Approach

The assessment applies a comparative document analysis framework, supplemented by engagement with academic and policy experts, consistent with the methodology used in the team's prior analysis of BioCCS and DACCS standards (Martirosian et al., 2025). For each of the four pillars, common requirements across the ICVCM CCPs and A6.4 are first established, after which the CRCF biochar methodology is assessed against those requirements. Alignment ratings are assigned using a Red-Amber-Green (RAG) scale: Green indicates good alignment likely to produce comparable outcomes with little or no outcomes that may risk integrity; Amber indicates partial alignment with gaps that may affect outcomes; and Red indicates material gaps likely to produce divergent outcomes and risks to integrity.

Key findings

Additionality

The CRCF DR PCR employs a standardised zero-baseline approach whereby any biochar activity generating net carbon removal is deemed additional. This simplified approach is not accompanied by the legal compliance check, prior consideration assessment, or financial and barrier tests that ICVCM and A6.4 require. In the absence of these checks, there is a risk of non-additionality credits being issued, particularly for biochar applied to agricultural soils, where production is already financially viable and public subsidies may alone be sufficient to fund activities. The DR PCR does not explicitly prohibit the simultaneous claiming of biochar removal credits and soil carbon sequestration credits on the same plot of land, creating a double-counting risk.

Quantification

The CRCF DR PCR requires comprehensive lifecycle accounting across the full biochar production and application chain, including uncertainty assessment and the use of conservative default factors. This broadly aligns with ICVCM and A6.4 requirements. The DR PCR assumes a zero-baseline which, while not giving evidence as to how this was quantified, as required by ICVCM and A6.4, is justified given that in the baseline scenario, activities associated with the biochar project would not take place and no emissions or removals can be associated with it. On leakage (the project activity leads to greenhouse gas fluxes in other sectors e.g. energy or land), the DR PCR relies on preventative safeguards rather than the identification, quantification, and deduction of leakage that

ICVCM and A6.4 require. The main safeguards are the EU cascade use of biomass principle and an assessment to ensure biochar for GGR is the primary purpose of the project, not energy production. While this minimises the land-use change risks and impacts on other sectors, no detailed analysis is provided to demonstrate that these safeguards adequately substitute for leakage accounting.

Permanence

The CRCF DR PCR takes a pragmatic approach to assessing the risk of reversal (carbon loss from storage) of natural in-situ degradation of biochar, given the practical limitations of post-application monitoring. It uses a conservative approach to quantify the stable fraction of biochar, then treats this as effectively permanent, requiring no further monitoring or assessment of reversal risk. The DR PCR offers two approved methods for calculating the stable fraction of biochar that yield divergent persistence estimates (200 years versus 1,000 years). A combined approach to using several (including more advanced) methods to assess 1000-yr persistence is endorsed by the Global Biochar C-Sink Standard. Given the conservative calculation of the stable fraction, and the requirement for regular review and update of methods in CRCF, this approach provides similar outcomes to the A6.4 requirements of monitoring and calculating reversal risk – with regards to natural in-situ carbon storage reversal only. The DR PCR does not address reversal risks arising from physical disturbance such as fires, land-use change, or demolition of structures incorporating biochar aggregates and includes no post-disturbance monitoring requirement or compensation mechanism. This contrasts with the treatment of BioCCS and DACCS under the EU CCS Directive (2009/31/EC) as well as risk reversal assessment requirements of A6.4.

Environmental sustainability

In the EU, environmental sustainability is governed through existing EU-level regulation along with a combination of high-level environmental guidelines for contaminant thresholds and regulations. The effectiveness of national regulations is often limited by monitoring and technical constraints (Pouikli et al., 2024; Giakoumis and Voulvoulis, 2026), relying on data and modelling which can be outdated or lack site specificity. Biochar contaminant limits exist for heavy metals and polycyclic aromatic hydrocarbons broadly aligned with EBC agro-grade standards, as well as prohibiting the use of co-processed non-biogenic materials. For application of biochar in soils, DR PCR establishes a maximum cumulative application threshold of 50t/ha (with limited evidence) as an additional safeguard. This represents strong alignment with ICVCM and A6.4 requirements on soil protection. However, protections for air and water quality rely on the EU Industrial Emissions Directive (IED), which applies only to facilities above a 50 MW thermal input threshold, potentially exempting smaller modular biochar production plants. Biodiversity requirements must adhere to the EU Regulation on Nature Restoration. Co-benefits of biochar, including improved nutrient cycling, crop yields, and ecosystem resilience, are part of sustainability requirements linked to EU objectives, requiring project-level monitoring and reporting. Many of these requirements are quite high-level, compared to A6.4's project-specific comprehensive framework for identifying, monitoring, reporting, and managing risk.

Social sustainability

The CRCF DR PCR does not include specific requirements for project-level social safeguards for GGR activities. Unlike ICVCM and A6.4, which set detailed requirements, the CRCF operates primarily at the certification scheme level and relies on existing EU and devolved national laws without specifying how social risks should be identified or managed in practice. Regulatory standards, monitoring, and implementation of compliance can vary nationally, risking fungibility in safeguards and enforcement for activities carried out in different countries. Legal compliance alone cannot guarantee the procedural justice outcomes necessary for high-integrity carbon removal, as evidenced by research on biochar interventions in Sub-Saharan Africa and GGR governance in the UK.

Recommendations

Additionality: strengthen additionality requirements

The CRCF DR PCR could require more rigorous additionality assessments, to include a legal compliance check, a prior consideration requirement, and financial or barrier analysis similar to ICVCM and A6.4 requirements. Where public funding alone is sufficient to make an activity financially viable without carbon revenues, this could be addressed in the certification of units issued.

Additionality: prevent double claiming across certification schemes

To prevent simultaneous certification of biochar removal credits and soil carbon sequestration credits on the same land, geolocation of all biochar application sites could be required to ensure full transparency between certification schemes operating in parallel.

Quantification: quantify and deduct leakage

The CRCF DR PCR could require the identification, minimisation, quantification, and explicit deduction of residual leakage, including indirect land-use change and market displacement effects consistent with the approaches mandated by ICVCM and A6.4.

Permanence: adopt more advanced and harmonised permanence methods

The CRCF DR PCR could recommend a combination of analytical methods consistent with the latest updates to the Global Biochar C-Sink Standard. This would improve confidence in the stable fraction estimate, reduce uncertainty, and achieve higher-integrity credits with longer persistence horizons. The DR PCR's minimum four-year review cycle provides a suitable mechanism to incorporate evolving scientific guidance, including forthcoming A6.4 biochar-specific updates and IPCC methodological guidance.

Permanence: introduce reversal risk management for physical disturbances

The CRCF DR PCR could establish provisions to address reversal risks arising from physical disturbances to biochar in soils and aggregates, including an appropriate post-application monitoring period, quantitative risk tools (drawing on the A6.4 reversal risk framework when available), and compensation mechanisms such as buffer pool contributions. This would bring the treatment of biochar into closer alignment with BioCCS and DACCS under the CCS Directive (2009/31/EC).

Environmental sustainability: evidence-base the application threshold and adopt a systematic co-benefit framework

The CRCF could adopt a structured environmental safeguards and co-benefits framework along the lines of Article 6.4, requiring operators to identify, monitor, report, and minimise negative environmental impacts and to assess positive co-benefits, ensuring consistency and fungibility across projects operating in different national regulatory environments.

Social sustainability: adopt project-level social safeguards

The CRCF could adopt the comprehensive A6.4 framework to ensure carbon removal activities uphold human rights, protect local communities, and prevent negative social impacts. Article 6.4 embeds fairness and justice, ensuring meaningful participation and equitable benefit-sharing, so no group is unduly burdened, and positive impacts reach communities and vulnerable groups. This approach would strengthen both the integrity and social legitimacy of biochar and other GGR activities.

1 Introduction

1.1 Context

Biochar is a carbon-rich material produced through the pyrolysis of organic matter, with applications spanning agriculture, environmental management, and, increasingly, greenhouse gas removal (GGR). Biochar Europe (formerly the European Biochar Industry Consortium) has documented 203 operational European plants producing ~84 kt of biochar as of 2024, with potential to scale to ~114 kt in 2025 (Biochar Europe, 2025). The largest end-use category for EU biochar by purchase volume in 2025 is animal farming (76%), where biochar is used to support animal health, feed efficiency and soil fertility, with agricultural applications accounting for a further 8–10% for crop yields (Mordor Intelligence, 2025). Application in construction materials such as cement, asphalt and concrete remains limited, with uptake constrained by cost and technical barriers despite the potential to reduce industrial carbon emissions (Mordor Intelligence, 2025).

Globally, biochar was estimated to sequester 0.79 MtCO₂/yr in 2023, with Europe contributing approximately 17% of that total (Pongratz et al., 2024). The 2023 Global Biochar Market Report states that global biochar production reached at least 0.35 Mt in 2023, which equates to 0.65 MtCO₂ removal¹ (Biochar Europe, 2025). Tracking the tonnage of carbon credits sold and delivered instead of what is produced, CDR.fyi (2024a) found 0.12 Mt/CO₂ of biochar carbon credits were delivered in 2023, and that less than 50% of biochar producers apply for carbon credits. The biochar carbon removal market globally grew from \$14.6M in 2022 to \$181.5M in 2024, a combined annual growth rate of 131.6% (CDR.fyi, 2025a; 2025b).

Following the rapid growth of the voluntary carbon removal market, and the need to scale high-integrity, internationally recognised standards, the United Nations Framework Convention on Climate Change (UNFCCC), European Commission (EC) and the UK Government have been developing standards for scalability and integrity for carbon markets. The EU have developed a Carbon Removal and Carbon Farming Regulation (CRCF) (2024/3012) and associated Delegated Regulation on permanent carbon removals (DR PCR) (2026/285) for DACCS (direct air carbon capture and storage), BioCCS (biomass with carbon capture and storage) and biochar. The UNFCCC has been developing the Paris Agreement Crediting Mechanism (PACM) (UNFCCC, 2022). Within the Voluntary Carbon Market (VCM) the Integrity Council for the Voluntary Carbon Market (ICVCM, 2024) has developed Core Carbon Principles (CCPs), which the UK government identified as a “*baseline mechanism for providing assurance on the integrity of carbon credit methodologies as a minimum basis for high integrity*” (DESNZ, 2025).

The UK Department for Energy Security and Net Zero (DESNZ) has asked the British Standards Institution (BSI) to develop a UK GGR (greenhouse gas removal) standard for BioCCS and DACCS and is considering a standard for biochar. These should be aligned, where possible in the UK context, with the CRCF, while considering what is best practice across other high-integrity standards. The BSI has published interim specifications for BioCCS and DACCS (BSI, 2025a; BSI, 2025b), but no equivalent specification exists yet for biochar carbon removals. Timely critical analysis of the alignment of CRCF with other high-integrity carbon removals standards would inform both EU and UK standards development.

1.2 Scope

This report assesses the alignment of the EU CRCF biochar methodology with two internationally recognised frameworks for high-integrity carbon credits: the Integrity Council for the Voluntary Carbon Market (ICVCM) Core Carbon Principles (CCPs) Assessment Framework (ICVCM, 2024) and the Article 6.4 (A6.4) mechanism under the Paris Agreement Crediting Mechanism (PACM) (UNFCCC, 2022). Given the policy and technical developments underpinning the ICVCM and A6.4, and the widespread international movement towards alignment with them

in voluntary and national carbon markets, they are relevant benchmarks against which to assess approaches to ensuring high quality carbon removal credits. For broader context, the analysis incorporates the European Biochar Certificate (EBC) (Carbon Standards International, 2025) and the complementary Global Biochar C-Sink Standard (Global Standards International, 2025), which contain biochar-specific detail comparable with the CRCF methodology.

¹ Assuming an average of 1.9 metric tonnes of CO₂ removed per metric ton of biochar.

The assessment examines four pillars that determine the integrity and credibility of carbon removal credits: additionality, quantification of removals, permanence and sustainability safeguards (environmental and social).

1.3 Prior work

In 2025, CO₂RE examined the alignment between the EU CRCF methodologies for BioCCS and DACCS against specific ICVCM CCPs and A6.4 requirements (Martirosian et al., 2025). That assessment identified partial alignment, with material gaps in additionality assessment, baseline determination, leakage quantification and permanence. Building on that work, this report extends the comparative analysis to biochar carbon removal, applying the same assessment framework to evaluate whether similar integrity concerns arise and whether biochar's distinct characteristics give rise to different methodological challenges. The assessment examines sustainability safeguards in greater depth, having been identified as a gap in the previous report as principles that feature prominently in the ICVCM CCPs. They are relevant to biochar with social and environmental risks and co-benefits along the entire life cycle from biomass generation, through pyrolysis, to application in end-uses that interact with land, food and industrial materials.

2 Background: Frameworks under assessment

The frameworks operate at different governance levels. The CRCF is primarily concerned with how certification schemes operate as opposed to individual projects. It prioritises accountability and transparency at the scheme level. In contrast, ICVCM offers a quality assurance label for carbon crediting programmes following their high-integrity principles, while A6.4 certifies mitigation activities and project developers directly. While CRCF, ICVCM and A6.4 apply across several GGR activities, the EBC and the Global Biochar C-Sink Standard assesses biochar only, for production quality, safety and removals. Consequently, the criteria and requirements across these frameworks vary significantly.

2.1 EU Carbon Removals and Carbon Farming Regulation (CRCF) and Delegated Regulation on Permanent Carbon Removals (DR PCR)

The EU CRCF Regulation (2024/3012) provides a framework for the certification of permanent carbon removals (through engineered processes with geological storage), carbon farming (via ecological processes in soils and biomass) and carbon storage in products (such as wood in construction). Detailed methodologies for permanent carbon removal activities such as BioCCS, DACCS and biochar are set out in a separate DR PCR (2026/285) adopted under this framework. In order to ensure the quality of carbon removals certified under the framework, removals need to meet several criteria, covering the aspects of quantification, additionality, long-term storage and sustainability (QU.A.L.I.TY). The DR PCR includes a periodic review of all aspects at least every four years. This includes technological and scientific progress and innovation and developments in legislation.

2.2 Integrity Council for the Voluntary Carbon Market (ICVCM) Core Carbon Principles (CCPs)

The ICVCM is an independent governance body that has established the CCPs, which serve as a global benchmark for high-integrity carbon credits in voluntary markets. The CCPs define requirements across ten assessment criteria, including additionality, robust quantification, permanence and sustainable development impacts, and are operationalised through the CCP Assessment Framework (ICVCM,2024). Already widely applied within the voluntary carbon market, the UK government has indicated, through consultation, its intention to endorse the ICVCM and adopt the CCPs as a minimum quality threshold for voluntary carbon credits.

2.3 Article 6.4 of the Paris Agreement Crediting Mechanism (A6.4)

A6.4 of PACM establishes a mechanism for countries to cooperate on climate action and trade carbon credits from emissions reduction and removal projects. These credits are expected to be used by countries to fulfill their nationally determined contributions (NDCs), and can further be used for other purposes such as international mitigation under the Carbon Offsetting and Reduction Scheme for International Aviation (CORSA) or as "non-authorised" (voluntary) mitigation. The A6.4 Supervisory Body of international experts has developed methodologies and requirements for activities generating carbon credits, taking into account environmental

integrity, transparency, and avoidance of double counting. These have been subject to extensive international review and approval. A6.4 is a modular system where cross-cutting rules such as additionality and permanence apply across all carbon removal activities (in scope) and are then supplemented by activity-specific methodologies. At the time writing, the supplementary methodology for biochar was still in preparation.

2.4 European Biochar Certificate (EBC) and the Global Biochar C-Sink Standard

The EBC and Global Biochar C-Sink Standard are included for broader context as they are well respected and have been developed over several years. They contain biochar-specific technical information, including permanence methodologies, sustainability and social governance components directly comparable to the CRCF. They do not include greenhouse gas flux quantification methods or baseline and additionality calculations. The latest version (at time of writing), EBC Standard 10.5E (Carbon Standards International, 2025), focuses on product quality and safety, sustainable biomass sourcing and safe pyrolysis. The EBC is interconnected with the Global Biochar C-Sink Standard 3.2 (Global Standards International, 2026), which focuses on quantifying carbon flux during production lifecycle and quantifying the permanent fraction of carbon stored in biochar. Both standards are part of a unified certification framework owned and managed by Carbon Standards International (CSI). CSI operates the Global C-Sink Registry, a platform for registering, tracking and retiring carbon credits.

3 Methodology

This assessment applies a comparative framework examining four key pillars that determine carbon credit integrity: additionality, quantification of removals, permanence and sustainability. For each parameter, the analysis first establishes the common requirements across ICVCM CCPs and A6.4 methodologies, identifying the key integrity criteria and assessment approaches that these frameworks mandate. The CRCF biochar methodology is then assessed against these requirements to determine the extent of alignment, including the DR PCR referred to in the text, although a detailed review of all regulations is out of scope. Where relevant, the assessment incorporates additional comparators including the European Biochar Certificate and the complementary Global Biochar C-Sink Standard to provide broader sectoral context. The methodological approach is document analysis combined with expert discourse (including academic and policy stakeholders), consistent with the approach used in the previous analysis (Martirosian et al, 2025).

The analysis assigns alignment ratings using a Red-Amber-Green (RAG) scale to indicate the degree of alignment:

- Green indicates good alignment of approaches and methods, likely leading to similar outcomes.
- Amber indicates some – but not complete – alignment, with gaps that may lead to differences in outcomes and possible risks to integrity.
- Red indicates limited alignment or major gaps in methodologies and approaches that are likely to lead to clear differences in outcomes and risks to integrity.

For each parameter, the assessment evaluates the practical consequences of misalignment for credit quality and environmental integrity as far as they are covered by the various high-level standards. The whole lifecycle of biochar is considered, from biomass growth through to application in a variety of end-uses, e.g. soils, animal feed and concrete.

EU CRCF			
Regulation (EU) 2024/3012 of the European Parliament and of the Council of 27 November 2024 establishing a Union certification framework for permanent carbon removals, carbon farming and carbon storage in products. PE/92/2024/REV/1	Delegated Regulation on Permanent Removals EU 2026/285: supplementing Regulation (EU) 2024/3012 of the European Parliament and of the Council by establishing the certification methodologies for permanent carbon removals activities	Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources	Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652
ICVCM			
Core Carbon Principles Assessment Framework and Procedure v1.1	Continuous Improvement Work Program report: Permanence v1.1		
Article 6.4			
Standard: Addressing non-permanence and reversals in mechanism methodologies v.01.1. A6.4-STAN-METH-007	Standard: Addressing leakage in mechanism methodologies v01.0. A6.4-STAN-METH-005	Tool: Article 6.4 sustainable development tool. v01.1. A6.4-TOOL-AC-001	Environmental and Social Management Plan Form. v01.1. A6.4-FORM-AC-015
Standard: Setting the baseline in mechanism methodologies. v01.0. A6.4-STAN-METH-004	Standard: Demonstration of additionality in mechanism methodologies v01.0. A6.4-SBM01-A11	Environmental and Social Safeguards Risk Assessment Form. v01.1. A6.4-FORM-AC-015	Sustainable Development Impact Form. v01.1. A6.4-FORM-AC-017
EBC			
European Biochar Certificate – Guidelines for a Sustainable Production of Biochar 10.5E. 15 th September 2025	Global Biochar C-Sink Standard 3.2. 15 November 2025	Amendment A to Global Biochar C-Sink Standard 3.2. 5 February 2026	

Table 1. Core documents reviewed for comparative analysis methodology. (Note: 1. Full references including links are found in the reference list. 2. This is not an exhaustive list of supplementary documents available or relevant, which are referenced in the main text.)

4 Results

4.1 Additionality

Additionality			
Sub-category	ICVCM	Article 6.4	Assessment of CRCF alignment
Regulatory additionality (activities exceed host country existing statutory obligations or legal requirements)	Mandatory	Mandatory	Not considered, with some justification
Prior consideration (the carbon credits are a pre-planned part of the activity, e.g. including stakeholder consultations)	Mandatory	Mandatory	Not considered, with some justification for biochar in materials. Higher risk for biochar in soil
METHODOLOGY			
Level of Stringency	High level of stringency across approaches	High level of stringency across approaches	Low level of stringency for standardised approach
Detailed Justification	Mandatory	Mandatory	Little detail to justify selection of standardised method only
Review Mechanism	Mandatory, but no specified timeline	Mandatory, but no specified timeline	Reviewed at least every four years along with standardised baseline
Independently Verified	Mandatory	Mandatory	Mandatory

Table 2. Alignment of assessment criteria for biochar: additionality. Standards: the EU-CRCF Regulation (Carbon Farming and Carbon Removal) and other related EU regulation and guidance, with the ICVCM Core Carbon Principles & Assessment Framework and Article 6.4 of the Paris Agreement. RAG rating: Green = good alignment of approaches and methods likely leading to similar outcomes; Amber = some alignment but not complete, some gaps that may lead to differences in outcomes; Red = limited alignment or major gaps in methodologies and approaches that are likely to lead to clear differences in outcomes and risks to integrity.

Mitigation projects, mitigation policies or climate finance are additional if they go beyond a business as-usual level, or baseline. This principle exists to ensure that carbon credits represent truly additional climate benefits that would not have occurred under business-as-usual circumstances, and would therefore not represent effective investments in climate action, risking the integrity of the carbon crediting system. Additionality criteria differ between standards but usually include some combination of methods such as regulatory requirements, financial tests, barriers analysis and a common practice test.

In the case of biochar, the assessment of additionality is important, as deployment already exists without reliance on credit revenues. Biochar producers may rely on revenue streams such as biochar sold to end-users such as farmers; payments to take in the feedstock through “gate fees” (fees paid for by the originator to dispose of waste streams such as food-waste digestate, sewage sludge or green waste); and the heat generated by the pyrolysis process sold into district heating networks or used to displace fossil heat on-site. These revenue streams allow the producer to be financially viable without carbon credits. According to one market analysis, “most producers in Europe do not generate income from carbon credits or depend significantly on carbon credits as a source of

revenue” (cdr.fyi, 2024), demonstrating that the biochar industry existed before carbon removals credits became a potential source of revenue.

Other sources include public funding such as Denmark’s Green Tripartite Agreement (State of Green, 2024), which has committed the equivalent of around 1.35 billion euros for biochar subsidies through 2045. This lowers the carbon finance requirement and could lower credit prices and subsidise the buyers of the units. If revenues only constitute a small part of the budget, this also poses a risk that activities are not additional.

While double counting is not covered under the umbrella of additionality in the wider carbon market, it can lead to lack of integrity in the carbon markets if not verified appropriately, and is therefore assessed under this category (see also section 5.2.1). Double counting is defined according to ICVCM as: “A situation in which a single GHG emission reduction or removal is counted more than once towards achieving mitigation targets or goals. Double counting can occur through double issuance, double use, and double claiming” (ICVCM, 2024). Biochar applied on soils could be double-counted since current soil sampling methods cannot distinguish between soil organic carbon and biochar (Rathnayake et al., 2024). This could mean that, without safeguards, permanent removal units could be claimed by the biochar producer while the farmer, who has added the biochar to their land, could additionally claim carbon farming units for soil carbon sequestration.

4.1.1 ICVCM approach

ICVCM requires a mandatory legal assessment demonstrating that activities exceed host-country statutory obligations. The assessment also requires documented evidence of any prior consideration of carbon credits that demonstrates an activity not being undertaken for reasons other than carbon finance.

Projects then select one of three core additionality pathways: investment analysis combined with market penetration assessment; barrier analysis with market penetration assessment; or a standardised approach, in which pre-approved methodologies are defined at an appropriate aggregation level including detailed justification, then reviewed regularly and independently verified.

The ICVCM further mandates that double issuance of credits should be prevented and that registries should prevent the further transference of credits after they have been retired.

4.1.2 Article 6.4 approach

An assessment must be conducted to determine whether proposed activities are already mandated by existing regulatory requirements. Participants must demonstrate that the potential benefits of the mechanism were considered before the activity was implemented by submitting a prior consideration notice within 180 days of the decision to implement the activity.

A6.4 requires methodologies to select between three additionality pathways: investment analysis with common practice analysis; barrier analysis with common practice analysis; or a performance-based approach. Performance-based approaches are a specific and more rigorous subset of standardised approaches that use quantifiable performance indicators to determine additionality. A6.4 further requires detailed justification and evidence behind the chosen indicators and thresholds that the activity is at a suitably standardised technology level and that the approach is timebound and includes an update mechanism.

A6.4 also requires that where “public funding [for an Article 6.4 activity], expressed in grant equivalents, is larger than the expected revenues from A6.4ERs”, mechanism methodologies shall require demonstration “...that public funding would not have filled the funding gap...in the absence of revenues from A6.4ERs. This may, for example, apply to public funding schemes that are designed to pay for the funding gap of mitigation activities.”

4.1.3 EU CRCF approach

The DR PCR (2026/285) employs a standardised approach, in which a zero-baseline is set and any biochar activity that results in net carbon removal and storage is deemed additional. The standardised baseline is expected to be reviewed and updated every four years to reflect changing circumstances. The additionality assessment, which assesses if the carbon removal is above zero, is reviewed by an independent verification and validation body.

The DR PCR (2026/285) explicitly allows other sources of finance such as public subsidies to be combined with revenues from the EU CRCF credits, and states that this should be indicated in the certification of compliance.

However, no specific guidance is provided on cases where the subsidies alone are sufficient to make a project viable and how they should be addressed in the final credits issued.

On double counting, the EU CRCF Regulation (2024/3012) further explicitly states that a certified unit should not be issued more than once, and a registry should be established that allows interoperability between certifiers to prevent the same activity being certified under two schemes. The use of units to contribute to third-party NDCs and international compliance mechanisms, such as the CORSIA programme, are also prohibited.

4.1.4 Alignments, risks and recommendations

Regulatory analysis and prior consideration: While a standardised additionality assessment is suitable for DACCS, BioCCS and biochar stored in cement and asphalt aggregates, the same approach could risk non-additionality credits for biochar applied to soils, as it does not consider that it might currently be used in the agricultural sector at the same site as a soil additive for soil health and improved yields (Biochar Europe, 2025). Little to no additionality risk is posed by biochar in materials, given the current lack of commercial deployment. The DR PCR does not check if there are any enforced legal requirements for these technologies or if operators have considered carbon credits prior to the start of the activity.

Rating: AMBER

Stringency level and appropriate level of technologies: Even though the CRCF (2024/3012) declares that permanent carbon removal units, carbon farming sequestration units and carbon storage in products should remain distinct, and that the same activity should not be certified under two different schemes, it does not explicitly prohibit two different activities being certified on the same plot of land simultaneously under different certification schemes, such as soil organic carbon sequestration under carbon farming and biochar application under permanent removals. Along with analysis that most biochar activities are already financially viable in Europe (CDR.fyi, 2024), this level of stringency is assessed as low compared to financial, barrier and common practice tests which require further details, although could be justified for biochar in materials.

Rating: AMBER

Detailed justification: Little to no detailed justification of approach for zero-baseline additionality as required by the ICVCM and A6.4, which makes it difficult to review the modelling, assumptions or evidence used to make this decision.

Rating: RED

Review mechanism: The DR PCR is expected to be reviewed and updated at least every four years.

Rating: GREEN

Independently verified: The CRCF regulation requires the baseline and additionality check to be reviewed by an independent verification and validation body.

Rating: GREEN

Recommendation: The CRCF DR PCR could require more rigorous additionality assessments using similar approaches to the ICVCM and A6.4, such as financial/barrier tests, a prior consideration assessment and a demonstration that public funding (where larger than revenues from expected carbon finance) would not have filled the funding gap in the absence of carbon finance.

Recommendation: To ensure certification for soil carbon sequestration activities are not mistakenly undertaken on the same plot of land where biochar credits are sought under CRCF, geolocation of any application sites could be used to ensure full transparency between different certification schemes.

4.2 Quantification

Quantification			
Sub-Category	ICVCM	Article 6.4	Assessment of CRCF Alignment
Baseline	Mandatory	Mandatory	Zero-baseline, with some justification
Lifecycle	Mandatory	Mandatory	Comprehensive lifecycle analysis with uncertainty accounted
Leakage	Mandatory	Mandatory	Leakage minimisation through cascade principle and 50% waste criteria but no detailed indirect land use change (iLUC) assessment

Table 3. Alignment of assessment criteria for biochar: quantification. Standards: the EU-CRCF Regulation (Carbon Farming and Carbon Removal) and other related EU regulation and guidance, with the ICVCM Core Carbon Principles & Assessment Framework and Article 6.4 of the Paris Agreement. RAG rating: Green = good alignment of approaches and methods likely leading to similar outcomes; Amber = some alignment but not complete, some gaps that may lead to differences in outcomes; Red = limited alignment or major gaps in methodologies and approaches that are likely to lead to clear differences in outcomes and risks to integrity.

The quantification pillar assesses the methods calculating the net carbon removal from the GGR activity, including lifecycle emissions from upstream and downstream emissions, which for biochar includes the production, collection and transportation of biomass or biomass fuel used at the production facility, the construction of the production facility, the energy consumption at the biochar production facility operations, the transportation of the biochar to the application site and the energy consumption for the application process. The pillar further includes the baseline analysis (the counterfactual fate of the feedstock), as well as leakage assessments, which are emissions occurring outside the activity boundary such as market and activity displacement (e.g. indirect land use change).

Baseline estimates that are inflated (showing more emissions or fewer removals than expected in the counterfactual) can risk over-crediting and creation of poor carbon credits with minimal climate benefit and in so doing, threaten the integrity of carbon markets. Previous issues in the carbon market relating to overinflated baselines, due to gaming of standardised approaches, have caused a loss of confidence and a decrease in the number of buyers (Badgley, et al. 2021; Lezak, et al. 2026).

Studies carried out assessing the availability of biomass potentials across the EU and the UK show that a wide range of biomass feedstock sources are available for biochar production, such as agricultural and forestry residues, dedicated energy crops and organic waste (food, manure, municipal) (Environment Agency, 2025). The counterfactual fate of biomass with the highest potential for biochar, such as agricultural residues, sewage sludge, manure and municipal solid waste, would, if not used for biochar, most likely generate greenhouse gas emissions through decay and decomposition. At the same time, real-world availability of these 'waste' products is constrained by competing uses such as bioenergy and biofuels (Material Economics, 2021). This makes assessing the counterfactual scenario complex, as it depends on factors such as the projected price of carbon, the rate of electrification of transportation and energy, as well as the sustainable limit of forest residues that can be sourced from forests without impacting soil health and biodiversity.

4.2.1 ICVCM approach

The CCPs establish four key requirements for conservative and scientifically robust quantification throughout a project's operational lifecycle. First, baseline scenario selection must be conducted conservatively by evaluating multiple scenarios, including the best available technology or statistically relevant historical data, accounting for uncertainties between candidate scenarios, incorporating existing government policies and legal requirements (with enforcement assumptions varying by income level), and addressing potential rebound effects from implementation activities. Second, the overall conservativeness in quantifying baseline emissions or removals

must be proportionate to the level of uncertainty inherent in the assumptions, models, parameters, data sources and measurement methods employed. Third, methodologies must account for potential perverse incentives that could lead project operators to artificially inflate baseline emissions or suppress baseline removals. Finally, baseline scenarios and their associated quantifications require regular updates or reviews at frequencies that appropriately reflect evolving circumstances, particularly changes in government policies and legal frameworks.

4.2.2 Article 6.4 approach

A6.4 outlines three types of baseline scenarios that can be implemented in a project in paragraph 36 of the Rules, Modalities and Procedures. These are: 1) Best Available Technology (BAT), which identifies the lowest-emitting, economically feasible and environmentally sound technology available in the baseline geographical area; 2) ambitious benchmark, which uses the average performance of top performers among comparable activities; or 3) existing actual or historical emissions, which is based on site-specific historical data and used when limited sector data is available or circumstances are highly heterogeneous. The unadjusted baseline emissions and/or removals are then quantified.

As a general rule, all baselines must be set below a conservatively determined business-as-usual (BAU) emissions level with methodologies that demonstrate this. The standard acceptable approaches for determining the BAU scenario are continuation of historical trends (with downward adjustments, as described above); implementation of an economically viable technology and/or practice; or a combination of the two, with both incorporating applicable policies and legal requirements. The downward adjusted baseline should then be compared against the BAU and if the BAU is lower, the baseline should be adjusted downward further.

A6.4, methodologies must apply a conservative approach, specify the validity period of proposed methodologies and periodically revise them to reflect updated analyses. The validity period may not exceed five years.

4.2.3 EU CRCF approach

Baseline: The DR PCR (2026/285) zero-baseline approach assumes that net fluxes within the project boundary under the counterfactual scenario are zero.

Lifecycle analysis: The DR PCR (2026/285) requires quantification of the upstream and downstream emissions and removals directly associated with the biochar activity. To ensure no significant emissions are overlooked, operators must conduct a materiality assessment, in which any source that is expected to contribute emissions equal to or greater than 2% of the gross carbon removals is also accounted for in the total.

Uncertainties in measured, estimated or default data are combined according to IPCC Good Practice Guidance and Uncertainty Management (Penman et al., 2000). If greater than $\pm 20\%$, no units shall be issued for that certification period. If between $\pm 2.5\%$ and $\pm 20\%$ uncertainty, an adjustment is required. For uncertainty less than $\pm 2.5\%$, no adjustment is needed. Conservativeness is incorporated by requiring operators to use the most conservative default factors for estimating emissions and optionally implement a 2% flat rate deduction for minor emissions that are complex to track.

Here the DR PCR (2026/285) aligns with A6.4, ICVCM and the Global Biochar C-Sink Standard by considering the entire lifecycle from biomass sourcing to the final point of application or incorporation. Uncertainty assessments and the requirement for conservativeness are also required and incorporated into the total removal quantified.

Operators are expected to also demonstrate that biochar application does not result in an overall negative effect on soil organic carbon stocks. This includes considering the risk of positive priming effects (where soil carbon decomposition accelerates due to the addition of biochar). If any evidence of significant loss of soil organic carbon is recorded by the certification body, no carbon removal units are issued, although this provision is weak given that there are no monitoring requirements for soil health or soil organic carbon change.

Leakage: The DR PCR (2026/285) primarily relies on preventative safeguards to minimise leakage risk in permanent removal activities. For biomass sectoral displacement, the EU's cascading use of biomass principle (introduced in REDIII (2023/2413)) establishes a hierarchy for biomass use in the following order: wood products, product life extension, reuse, recycling, bioenergy, and disposal. This principle aims to prevent biomass displacement and minimise indirect land-use change by ensuring biomass is directed to its highest-value application. However, the principle has limited specification on methods of implementation or compliance for member states.

The DR PCR (2026/285) further imposes a 50% energy-content assessment to determine whether biochar is considered the main product of a production activity. Any production batch where biochar accounts for 50% or more of total energy output (energy content of biochar vs energy produced for use such as heat), must use only waste or residual feedstocks as defined under REDIII. This acts as a biomass leakage safeguard by preventing facilities from being designed primarily for biochar production, which could create unsustainable demand for biomass. For example, a facility producing biochar alongside heat and electricity must use waste or residue feedstocks (such as sawdust, agricultural residues or forestry residues) where biochar represents the majority of energy outputs. If biochar is a co-product representing less than 50% of total energy content, purpose-grown energy crops (such as miscanthus or short-rotation coppice) may be permitted.

4.2.4 Alignment, risks and recommendations

Baseline: The DR PCR adopts a zero baseline within the defined project boundary and does not show evidence of considering other baseline scenarios, as required by ICVCM and A6.4. This follows from the methodological design, in which the system boundary begins at the point of feedstock collection for waste and residue feedstocks and encompasses only the biochar production and application processes. In the absence of the project, no activities would occur within this boundary, and therefore no emissions or removals would be recorded. This justifies a zero baseline within the accounting framework. However, this does not imply that no removals or emissions would occur in the real-world counterfactual, as the fate of biomass outside the boundary, such as alternative uses in materials or for energy displacement, should be addressed in the leakage assessment.

Rating: AMBER

Quantification: Quantification of the full lifecycle of the biochar production process (collection, production and application as well as dedicated biomass production) is required by the DR PCR, including accounting for uncertainty and the need to use conservative estimates.

Rating: GREEN

Leakage: The CRCF DR PCR (2026/285) diverges from the ICVCM and A6.4 requirements, as it does not require leakage identification and quantification to be carried out. Instead, preventative measures are intended to minimise the impact of biochar production, such as the cascade use principle and ensuring that only waste and residues are used if more than 50% energy output of a production activity is biochar. While it does note that significant indirect-land use risk is not expected, it does not provide detailed analysis or justification demonstrating how these preventative measures adequately substitute for leakage quantification, or how indirect market effects or activity-shifting emissions have been comprehensively assessed and found to be negligible.

Rating: AMBER

Recommendation: CRCF DR PCR (2026/285) could identify and minimise potential leakage such as indirect land-use change or market displacement, then quantify and deduct any remaining leakage, using approaches such as in A6.4 and ICVCM, with detailed information of the methodology and assumptions.

4.3 Permanence

Permanence			
Sub-Category	ICVCM	Article 6.4	Assessment of CRCF Alignment
Approach to Permanence	Approached through “material risk of reversal” (implicitly low risk for biochar)	Emphasis on calculating risk of reversal through assessment tool. Some reference to 100-year timeframe	Treats biochar as a permanent removal if it meets the criteria for high stability biochar (conservative calculation) for at least 200 years. Methodologies could be updated using more rigorous approach of the EBC/Global Biochar C-Sink Standard which considers at least 1000 years
Approach to Reversal Risk	Requires definition of avoidable vs unavoidable risk. Risk assessment mandatory using publicly available methods	Defines avoidable vs unavoidable risk. Must provide evidence of reversible risk over a 100-year timeframe, or remediation of reversals	<p>No requirement for calculating risk of reversal:</p> <p><i>In situ</i> decay: justified by conservative calculation of stable fraction of biochar and impracticability of soil monitoring</p> <p>Reversal due to avoidable or unavoidable disturbances (e.g. fire, land use change, demolition) not considered.</p>
Monitoring Period	No monitoring period once material risk for reversal is calculated and safeguarded	Requires monitoring until negligible risk or reversal or reversal remediated. Minimum period defined considering the mitigation activity type and its associated reversal risks.	<p>No monitoring required post application into soils or products:</p> <p><i>In situ</i> decay: Justified by low risk of reversal for stable biochar and impracticability of soil monitoring</p> <p>Reversal due to disturbances. Contrasts with long-term monitoring for BioCCS and DACCS under CCS directive (2009/31/EC)</p>
Approach to risk management / compensating for reversals	Compensation of avoidable risks only. Not considered for biochar (or CCS but buffer pools for other biogenic activities)	Remediation of avoidable and unavoidable risks. Buffer pool determined using the reversal risk assessment tool or specific methodologies	While buffer pools “could be included” according to CRCF Regulation (EU) 2024/3012, the Delegated Regulation on Permanent Carbon removals (EU) 2026/285 implicitly excludes risk management and compensation for biochar as it is considered permanent at the point of application

Table 4. Alignment of assessment criteria for biochar: Permanence. Standards: the EU-CRCF Regulation (Carbon Farming and Carbon Removal) and other related EU regulation and guidance, with the ICVCM Core Carbon Principles & Assessment Framework and Article 6.4 of the Paris Agreement. RAG rating: Green = good alignment of approaches and methods likely leading to similar outcomes; Amber = some alignment but not complete, some gaps that may lead to differences in outcomes; Red = limited alignment or major gaps in methodologies and approaches that are likely to lead to clear differences in outcomes and risks to integrity.

Permanence refers to the durability of carbon storage following an anthropogenic activity to remove CO₂ from the atmosphere and store it, while reversal risk is a project’s susceptibility to re-releasing stored CO₂ back to the atmosphere.

Biochar activities produce a quantifiable fraction of stable biochar that is expected to store carbon for at least several centuries through its application to soils or incorporation into products. Due to practical difficulties,

complexities and large uncertainties in measuring greenhouse gas fluxes associated with biochar decay post-application in soils and other uses (Chiaramonti et al., 2024 and 2026), methods to address permanence rely on estimating the stable fraction of biochar (Box 1).

4.3.1 ICVCM approach

Permanence risks must be transparently identified, conservatively calculated and independently verified. Any reversible storage is managed through conservative accounting and program safeguards. ICVCM explicitly treats biochar as a category with material reversal risk that requires reversal risk assessment and management of material risks, without explicitly giving methods, leaving project operators to provide their own methods and evidence.

ICVCM CCPs do not explicitly mention monitoring for biochar or other “permanent” GGR activities, i.e. BioCCS and DACCS (for non-permanent biogenic GGR activities such as soil carbon, and ecosystem sinks, it requires monitoring for a minimum of 40 years). Buffer pools are not required for biochar or other “permanent” activities (they are considered for other biogenic GGR activities).

ICVCM recently released the *Continuous Improvement Work Program report: Permanence* (May 2025, Version 1.1). It provides recommendations “for information only” on reversals definitions, extension and cessation of monitoring periods, buffer pool stress testing, projectlevel risk assessment and methodologies innovation, although there are no activity-specific methods.

4.3.2 Article 6.4 approach

A6.4 sets out rules to ensure reversals are identified and remediated (A6.4-stan-meth-007, V 1.0, 2025). It is methodologically detailed (providing mathematical equations) and distinguishes avoidable from unavoidable reversals. Projects must apply a reversal risk assessment tool (under development² as part of the 2026 workplan³) or alternative activity-specific methodologies (also in A6.4 development). The tool will be used to calculate the fraction of issued units to contribute to the reversal risk buffer pool account. The tool can be parameterised for biochar, and A6.4 is expected to give more details on specific methods in future updates.

A6.4 requires definition of a minimum period for monitoring during the post-crediting monitoring period, considering the mitigation activity type and its associated reversal risks. Projects shall carry out postcrediting monitoring, which may terminate during the post-crediting monitoring period through demonstration of negligible risk of reversals. The minimum period is determined by the mitigation activity type and its associated reversal risks. A6.4 uses a >100-year period for negligible risk calculations, starting after the end of the last active crediting period (A6.4-stan-meth-007, V 1.0, 2025). Note that the previously reviewed (Martirosian et al., 2025) draft version (A6.4-MEP008-A03 V 02.2) had an indefinite time period.

4.3.3 EU CRCF approach

The CRCF addresses permanence in a practical and conservative way, with methodologies outlined in the Delegated Regulation on Permanent Carbon removals (DR PCR (EU) 2026/285) based on current available knowledge reviewed at least every four years. To demonstrate a permanent fraction of biochar carbon, one of two parallel quantification methods are recommended, rather than a single harmonised approach, without indicating how the methods compare (see Box 1). An obvious inconsistency is that the random reflectance method predicts permanence over 1,000 years compared to 200 years for the decay function method. DR PCR requires a 2.5% conservatism factor to be added on to the uncertainty calculation for permanence assessment by the random reflectance method, whereas the decay function method is treated as having no uncertainty, as the decay function is already considered a conservative basis for estimation.

Permanence is established at the point of biochar application to soils or products, with evidence provided through certification schemes, certification bodies or relevant competent national authorities.⁴ DR PCR only requires

² <https://unfccc.int/process-and-meetings/the-paris-agreement/article-6/article-6-4-pacm/methodologies#Development-of-A64-methodologies-and-methodological-tools->

³ [3.2.MEP012-Tool-Reversal-risk-assessment.pdf](#)

⁴ A new Commission Implementing Regulation (EU) 2025/2358 lays down rules on certification schemes, certification bodies and audits under the CRCF.

verification of application happening, not the mode or effectiveness of application, which may affect persistence or environmental impacts (see environmental sustainability section 4.4.1). The DR PCR ends monitoring once biochar application or incorporation is verified, with at least one year of site access if the application was not directly supervised. "Operators are not subject to further monitoring...as the risk of reversal is characterised through the assessment of the permanence fraction of the biochar and is not practically possible to identify reversals after the point of application or incorporation" (Section 3.2, DR PCR).

Thus, the CRCF implicitly allows a verified and conservatively quantified stable fraction to be treated as permanent, with no reversal risk and no need for monitoring, management or compensation mechanisms. This contrasts somewhat with the main CRCF regulation, which states "*buffers and up-front insurance mechanisms could be included*" (without giving explicit methodologies) (introduction (23), EU 2024/3012). Buffers and other mechanisms are not mentioned in DR PCR (which covers BioCCS, DACCS and biochar). "Mechanisms" are mentioned in the CCS Directive (2009/31/EC), which applies to BioCCS and DACCS only.

Box 1. Methodologies to calculate biochar permanence: CRCF versus EBC/Global Biochar C-Sink Standard

Permanence is assessed through estimating biochar persistence due to practical difficulties in measuring post-application biochar permanence in soils (Chiaramonti et al., 2024 and 2026). The methodologies are pragmatic and predictive, determined through laboratory methods and modelling.

1. The decay function method calculates remaining carbon after 200 years using decay data based on incubation experiments in the lab in combination with modelling (Woolf et al., 2021) rather than long-term field data, which are not available. Carbon surviving millennium timescales is difficult to infer. It is parameterised by the hydrogen to organic carbon H/C_{org} ratio, and the annual average temperature at location of application or incorporation (e.g. soil temperature and air temperature for incorporation in soils and products). This early method has relatively more available data than others, but does have its criticisms, not least that incubation data are only typically available for periods of a year and, hence, the permanence timescale of 200 years is short compared to other methods.
2. The random reflectance method calculates the stable fraction of biochar carbon at the microscale for timescales typically around 1,000 years, but literature in terms of comparisons with other approaches is limited (Petersen et al., 2023; Sanei et al., 2024).
3. The hydrolysis (HyPy) method is used to calculate the residual polyaromatic fraction, which is the most stable fraction likely to persist >1000 years, determined after pyrolysis at high pressure (150 bar) hydrogen atmosphere and high temperature (550 °C) (Meredith et al., 2012; Hagemann et al., 2025). This fraction comprises eight or more aromatic ring structures. Literature on biochar persistence in relation to HyPy is increasing (McBeath et al., 2015; Howell et al., 2022; Hagemann et al., 2025).
4. The solid-state electric conductivity (SEC) method calculates the electrical conductivity of the solid biochar matrix that correlates with biochar stability. It is a practical and cost-efficient proxy complementing other methods (Hagemann et al., 2025).

The CRCF DR PCR gives the option of decay function or inertinite reflectance (random reflectance 2%). These methods produce different results for different timescales, and their treatment of uncertainty also differs.

The Global Biochar C-Sink Standard (version 3.2, 15 November 2025 and Amendment A, 5 February 2026) partitions biochar into fractions depending on persistence: persistent aromatic carbon (PAC) is a carbon sink for several millennia; and semi-persistent carbon (SPC) may be decomposed within the first 1,000 years after the application to soil, and hence is considered a temporary carbon sink. This empirical, proxy-based approach provides the technical foundation needed to justify treating a fraction as effectively permanent. Amendment A (5 February 2026) replaces PAC with geological persistent carbon (GPC) and introduces an upper persistence class of biochar, in which GPC is conservatively defined as ≥90% of the total organic carbon (the remaining fraction is SPC). Amendment A notes that there are newer methods than the decay function and recommends (but does not require) a combination of mean random reflectance and HyPy, with SEC as a complementary proxy, to define the upper persistent class with permanent carbon fraction of at least 90% that will persist for a period of at least 1,000 years. Due to the pilot nature of these methods, certification of the upper persistence class for production and soil application in 2025–2026 was limited to a maximum of 1,000 tonnes.

Random reflectance and HyPy measurements (methods 2 and 3) are currently considered the most reliable methods to determine the size of the polyaromatic carbon of biochar for a timescale of 1,000 years (McBeath et al., 2015; Petersen et al., 2023). Key research gaps include longer-term land and field trials and the effects of soil types and climatic conditions on biochar and its decay rates. Note: IPCC (2019) inventory methods guidance currently includes method 1 for 100-year persistence, with the ongoing update tasked to include new methodological guidance and default factors for biochar application in soils and other durable product (IPCC, 2025).

4.3.4 Alignment, risks and recommendations

Permanence methodology: CRCF, ICVCM and A6.4 all require conservative quantification of permanence and updating of methods (A6.4 and ICVCM do not recommend any specific methods). The DR PCR allows for a 200-year minimum persistence of stable biochar if using the decay function method, and an even more conservative approach if using the 1000-year timeframe random reflectance method. It does not include the wider range of longer-timescale analytical methods (HyPy and SEC) recommended in the Global Biochar C-Sink Standard. There is some risk of over- or under-estimation of removals due to evidence gaps on decay rates and stability in soils or other materials in which biochar is incorporated. The risk is reduced using a conservative approach to calculations, but there is still some risk of over-crediting if the stable fraction of biochar is overestimated.

Rating: AMBER

Recommendation: The CRCF DR PCR could recommend a combination of new and more advanced comprehensive methods to quantify the stable fraction of biochar to improve uncertainty and unlock higher-integrity, longer-horizon 1,000-year credits. For example, it could follow the latest updates of the Global Biochar C-Sink Standard, and any biochar-specific methods updates under A6.4 and IPCC when available. CRCF DR PCR's specification that review and update processes must happen every four years at a minimum is a reasonable timeframe.

Approach to risk reversal and monitoring for *in situ* natural degradation: A post-application monitoring plan for biochar application in soils or products in terms of directly measuring or monitoring any carbon loss due to natural biochar degradation processes is impractical (e.g. complex, heterogenous and costly) and therefore not included in CRCF DR PCR. This pragmatic approach is further justified by a conservative approach to calculating the stable fraction of biochar.

Rating: GREEN

Approach to risk reversal and monitoring for disturbance/degradation: Biochar storage could be at risk of reversal due to avoidable or unavoidable disturbances, e.g. soil deep ploughing, land-use change, fires or demolition/destruction of structures containing aggregates. There is a lack of quantified scientific evidence on such risks. Verra VM0044 Biochar methodology, which is CCP Certified (Verra, 2025), recommends risk management for surface application of biochar – that it *must* be mixed with other substrates such as compost, manure or digestate from anaerobic digestion before application to avoid being lost due to fire or erosion. This draws upon similar advice given by the International Biochar Initiative (IBI, 2010).

The CRCF DR PCR and ICVCM calculate stable biochar as having low risk of reversal, then essentially treat this as a zero-reversal risk, as it does not require a post-application monitoring period, specific calculations of risk reversal or compensation mechanisms. This contrasts with the long-term monitoring for BioCCS and DACCS geological storage under the CCS Directive (2009/31/EC). A6.4 retains explicit post-issuance reversal management mechanisms.

It further requires long-term monitoring of reversal risk, application of quantitative tools and a buffer pool. This produces different durations of liability and monitoring across standards.

If buffers were to be included in DR PCR, more rigorous quantification methods for the stable fraction (see above) would further justify smaller buffers for the permanent carbon fraction while retaining robust compensation for semi-permanent carbon fraction. However, better methods for calculating persistent biochar under fixed conditions will still not address intended or unintended consequences as a result of soil or aggregate disturbances. There are still risks of unmonitored or un-compensated reversals due to future disturbances.

Rating: RED

Recommendation: The CRCF DR PCR could address risks of reversals due to disturbance/destruction of biochar in soils or aggregates to better align biochar with the treatment of BioCCS and DACCS under the CCS Directive (2009/31/EC). It could use the approach of the A6.4 risk reversal tool (and biochar-specific updates) when available, including monitoring periods and compensation mechanisms such as risk management and buffer pools.

4.4 Sustainability

Sustainability requirements in carbon crediting frameworks typically address two interconnected dimensions: Environmental sustainability is concerned with the impacts of carbon removal activities on air, water, soil, biodiversity and land use. Social sustainability addresses the rights, livelihoods and wellbeing of workers and communities affected by project activities, including labour standards, community consent and equitable benefit-sharing.

Both environmental and social sustainability are governed by a complex landscape of pre-existing international, regional and national legislation, and regulation within which any activities, including GGR, must operate (e.g. for the EU and UK see Štrubelj and Ghaleigh, 2025; Van Looy and Ghaleigh, 2026).

4.4.1 Environmental sustainability

Environmental Sustainability			
Sub-Category	ICVCM	Article 6.4	Assessment of CRCF Alignment
Water	Mandatory	Mandatory	Mandatory, reliant on existing legislation/regulation, less detailed parameters compared with A6.4
Air	Mandatory	Mandatory	Mandatory, but only applies for larger scale biochar production. Reliant on existing legislation/regulation
Soil	Mandatory	Mandatory	Mandatory
Biodiversity Conservation	Mandatory	Mandatory, with tools and monitoring plan	Mandatory, with less detail than A6.4
Biomass sourcing sustainability	Mandatory	Mandatory	Mandatory
Co-benefits	Considered through SDG impacts only	Mandatory, considered through SD and SDG impacts	Mandatory, considered via EU sustainability goals

Table 5. **Alignment of assessment criteria for biochar: environmental sustainability.** Standards: the EU-CRCF Regulation (Carbon Farming and Carbon Removal) and other related EU regulation and guidance, with the ICVCM Core Carbon Principles & Assessment Framework and Article 6.4 of the Paris Agreement. RAG rating: Green = good alignment of approaches and methods likely leading to similar outcomes; Amber = some alignment but not complete, some gaps that may lead to differences in outcomes; Red = limited alignment or major gaps in methodologies and approaches that are likely to lead to clear differences in outcomes and risks to integrity.

Environmental sustainability can be impacted in both negative and positive ways across the lifecycle of biochar projects. Biomass feedstock for biochar is typically from waste streams and residues; if the counterfactual was to spread it on fields, this could have adverse impacts on nutrient cycling, or it could reduce contamination (Environment Agency, 2025). The pyrolysis process releases pollutants (Cornelissen et al. 2024; Environment Agency, 2025) and uses energy with outcomes impacted by the method of pyrolysis, gasifier use (lowering grid energy use) and feedstock. Application to soil, animal feed or aggregates can improve soil quality, leading to higher crop yields and increased ecosystem resilience, while contaminants can have adverse impacts on water and soil (Environment Agency, 2025). There are uncertainties in robust quantification of impacts across a range of conditions due to limited long-term monitoring data on a range of feedstocks, application rates, soil types and environmental conditions.

A range of chemical contaminants are associated with soil application, including heavy metals, polycyclic aromatic hydrocarbons (PAHs) and dioxins and furans (PCDD/F) (Environment Agency, 2025). The most high-risk feedstocks include paper mill and sewage sludge (Li, et al., 2019). Biochar has been shown to leach heavy metals above acceptable water discharge thresholds associated with low-temperature or poorly designed pyrolysis

(Buss et al., 2022). Utilising non-biogenic waste material such as painted timber or plastic-contaminated wood waste introduces further contaminants (Williams et al., 2023; Kumar et al., 2024). Biochar fragments release fine particulate matter (PM) (Gerald and Parikh, 2019), while pyrolysis itself emits a range of pollutants including PM, PAHs and nitrogen dioxide (Pivato et al., 2024).

Biochar's effects on soil microbial communities are uncertain, with both benefits, such as improved nutrient cycling and microbial biomass, and risks, including reduced fungal diversity and decomposition of existing soil organic carbon (Dai et al., 2018; Dai et al., 2021).

4.4.1.1 ICVCM approach

The ICVCM CCPs address environmental sustainability through resource efficiency, pollution prevention, biodiversity conservation and sustainable management of living natural resources. The compliance structure includes requirements to follow all "local laws, objectives, programs and regulations and, where relevant, international conventions and agreements" (Section 7.1a.1). Project operators are required to identify and minimise specified environmental impacts and risks in design *prior to project registration* (Section 7.1b.2). These include pollutant emissions to air, discharges to water, noise and vibration, waste generation, the release of hazardous materials, negative impacts on terrestrial and marine biodiversity and ecosystems, habitat loss for rare and endangered species, conversion of natural forests, grasslands or wetlands, and soil degradation, erosion, water consumption, and water stress. ICVCM does not prescribe specific thresholds or emissions limits.

The ICVCM does not explicitly prescribe means for measuring risks and co-benefits, beyond requiring projects to identify and minimise/mitigate negative impacts through "qualitative methods". It encourages consideration of SDGs by requiring projects to provide information on how the activity is aligned with the host country's relevant SDGs, qualitatively assess how impact is delivering positive impacts "where possible", and to provide any standardised tools or methods that were used to assess impacts. These *shall* be included in the validated project design document (Section 7.11, ICVCM, 2024).

4.4.1.2 Article 6.4 approach

Article 6.4 addresses sustainability through the Sustainable Development Tool (A6.4-TOOL-AC-001) (UNFCCC, 2025), and the associated Environmental and Social Safeguards Risk Assessment form (ESRA) (A6.4-FORM-AC-15) (UNFCCC, 2025a), Environmental and Social Management Plan form (ESMP) (A6.4-FORM-AC-16) (UNFCCC, 2025b), and Sustainable Development Impact form (SDI) (A6.4-FORM-AC-17) (UNFCCC, 2025c). The forms and tool function as an interconnected, overarching framework to identify, monitor, report and mitigate project impacts. Project participants are required to establish activity-level environmental and social indicators, provide data and sources, information on monitoring procedures and methods, monitor these at least annually, and submit this for independent verification (UNFCCC, 2025b).

The A6.4 Sustainable Development Tool (UNFCCC, 2025) addresses pollution prevention and biodiversity conservation by establishing avoidance as the primary requirement, permitting minimisation only where complete avoidance is not technically or financially feasible. A6.4 imposes a continuous monitoring and verification obligation throughout the lifecycle of a project. Projects are required to proactively demonstrate measures for soil and groundwater protection to be in place prior to activity commencement, plus water use efficiency measures, measures to respond where preexisting pollution at the site already exceeds legally permitted levels, and activities to maintain or enhance biodiversity and ecosystem functionality. The SDI form requires projects to identify and assess positive and negative impacts across the 17 SDGs, and design plans for mitigating negative impacts

including identifying sustainable development objectives in the host country and establishing specific indicators (UNFCCC, 2025c).

4.4.1.3 EU CRCF approach

In the EU, environmental sustainability is governed through existing EU-level regulation along with a combination of high-level environmental guidelines for water, air and soil impacts, contaminant thresholds and regulations that together minimise environmental and climate impacts. These include: the European Climate Law (EU) 2021/1119; the Land Use Land Use Change and Forestry regulation (LULUCF EU 2018/841); the Industrial Emissions Directive, which regulates pollution prevention and control across air, water, and soil for *large* industrial facilities (operators above thermal input of 50MW) (EU 2010/75); the Registration, Evaluation, and Restriction of Chemical Substances Regulation (REACH) (EU 1907/2006); the Renewable Energy Directive (RED) (EU 2018/2001 and updates), which places restrictions on sourcing from high-biodiversity-value or high-carbon-stock land and reinforces the cascade

use principle (see point 28, EU 2024/3012); and the Soil Monitoring Law (EU Directive 2025/2360), which sets requirements for soil health monitoring and protection against degradation and contamination.

The DR PCR (2026/285) addresses soil contaminant risks through compliance with Regulation EU 2019/1009 on fertiliser products and amendments, which excludes sewage sludge, industrial sludge and mixed municipal waste, the feedstocks responsible for most significant risk. The DR PCR establishes contaminant control requirements for biochar incorporated in soils (section 4.4.1, 4.4.2) and products (4.4.3) through mandatory laboratory analysis and threshold values for heavy metals, polycyclic aromatic hydrocarbons (PAHs), and other potentially harmful compounds aligned with the EBC agro-grade thresholds. It prohibits the soil application of biochar in which non-biogenic material has been co-processed. Operators must evaluate and address any potential risks to the status or ecological potential of bodies of water, although further monitoring on how to assess this is not detailed. Operators are required to demonstrate that there is no significant risk of albedo-driven climate offset (section 1.1.2.2.1.), but no methodology or guidance is provided.

For biochar applied to agricultural and forest soils, a quantitative control is implemented through a maximum cumulative application rate of 50 t/ha (ibid, Para 1.1.2.2.1). There is no supporting evidence given for this threshold. Although some evidence exists to support no adverse effects after biochar application of 50t/ha on agricultural, sandy loam soils (Zhang et al., 2024; Brown et al., 2025), there is limited evidence of impacts for biochar spreading across a range of soil types and feedstocks to support an evidence-based threshold. Research emerging from the UK Biochar Demonstrator indicates positive co-benefits and no adverse environmental impacts of biochar from woody biomass feedstock applied at a cumulative rate up to 20t/ha monitored for four years (Westbury, et. al., 2025). In the UK, waste regulation in England currently permits only 1t/ha/yr without cumulative limitations (EA, 2026).

Biodiversity is addressed in CRCF DR PCR (Section 4.1.6) by requiring operators to adhere to the Regulation on Nature Restoration (EU 2024/1991) to “*evaluate and address any potential risks to the good condition or resilience of ecosystems or to the conservation status of habitats and species, including those of Union interest or to the achievement of targets or obligations set out in national restoration plans established*”. The regulation lists EU and national level targets, which “*should put in place restoration measures to ensure the recovery of protected habitats and species... across Union areas...and to maintain and restore natural habitats and species of wild fauna and flora of Union interest*” (EU 2024/1991).

The DR PCR requires that local contexts must be considered and that it is “*...reasonable to expect no overall negative effect on biomass production, site condition or soil health and no significant reductions in the storage of other soil organic carbon through positive priming effects from the application of biochar*” (Section 4.1.6.1). If significant negative impacts are identified, there will be no removal credits applied.

Co-benefits are included in the CRCF (2024/3012) as part of the sustainability requirements in Article 7, listing where a carbon removal activity may generate co-benefits for wider EU sustainability objectives (e.g. *climate change mitigation beyond the net carbon removal benefit, adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, and protection and restoration of biodiversity and ecosystems*).

4.4.1.4 Alignment, risks and recommendations

While ICVCM and A6.4 explicitly require risk management, CRCF implicitly relies on existing laws and regulations. For contamination risks, the EU CRCF and related regulations, as well as the EBC, tend to give specific thresholds, whereas A6.4 gives a process for assessing risks that can be more responsive to different site conditions, but also more burdensome to the project operator in terms of finding relevant scientific and local regulatory information. EU Directives are intended for to Member States to implement, interpret and regulate, resulting in variability of outcomes and implementation. Although risks such as air and water pollution are covered by national regulations, their effectiveness is often limited by a lack of monitoring and technical constraints (Pouikli et al., 2024; Giakoumis & Voulvoulis, 2026), often relying on data and modelling which can be outdated or lack site specificity. This may result in a lack of fungibility across localities and create varying results in environmental sustainability standards.

Soil: The CRCF DR PCR (2026/285) provides meaningful protection against the most clearly characterised environmental risks associated with biochar soil application, showing strong alignment with the requirements of ICVCM and A6.4.

Rating: GREEN

Air and water: The CRCF DR PCR (2026/285) requires operators to address air and water pollution via the Industrial Emission Directives (EU 2010/75). Monitoring of pollutants is required for permitting, using best available techniques. However, only operators above thermal input of 50MW are required to comply for permitting, while smaller modular biochar production plants may be exempt. The lack of a water and air pollution compliance requirement for smaller projects creates a risk that smaller-scale projects may implement fewer environmental safeguards compared to ICVCM and A6.4, which impose environmental safeguards and monitoring on projects of all size, with A6.4 including a robust and detailed framework.

Rating: AMBER

Biodiversity conservation: The Regulation on Nature Restoration (EU 2024/1991) required in the CRCF DR PCR is aimed at the national level and is quite high-level compared to A6.4's comprehensive and project-specific framework.

Rating: AMBER

Sustainable sourcing of biomass: Within the CRCF DR PCR (2026/285), safeguards are addressed through adherence to sustainable sourcing of biomass in RED (EU 2018/2001), updates such as the cascading use of woody biomass guidance RED III (EU 2023.1185), and adherence to the Regulation on Nature Restoration (EU 2024/1991). A further requirement restricts feedstocks to waste or residue streams only in biochar production facilities where biochar constitutes the predominant output in terms of energy content of the biochar compared to energy produced for other uses (Section 4.3.2). Given the predominance of waste streams in biochar production, and the lower expected scaling and non-waste resource demands, this is likely sufficiently low-risk in comparison with more explicit safeguards in A6.4 and ICVCM.

Rating: GREEN

Co-benefits of biochar: CRCF addresses co-benefits in terms of EU sustainability objectives, requiring CRCF-level monitoring and reporting. ICVCM requires information on alignment with host-country SDGs and to qualitatively assess positive impacts where possible. A6.4 offers a comprehensive and detailed framework to identify positive and negative impacts of project operations.

Rating: AMBER

Recommendation: The CRCF DR PCR biochar application threshold is a pragmatic approach to avoid adverse environmental impacts, but evidence should be provided to justify thresholds across different site conditions as part of the regular review and update process. CRCF could also adopt the comprehensive A6.4 framework for evidencing environmental sustainability, ensuring risks and co-benefits are identified, monitored and assessed, and risks minimised. This would provide operators and certification bodies with a consistent basis for compliance, and ensure a level of fungibility between projects carried out in different countries with different regulatory requirements and enforcement practices.

4.4.2 Social sustainability

Social Sustainability			
Sub-Category	ICVCM	Article 6.4	Assessment of CRCF Alignment
Land acquisition and involuntary resettlement	Mandatory	Mandatory	Not considered
Indigenous peoples, local peoples and heritage	Mandatory	Mandatory	Not considered
Respect for human rights	Mandatory	Mandatory	Not considered
Stakeholder engagement	Mandatory	Mandatory	Partial Alignment
Gender Equality	Mandatory	Mandatory	Not considered
Robust Benefit Sharing	Mandatory	Mandatory	Not considered
Labour rights and working conditions	Mandatory	Mandatory	Not considered
SDG Impacts	Mandatory	Mandatory	Not considered
Corruption	Not considered	Mandatory	Not considered
Knowledge-exchange and training	Not considered	Not considered	Mandatory. The CRCF includes a requirement for certification schemes to ensure wider knowledge exchange.

Table 6. Alignment of assessment criteria for biochar: social sustainability. Standards: the EU-CRCF Regulation (Carbon Farming and Carbon Removal) and other related EU regulation and guidance, with the ICVCM Core Carbon Principles & Assessment Framework and Article 6.4 of the Paris Agreement. RAG rating: Green = good alignment of approaches and methods likely leading to similar outcomes; Amber = some alignment but not complete, some gaps that may lead to differences in outcomes; Red = limited alignment or major gaps in methodologies and approaches that are likely to lead to clear differences in outcomes and risks to integrity.

Carbon removal projects can create risks relating to land use, labour conditions, community rights and cultural heritage, even in jurisdictions with strong regulatory frameworks. This section considers how social sustainability criteria are applied to biochar activities in practice.

4.4.2.1 ICVCM and Article 6.4 approach

Labour rights and working conditions

ICVCM and A6.4 include detailed requirements relating to safe and healthy working conditions, non-discrimination, protection of vulnerable workers, prohibition of forced and child labour, freedom of association and grievance mechanisms. A6.4 also includes education programmes and gender-sensitive risk assessments.

Land acquisition and involuntary resettlement

ICVCM and A6.4 require avoidance of physical and economic displacement and set out detailed mitigation measures where displacement cannot be avoided.

Indigenous Peoples, local communities and cultural heritage

A6.4 includes extensive requirements for Free, Prior and Informed Consent (FPIC), cultural heritage protection and equitable benefit-sharing. The ICVCM references international instruments such as the UN Declaration on the Rights of Indigenous Peoples and ILO Convention 169.

Human rights

A6.4 requires human rights due diligence. The ICVCM mandates respect for human rights.

Stakeholder engagement

A6.4 calls for a structured stakeholder engagement process. The ICVCM requires responsiveness to stakeholder views.

Gender equality

ICVCM and A6.4 include explicit requirements relating to equal opportunities and protection from gender-based risks. A6.4 also includes gender-related risk identification as part of its broader safeguards. The ICVCM references non-discrimination and equal treatment within its Core Carbon Principles.

Benefit-sharing

A6.4 includes requirements for equitable benefit-sharing, particularly for Indigenous Peoples and local communities, and links these provisions to engagement and consent processes. The ICVCM refers to contributing positively to sustainable development but does not include detailed benefit-sharing requirements.

Corruption prevention

A6.4 includes explicit anticorruption safeguards requiring activities to avoid practices that could undermine integrity or create adverse impacts. The ICVCM includes expectations relating to integrity and responsible conduct, although corruption prevention is not presented as a standalone requirement.

Sustainable Development Goals (SDGs)

A6.4 includes references to sustainable development within its overarching objectives. The ICVCM also refers to sustainable development in general terms within its Core Carbon Principles, but does not include SDG-specific requirements.

4.4.2.2 EU CRCF approach

The CRCF does not contain a dedicated set of social sustainability requirements for biochar activities. Instead, it requires certification schemes to operate independently and transparently, whilst implicitly relying on existing EU regulations or directives without explicitly referencing them, unlike the approach taken for environmental sustainability. This absence creates uncertainty regarding how, or even if, social risks are anticipated to be managed in practice. Non-governmental organisations (NGOs), such as Carbon Market Watch (2026), have criticised this lack of transparency, emphasising that explicit social safeguards are essential for supporting rural communities and preventing growing inequalities within the land sector.

Social considerations are referenced only in broad terms, such as the expectation that certification methodologies should consider the rights of local communities and Indigenous Peoples. There are no specific provisions for labour rights, displacement, Indigenous rights, cultural heritage, gender equality, benefit-sharing or corruption prevention. Even though the CRCF has specific guidance for biochar activities (the biochar annex), it does not set detailed social safeguards or operational requirements for individual biochar projects. The CRCF social provisions apply to biochar activities wherever its certified schemes operate, whether within the EU or in non-EU countries.

The CRCF refers to the need for the Commission to consider risks such as land speculation and impacts on rural communities, but does not establish project-level requirements. These broad CRCF references to land-related risks apply in both EU and non-EU contexts, as they form part of the requirements that certification schemes must meet regardless of where projects are located. In addition, the CRCF requires certification schemes to have stakeholder consultation processes, although it does not set requirements for project-level engagement. There is also a requirement for certification schemes to ensure wider knowledge exchange, including knowledge-sharing events and best practice dissemination.

4.4.2.3 EBC

The EBC focuses specifically on biochar production processes and includes operational requirements relating to worker safety, handling of hazardous materials and process monitoring. Workers must be informed of risks and provided with appropriate protective equipment, and safety procedures must be documented. However, the EBC does not address broader social sustainability categories such as non-discrimination, forced labour, Indigenous rights, displacement, gender equality or benefit-sharing.

4.4.2.4 Alignment, risks and recommendations

The CRCF, ICVCM and A6.4 frameworks take fundamentally different approaches to social sustainability. The CRCF focuses on certification scheme-level governance but does not set standalone project-level social safeguards. By contrast, ICVCM and A6.4 include comprehensive project-level social protections. Because ICVCM and A6.4 apply to all mitigation activities, their social safeguards would apply to biochar in the same way as to any other activity. Therefore, what is presented in this social sustainability section could equally apply to other GGR technologies such as DACCS and BioCCS.

As ICVCM and A6.4 embed detailed safeguards such as labour rights, the rights of Indigenous Peoples, cultural heritage, land acquisition, gender equality, benefit-sharing and corruption prevention, they take a fundamentally different approach from the CRCF, which focuses on how certification schemes operate rather than on individual projects. As a result, the scope and depth of social sustainability provisions vary significantly across the frameworks.

ICVCM and A6.4 treat social safeguards as an integral part of ensuring that mitigation activities are carried out responsibly and that affected people are protected from harm. Social sustainability considerations apply in all jurisdictions, since the risks addressed by A6.4 and ICVCM can emerge wherever mitigation activities take place, including within the EU and UK. Both frameworks set global expectations for identifying, managing and monitoring social impacts. They embed principles of procedural justice (O’Beirne et al., 2020; Pues et al., 2026) – i.e. who gets heard, who gets influence – by requiring fair and transparent processes, such as structured engagement and human rights due diligence, so that all affected people have meaningful opportunities to be informed, express their views and influence decisions. Distributive justice (Li et al., 2025; Pues et al., 2026) – who bears burdens, who gets benefits – is reflected in requirements for safe working conditions, and the fair sharing of benefits, ensuring that no group is unduly burdened. Recognition justice (Pues et al., 2026) – whose heritage, identity or vulnerability is acknowledged – is incorporated through measures that protect cultural heritage, community rights and the circumstances of groups who may be especially exposed to harm. These issues are relevant everywhere, as land-use pressures, labour conditions and supply chain impacts can arise in any location. Importantly, compliance with EU or UK law alone does not guarantee these forms of justice. Many risks addressed by ICVCM and A6.4 occur even within lawful activity, so legal compliance cannot assure meaningful participation, equitable impact distribution, or recognition of affected groups.

Although EU and UK regulatory frameworks are strong and internationally well regarded on social sustainability, they cannot by themselves ensure the procedural, distributive and recognition justice outcomes required for high-integrity carbon removal. Justice depends on how decisions are made, who is included and how impacts are shared – factors that require explicit project-specific social safeguards. The importance of such safeguards becomes even clearer when considering empirical evidence from different geographical contexts. Across Africa, the formation and use of carbon-rich soils is shaped by gendered labour, land relations and local biomass flows, and these dynamics have been shown to have major implications for biochar production/use and carbon market interventions. Ethnographic research on African Dark Earths (AfDE) (Frausin et al., 2014; Leach et al., 2012) shows that these soils are created primarily through women’s everyday work of cooking, palmoil processing and potash production. These processes generate the biochar that makes the soil fertile, whilst men typically engage later by planting tree crops on biochar-enriched sites. AfDE patches are embedded within lineage-based and marriage-linked tenure systems, often coinciding with old settlement sites, household compounds or areas tied to ancestral authority. Biochar initiatives that reframe soil carbon as a marketable commodity risk disrupting these systems, potentially driving large-scale land grabs for biochar feedstocks as well as causing farmers to “labour within the carbon industry while others make profits from their assets” (Leach et al, 2012: 302). This demonstrates that biochar interventions interact with culturally embedded land relations, gendered labour and locally governed feedstock flows. These are factors that must be recognised to avoid reinforcing inequities or undermining existing livelihood systems.

In the UK, GGR developments face their own challenges of legitimacy and inclusion, revealing a similar need to foreground justice considerations when new governance arrangements are being devised. Achieving a just transition to net zero in the UK depends on GGR projects upholding procedural justice. However, a case study in Selby around BECCS suggests that current governance arrangements do not consistently meet this requirement and at the same time, existing legal frameworks are not always able to deliver procedural justice in GGR deployment (O’Beirne et al., 2020). The study revealed that residents often lacked accessible, impartial information about BECCS, with some describing interactions as “technical gobbledygook ... to offset their worries or woes” (O’Beirne et al., 2020: 270), highlighting a failure to recognise and include affected stakeholders. This undermines the justice principles of participation and fairness, which are required for legitimate decision-making. The study suggests that presuming public consent based on superficial awareness risks generating only the appearance of

legitimacy rather than genuine social licence (O'Beirne et al., 2020). Without embedding inclusive, informed and deliberative processes into GGR governance, the UK risks jeopardising both social legitimacy and the broader net-zero transition.

Whether in Africa or the UK, biochar and aligned GGR interventions can generate risks that are not captured by governance frameworks alone. They show that social sustainability is not an abstract principle, but a lived reality shaped by gender, land tenure, cultural authority and community participation. For the UK, this means GGR governance needs to address justice deficits in decision-making to avoid undermining trust and compromising a just transition. For international contexts, it means recognising that carbon removal activities intersect with existing social systems in ways that require explicit, enforceable project-level safeguards to prevent harm and uphold procedural, distributive and recognitional justice.

While there is increasing discussion around the potential use of biochar in construction materials and aggregates as part of carbon removal strategies, there is currently no social sustainability research examining how such applications interact with real-world social systems. This absence is significant as it means that questions of labour, land relations, equality, supply chain dynamics and governance arrangements remain unexamined in this emerging domain. The lack of evidence does not imply an absence of risk; rather, it highlights that social sustainability concerns may be overlooked unless they are explicitly built into project-level safeguards.

Labour rights and working conditions

Not mentioned within the DR PCR.

Rating: RED

Land acquisition and involuntary resettlement

Not mentioned within the DR PCR.

Rating: RED

Indigenous Peoples, local communities and cultural heritage

Not mentioned within the DR PCR.

Rating: RED

Human rights

Not mentioned within the DR PCR.

Rating: RED

Stakeholder engagement

The CRCF requires certification schemes to have stakeholder consultation processes, although it does not set requirements for project-level engagement.

Rating: AMBER

Gender equality

Not mentioned within the DR PCR.

Rating: RED

Benefit-sharing

Not mentioned within the DR PCR.

Rating: RED

Corruption prevention

Not mentioned within the DR PCR.

Rating: RED

Sustainable Development Goals (SDGs)

Not mentioned within the DR PCR.

Rating: RED

Knowledge exchange and training

The CRCF requires certification schemes to ensure wider knowledge exchange, including knowledge-sharing events and best practice dissemination.

Rating: GREEN

Recommendation: The EU CRCF could adopt the comprehensive A6.4 framework to ensure carbon removal activities uphold human rights, protect local communities and prevent negative social impacts. Article 6.4 embeds fairness and justice, ensuring meaningful participation and equitable benefit-sharing so no group is unduly burdened and positive impacts reach communities and vulnerable groups. This approach would strengthen both the integrity and social legitimacy of biochar and other GGR activities in the UK.

5 Discussion

5.1 Recommendations for standards alignment

The CRCF, ICVCM, A6.4 and EBC are all different to one another in purpose and scope, making them difficult to compare directly. While they have somewhat different aims, they are all trying to achieve high-integrity outcomes; thus, there are many common areas of consideration. Yet inevitably, for a field in the early stages of development, there are areas where they could be better aligned.

Additionality risk for biochar was assessed as higher than for BioCCS in the previous report (Martirosian et al., 2025), primarily because biochar is already deployed commercially as a soil amendment for agronomic purposes such as animal feed, independently of any carbon finance. The CRCF's standardised zero-baseline approach does not account for this prior commercial use, raising the risk that non-additional credits could be issued for soil application activities. In contrast, little to no additionality risk is posed by biochar incorporated into materials, given the current lack of commercial deployment in that end-use. The quantification risk is lower as a comprehensive lifecycle assessment of the biochar production is carried out. However, leakage assessment risk is possible given the competing uses of biomass such as bioenergy and biomaterials.

The CRCF approach to permanence was assessed as higher risk for biochar than for BioCCS and DACCS in the previous report (Martirosian et al., 2025). Compared to BioCCS and DACCS in the CCS Directive (2009/31/EC), reversal risks due to disturbance/destruction of soils or aggregates are not considered, managed or mitigated. Reversal risks due to *in situ* natural decay in soils are managed through conservative calculation of the permanent fraction of biochar, although rigour could be improved by using a combination of best-practice methods as the science continues to emerge.

An in-depth review of environmental and social sustainability was a gap in our previous analysis of BioCCS and DACCS (Martirosian et al., 2025), and some of the findings of this report are relevant to those activities as well as to biochar. For both aspects of sustainability, there is a common risk that reliance on regional or national legislation and regulation under the CRCF can lead to lack of fungibility in safeguards in projects carried out in different countries, and risks due to lack of monitoring, verification and enforcement within countries. Adoption of a more explicit structured framework as developed under A6.4 could support a more rigorous approach to high-integrity safeguards while still working within regional and national legislation.

The recommendations arising from this report are:

Additionality

Recommendation: The CRCF DR PCR could require more rigorous additionality assessments using similar approaches to the ICVCM and A6.4. These could include legal/financial/barrier tests, a prior consideration assessment and a demonstration that public funding (where larger than revenues from expected carbon finance) would not have filled the funding gap in the absence of carbon finance.

Recommendation: To ensure certification for soil carbon sequestration activities are not mistakenly undertaken on the same plot of land where biochar credits are sought under the CRCF, geolocation of any application sites could be used to ensure full transparency between different certification schemes.

Quantification

Recommendation: The CRCF DR PCR could identify and minimise potential leakage such as indirect land-use change or market displacement, then quantify and deduct any remaining leakage, using approaches such as in A6.4 and ICVCM, with detailed information of the methodology and assumptions.

Permanence

Recommendation: The CRCF DR PCR could recommend a combination of new and more advanced comprehensive methods to quantify the stable fraction of biochar to improve uncertainty and unlock higher-integrity, longer-horizon 1000-year credits. For example, it could follow the latest updates of the Global Biochar C-Sink Standard, and any biochar-specific methods updates under A6.4 and IPCC when available. CRCF DR PCR's requirement to review and update processes every four years at a minimum is a reasonable timeframe.

Recommendation: The CRCF DR PCR could address risks of reversals due to disturbance/destruction of biochar in soils or aggregates to better align biochar with the treatment of BioCCS and DACCS under the CCS Directive (2009/31/EC). It could use the approach of the A6.4 risk reversal tool (and biochar-specific updates) when available, including monitoring periods and compensation mechanisms such as risk management and buffer pools.

Environmental sustainability

Recommendation: The CRCF DR PCR biochar application threshold is a pragmatic approach to avoid adverse environmental impacts, but evidence should be provided to justify thresholds across different site conditions as part of the regular review and update process. The CRCF could also adopt the comprehensive A6.4 framework for evidencing environmental sustainability, ensuring risks and co-benefits are identified, monitored and assessed, and risks minimised. This would provide operators and certification bodies with a consistent basis for compliance, and ensure a level of fungibility between projects carried out in different countries with different regulatory requirements and enforcement practices.

Social sustainability

Recommendation: The CRCF could adopt the comprehensive A6.4 framework to ensure carbon removal activities uphold human rights, protect local communities and prevent negative social impacts. Article 6.4 embeds fairness and justice, ensuring meaningful participation and equitable benefit-sharing so no group is unduly burdened and positive impacts reach communities and vulnerable groups. This approach would strengthen both the integrity and social legitimacy of biochar and other GGR activities.

5.2 Broader context

5.2.1 Interaction between carbon and nature markets: rewarding co-benefits while ensuring additionality

Non-carbon crediting systems, such as those proposed under the EU Nature Credits initiative (COM/2025/374) and the UK Nature Investments Standards⁵ Nature markets – Overarching principles and framework – Specification (BSI Flex 701, 2025), aim to incentivise nature-positive actions through dedicated environmental credits, with consultations on their design currently underway. These systems fall outside the scope of the ICVCM CCPs, A6.4

⁵ [Nature Investment Programme | BSI](#)

and the EU CRCF, which credit greenhouse gas removals or reductions only, although A6.4 allows for identification, monitoring and reporting of co-benefits.

Biochar sits at the intersection of nature and carbon credits: alongside its carbon storage function, evidence indicates positive impacts on plant growth, reduced nitrate leaching from soils, potential benefits to soil microbial communities (Environment Agency, 2025) as well as feed quality (Ayneshet and Temesgen, 2025). Some of these are of economic benefit so may be done anyway by land or livestock owners with or without the need for credits. They may create economic benefits for carbon project operators if they directly benefit. If co-benefits do not have a direct significant economic benefit to the operator carrying out the activity, then other ways of incentivising them may need to be found.

Two mechanisms central to this are: 1) stacking, which involves selling multiple distinct environmental credits arising from the same activity to different buyers, and 2) bundling, where multiple benefits are combined into a single credit. A challenge arises in relation to additionality where activities must demonstrate that it would not have occurred without the relevant revenue stream and the presence of a parallel revenue stream weakens that case for both – nature credit revenue can erode the additionality of an associated carbon credit, and vice-versa. Existing carbon frameworks do not currently address this interaction explicitly, having been designed against a counterfactual of carbon revenue alone.

For carbon farming activities, the CRCF requires certified activities to demonstrate co-benefits for biodiversity and ecosystems alongside carbon storage, effectively bundling environmental outcomes into the certified unit. By contrast, the methodology for biochar applies only the minimum sustainability requirements of the “do no significant harm” principle, and co-benefits are neither required nor recognised within the carbon unit. Biochar’s potential nature benefits therefore sit outside the scope of CRCF certification and would only be monetisable through separately stacked credits in adjacent markets.

Even where stacking between nature and carbon markets is excluded, it is still important that biochar production and application is subject to fungible high-integrity principles, standards and methods across markets. This could be the focus of a separate review.

5.2.2 Scaling impacts of biochar production

Current literature suggests that planned EU biochar can theoretically be sustained from feedstocks such as agricultural residues, sewage sludge, digestate fibre, woody green waste, wood waste and manure, where many of these feedstocks are currently underutilised and could end up in landfills or low-value incineration (Material Economics, 2021) (Environment Agency, 2025). As green policies and mandates are expected to encourage the collection and utilisation of these feedstocks, the future available biomass supply in Europe is expected to increase (Material Economics, 2021).

At the same time, real-world availability of these “waste” products could be constrained by competing uses from RED III biofuel mandates and ReFuelEU (European Commission, 2023) and REPowerEU (European Commission, 2022) targets. This makes assessing the counterfactual scenario (no biochar carbon credit project) complex, as it depends on factors such as the projected price of carbon and the rate of electrification of transportation and energy, as well as environmental regulations protecting the amount of residues that can be sourced from forests without impacting soil quality (RED III) and the LULUCF regulation (EU 2018/841). Current analysis cautions that different EU climate policies each create their own demand for biomass, but no mechanism exists to coordinate between them or prevent the same biomass from being claimed by multiple sectors simultaneously (Pahle, 2026).

If these domestic supply constraints are not addressed through coordinated governance, increasing reliance on imported biomass is a foreseeable consequence. The EU already imports significant volumes of wood pellets, palm oil derivatives and agricultural commodities for bioenergy (Avitabile, 2023). Biochar production, especially if associated with large-scale bioenergy expansion, could risk land degradation, land-use change and food insecurity, although there is currently a lack of research on the global impacts from biochar and work is underway to incorporate them into Integrated Assessment Models (Buss, 2025).

All of this raises concerns around indirect land-use change, biodiversity loss and social impacts in exporting countries. Ensuring that biochar, and other biomass-reliant carbon removal methods, scale sustainably will therefore require domestic biomass allocation governance as well as robust supply-chain due diligence requirements and alignment with environmental and societal safeguards and assessments.

5.2.3 Monitoring, reporting and verification (MRV)

There are multiple points requiring MRV across the biochar value chain. Regulators and standards have to manage creation of an MRV system that ensures consistency of inputs and outputs (as discussed in prior paragraphs), while also ensuring additionality, leakage minimisation, risk management and durability of storage are upheld (Mercer and Burke, 2023). As an example, Table 7 gives an overview of the MRV required by the EBC and how CRCF aligns with it.

Aspect	Key points in EBC	Alignment with CRCF
Production facilities	Entire production site to be inspected and certified, once a year. Exemptions only for biochar application <10t/yr.	Certification scheme operated and production batches defined
Feedstocks	Defined for each class of biochar, where plastic is allowed for basic (aggregate) grade biochar.	Less comprehensive classification
Plant performance	GHG emissions and energy utilisation are quantified in some detail.	Broadly comparable
Companies processing certified biochar	Must also be EBC-certified. Common processes include blending with additives, process activation by thermal processing and biological/chemical activation.	Not covered
Production and sampling protocols	Production batches need to be registered and complete production records kept. The variations allowed within a single batch are limited. Daily samples taken, which are bulked to generate monthly samples that need to be retained for two years.	Less detailed
Biochar analysis for use/grade assessment	Obligatory analyses: organic C content, molar H/C _{org} and O/C _{org} ratios, PAHs, heavy metals, nutrient contents, pH, salt content, bulk density, water content, water holding capacity and conductivity.	Fewer biochar grades, but analyses required are comparable.
Calculation of persistent/stable biochar	EBC defines geological (1,000-year) persistent biochar in terms of reflectance, PAC from HyPy and conductivity that will merit 90% credit payment.	Inertinite reflectance and decay models applied conservatively

Table 7. Summary of MRV (control, quality management and certification) required by EBC and alignment with CRCF.

An overly prescriptive approach to MRV adds cost across the value chain, but entails a higher degree of confidence in quality of the biochar removal process, whereas a more permissive approach, potentially relying on ex-ante verification, lowers MRV costs and reduces cost impediments to scaling. A pilot study by Mercer et al. (2024) finds that MRV costs for biochar are cost efficient, in relation to other pathways, with relative MRV costs constituting 7–9% of total removal costs. For some pathways, MRV can account for 50% and up to 73% of total removal costs. Biochar project operators do not consider MRV to be a significant barrier to up-scaling.

5.3 Limitations of study

The CRCF, Article 6.4, ICVCM and the EBC are subject to ongoing consultations and updates. Therefore, some aspects of the assessment may become out-of-date.

Results may be different when comparing CRCF methodology with methodologies of carbon registries within the VCM, such as Isometric, Puro.earth, Verra and Gold Standard. Some of these may have more robust assessment frameworks or methods in some areas. However, this was out of scope of the analysis and many of these individual carbon registries are adopting the ICVCM principles.

5.4 Future work

Ongoing work within CO₂RE includes a) an assessment of additionality baselines, leakage and permanence across individual VCM methods (e.g. Isometric, Puro.earth, Verra and Gold Standard), and b) a full assessment of sustainability criteria for CDR technologies. These future assessments will include a broader range of GGR activities than BioCCS, DACCS (Martirosian et al., 2025) and biochar (this report). These reviews will be carried out using the CO₂RE Evaluation Framework, which will be published in 2026.

Some key evidence gaps are highlighted in this document. Systematic analyses of uncertainties in methods used to calculate full lifecycle impacts (net GHG flux and sustainability across the full project lifecycle) would support ongoing development of GGR standards and IPCC methods updates. Advanced methods of pyrolysis and biochar applications (e.g. cement/concrete incorporation, landfill burial) are technologically less mature (Supraja et al., 2023; CO₂RE and ERM, 2025), and hence more research and trials are necessary to minimise reversal risk and secure long-term storage. Long-term monitoring of environmental impacts across different site conditions, applications approaches and management would give confidence in better environmental safeguards and co-benefits. Further research is required to examine the social sustainability implications of using biochar in construction materials and aggregates before biochar deployment scales. Currently, no studies investigate how these applications interact with real-world social systems. Without this evidence, potential opportunities and risks may remain unknown. The use of case studies could help support land managers, project developers and policymakers to assess the outcomes of specific choices for standards approaches and methodologies.

6 Conclusions

This report assesses the extent to which the CRCF delegated act methodology for biochar aligns with the ICVCM Core Carbon Principles and the UNFCCC Article 6.4 mechanism as internationally recognised benchmarks for high-integrity carbon crediting. Each instrument operates within a distinct governance context: the ICVCM CCPs provide a voluntary standard for credits issued under private carbon markets and do not specify methodologies; Article 6.4 is an intergovernmental crediting mechanism under the Paris Agreement, supporting both compliance and voluntary climate objectives; and the CRCF is an EU regulation functioning as a framework for certifying carbon removal schemes rather than individual projects. These structural differences notwithstanding, the comparison reveals both areas of alignment and gaps.

The analysis reveals partial alignment of the CRCF with ICVCM and A6.4 on lifecycle quantification, environmental safeguards and biomass sourcing, although material gaps remain.

- For additionality and quantification, zero-baseline assumptions are less problematic for biochar than they were for BioCCS (Martirosian et al., 2025), but there are small risks to additionality as biochar is already applied as soil conditioner. Leakage also remains a risk given possible competition with other biomass competing industries.
- On permanence, the absence of post-application monitoring and reversal risk compensation for biochar in soils and aggregates represents a divergence from ICVCM and A6.4, as well as from the treatment of BioCCS and DACCS under the EU CCS Directive (2009/31/EC). While this is low-risk for decomposition *in situ* due to conservative quantification (especially if methods are updated), it excludes risks of disturbance/destruction of soils and aggregates.
- The reliance on national legislation for environmental and social governance in the CRCF, compared to project-level requirements under ICVCM and A6.4, can lead to a lack of fungibility in projects carried out in different countries with different requirements, monitoring and compliance.
- Although the EU has various legal requirements that take into account the social dimensions of carbon removal/storage through carbon markets, social injustices can still arise if these are not addressed directly

through the design of certification schemes. As such, it is important and worthwhile to include explicit reference to measures to avoid social injustices in scheme design.

The review mechanisms built into the CRCF and the continued development of A6.4 and the ICVCM provide structured opportunities to incorporate the findings of this report and any new emerging evidence. With the BSI developing a GGR standard for biochar, there is an opportunity to consider pursuing selective alignment by adopting the CRCF's methodological foundations whilst incorporating more rigorous provisions in areas where ICVCM and A6.4 set a higher standard, including leakage quantification, reversal risk management and environmental and social safeguards.

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