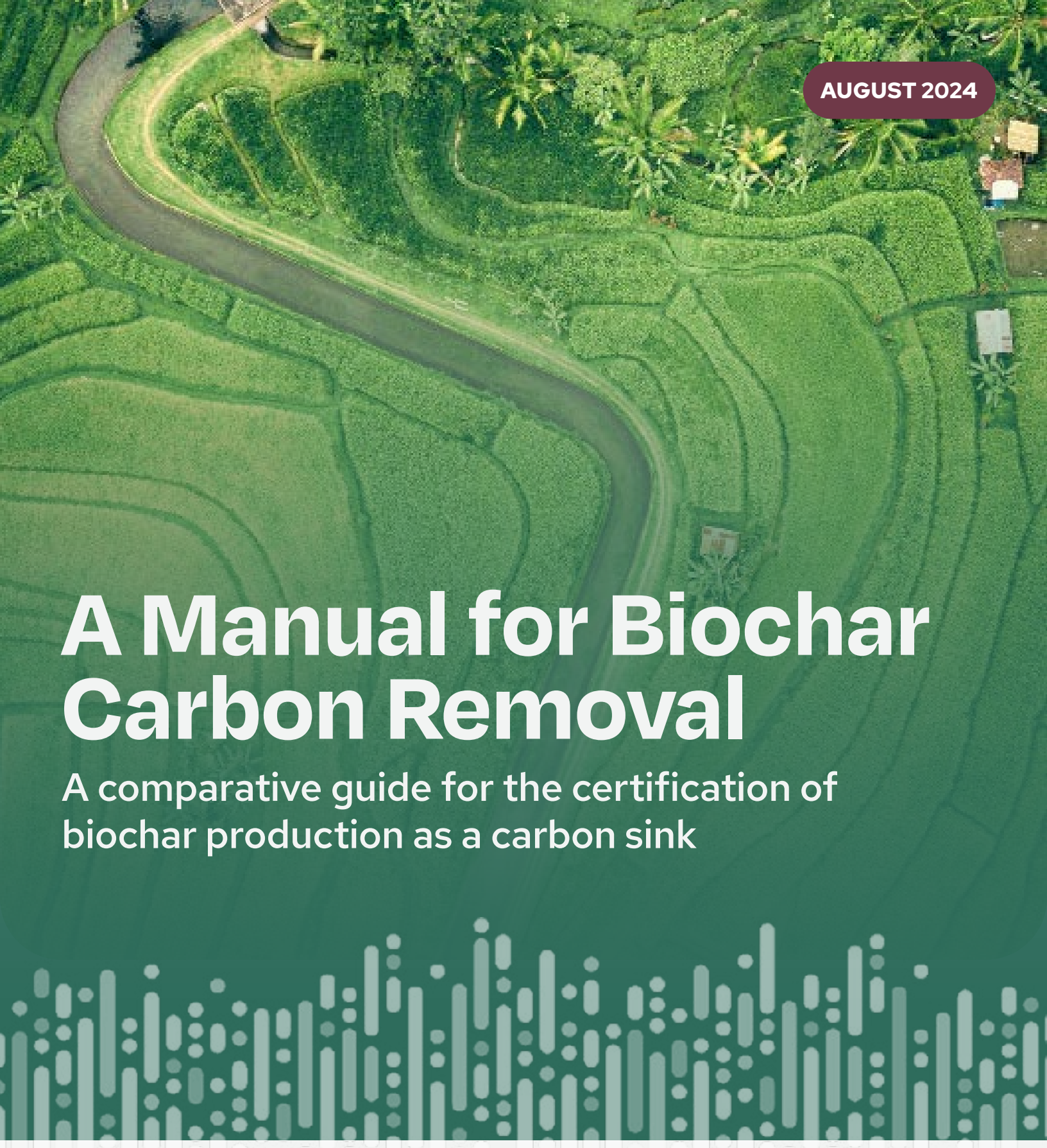


AUGUST 2024

A Manual for Biochar Carbon Removal

A comparative guide for the certification of biochar production as a carbon sink

International Biochar Initiative

IN COOPERATION WITH:

HAMERKOP
CLIMATE CHANGE & FINANCE

Table of Contents

Introduction 3

Biochar on the Carbon Market 5

Variability of Biochar 9

Guidance for Design of Biochar Projects 12

Guide for Selecting the Right Methodology 14

Appendix 25

Cost Comparison by Standard 26

Main Steps for Certification by Standard 27

- Puro.earth 27
- Verified Carbon Standard (VCS) 28
- Carbon Standards International (CSI) 29
- Riverse 31
- Climate Action Reserve (CAR) 32

Glossary 33

References 35

Introduction

This e-book provides a roadmap for biochar producers, investors, and stakeholders keen on understanding the intricacies of certifying biochar for carbon removal.

In this guide, we provide an overview of the various methodologies established by existing certification standards. Our goal is to offer practical insights and comparisons to assist producers and investors in selecting the most appropriate approach for their specific biochar projects.

Whether you are a biochar producer aiming to demonstrate the environmental benefits of your practices or an investor considering opportunities in carbon markets, this handbook is designed to equip you with the necessary knowledge and guidance to navigate the certification process effectively. We will update this publication periodically to keep pace with this rapidly developing industry.

We believe that biochar production has a strong potential for the global reduction in greenhouse gases. Our aim is to empower biochar producers to demonstrate the credibility of their carbon removal efforts and to assist project developers in making informed decisions that drive positive environmental impact.

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Introducing Biochar

What is biochar?

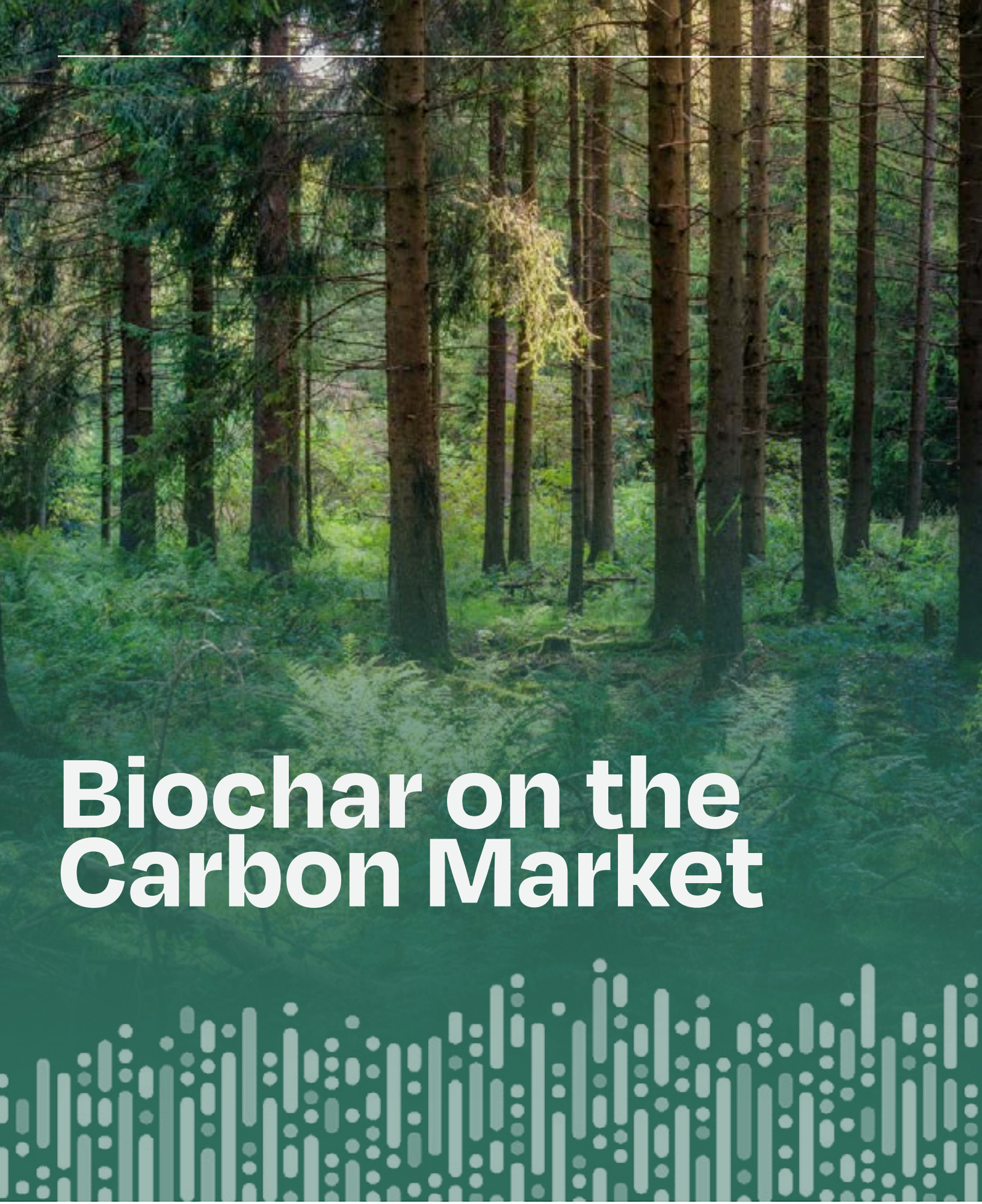
Biochar is a carbon-rich, charcoal-like solid made from organic matter (such as poultry litter, rice husks, tree prunings, etc). When organic matter (also called biomass) faces high heat in the absence of oxygen, it changes form to become biochar through the process of thermochemical conversion, known as pyrolysis.

Biochar is a climate change solution tool. When biomass decomposes naturally, it releases greenhouse gases (GHG) into the atmosphere – living plants absorb carbon dioxide (CO_2) via photosynthesis throughout their life and once they die, all of this CO_2 is released back into the air. However, when biomass is transformed into biochar through pyrolysis, the carbon can instead be stored for hundreds of years (or more), preventing such GHG emissions.

What are the benefits of biochar?

In addition to storing carbon, this carbon-rich product offers a wide array of other benefits. When applied to soil, biochar behaves as an amendment able to increase the availability of water and nutrients while balancing soil composition. This breeds healthy soil, which increases plant growth/crop yields whilst reducing the need for excess fertilizers and irrigation. Biochar has thus been used in a number of diverse agricultural applications over several centuries across the world, notably in the context of organic or regenerative farming.

The production process of biochar creates valuable co-products such as bio-oil and syngas as biomass undergoes pyrolysis and gasification. The energy generated from the production of biochar can be utilised by the biochar production facility to make the process self sufficient and eliminate the requirement for external fossil fuel power. Any excess energy produced can be used as thermal energy onsite, or converted into electrical energy. From carbon sequestration to energy production and soil improvement, the biochar system is one of circularity with a wealth of regenerative benefits.



Biochar on the Carbon Market



The voluntary carbon market offers a catalytic financial boost that promotes industry growth and further scales the many socio-environmental co-benefits associated with biochar production.

As consumer demand and global policy trend increasingly toward climate change solutions, carbon emissions and sequestration projects gain a financial stake in market dynamics. The carbon market financially incentivizes carbon sequestration projects, whose carbon removal can be scientifically calculated, objectively verified, market-valued, and sold as "carbon credits" to companies eager to offset their carbon emissions.

Biochar is a carbon sequestration technology with immense traction on the carbon market. In 2023, biochar was responsible for 94% of long-term carbon removal credits delivered (*cdr.fyi, 2024*).

Calculating the Carbon Sink: Carbon Accounting and Certification

A biochar project quantifies the precise amount of carbon that it sequesters through rigorous scientific processes. The carbon sequestered is measured in terms of CO_2.

Once verified, the amount of calculated CO_2 removal is publicly registered and monetized on the carbon market in the form of carbon credits (or "removal credits"): one tonne of CO_2e sequestered = one carbon credit. Sellers on the carbon market have

Empowering Communities and Incentivizing Sustainability: Carbon Finance Catalyzes the Biochar Industry

While biochar is produced in most countries around the world, it has particularly significant potential in countries of the Global South where there is a high abundance of crop residue appropriate for feedstock and tropical soils that uniquely appreciate biochar as an amendment (famously demonstrated by the evidence of biochar use found in soils of ancient Amazonian civilizations) (*Lehmann 2008*).

In farming communities with limited resources, the use of biochar can enhance quality of life by increasing crop yields while reducing the need for irrigation and fertilizers, thus increasing revenue.

Moreover, studies highlight the potential of biochar to help mitigate climate-related risks in agriculture, notably by providing higher drought resistance (*Obia et al. 2019, Koide et al. 2015*).

This could benefit small farmers in a broad range of countries who often lack resources to adapt to changing climate conditions.

projects that sequester carbon, and buyers have a need to compensate for GHG emissions from their activities.

Buyers purchase carbon credits on the voluntary carbon market to help balance out their company or activity's unavoidable GHG emissions, e.g., emissions that could not be avoided first by decarbonizing their systems and supply chain. For example, if a company undergoes all possible reduction efforts and still emits 30 tonnes of CO_2, it could buy 30 durable carbon removal credits. These credits would balance out the company's residual fossil emissions and they could potentially consider their activities as having "net zero emissions".

In order to register and sell sequestered carbon as carbon credits, biochar producers must align their specific activities with the requirements of a certification standard and follow its methodologies to quantify and monitor the GHGs emitted and sequestered from their activities and/or products.

Carbon Certification Standards

To ensure biochar production and use has a net-positive climate impact, several carbon certification standards have developed carbon quantification and monitoring methodologies. This paper offers insight into five of the standards that are available to project developers and biochar producers who aim to certify their biochar process and products for exchange on the carbon market. The following carbon certification standards offer biochar producers the ability to issue carbon credits:

Puro Standard

Puro.earth holds the Puro Standard. Puro was the first carbon credit issuer for biochar production activities and thus was the first to come up with a methodology to quantify biochar carbon removal capacities in line with the expectation of the carbon markets. It currently holds a wide range of accredited projects.

Climate Action Reserve (CAR)

Climate Action Reserve is a recognized carbon standard targeting carbon projects across North America. They recently released the U.S. and Canada Biochar Protocol to start certifying biochar projects in the U.S. and Canada.

Carbon Standards International (CSI)

CSI was the first standard to distribute a certificate to attest the sustainable production of biochar, through the European Carbon Certification (EBC). The organisation has now developed two biochar methodologies: the Global Biochar C-sink methodology to quantify emissions removal of a broad range of biochar activities; and the Global Artisan C-Sink methodology, targeting the artisanal production of biochar most notably by small-scale farmers located in lower income countries.

Riverse Standard

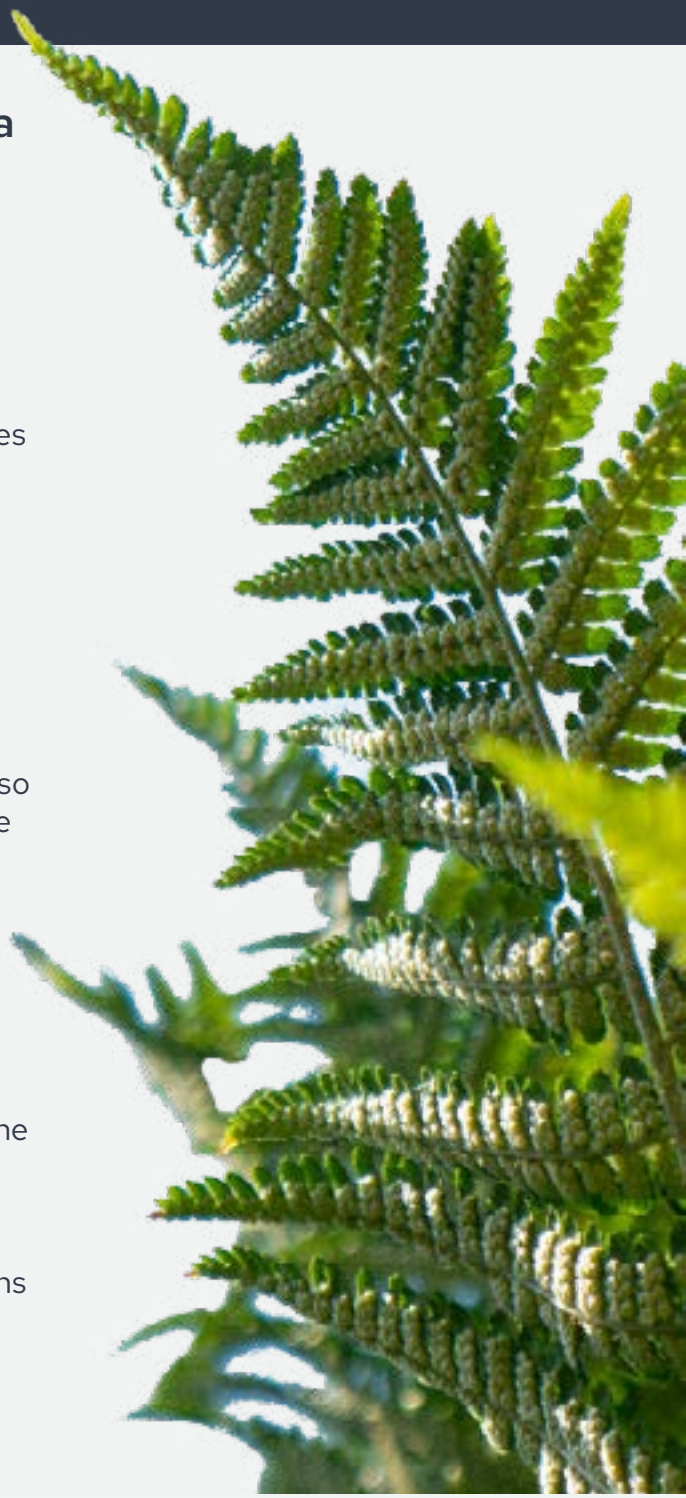
Riverse is a pan-European certification standard which targets carbon projects developing green technologies at industrial scale. Their BECCS & Biochar methodology was created to certify biochar and bio-oil production.

The Verified Carbon Standard (VCS)

VCS is one of the largest carbon certification standards on the market and is administered by Verra. It has recently developed a new methodology to measure emissions removal of biochar projects. The standard offers VM0044 Methodology for Biochar Utilization in Soil and Non-Soil Applications for the certification of biochar production worldwide.

Carbon Certification Standards *(cont.)*

Whilst all methodologies are based on the same carbon accounting principles from the International Organization for Standardization (ISO), and all certify measurable and verifiable emission removals, specific certifications may be more appropriate for certain types of biochar production activities. The most relevant certification standard and methodology for one's activities will depend on various factors, of which the most significant would be the production technology involved, the feedstock used, and the biochar end-use. This is all to say, each standard has their own eligibility criteria.



Biochar to Carbon Credits: Eligibility Criteria

The principal criteria for certifying biochar projects and quantifying emissions are common to all approaches. The main eligibility components of biochar projects involve the evaluation of a biochar's feedstock, production facility, and end-use application.

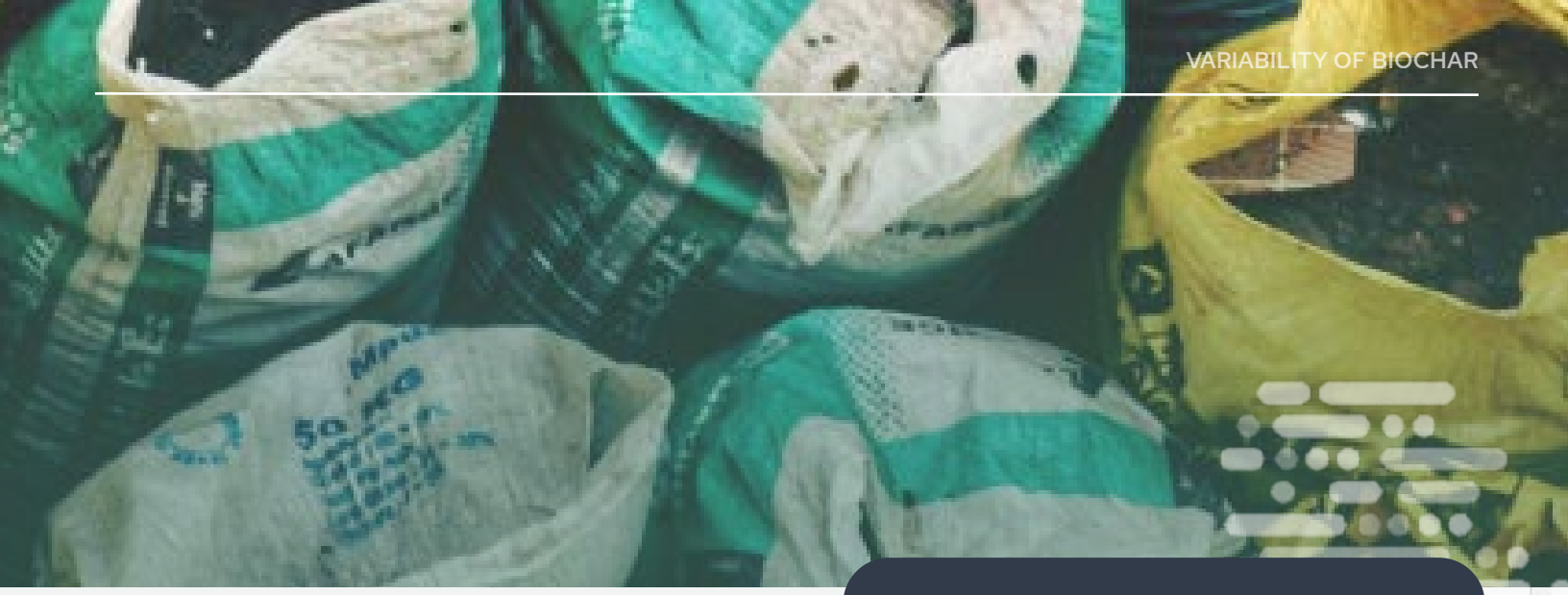
In order to issue carbon credits, the standards' methodologies require that biochar producers evaluate each step of their product lifecycle. This includes the sourcing and transportation of biomass feedstock, the transformation of biomass into biochar through eligible production technologies, and the distribution and end-use of the biochar.

The entire biochar production process must account for all the GHG emitted across the biochar's entire lifecycle (from biomass growth to biochar application), including CO_2 but also methane (CH_4) and nitrous oxide (N_2O). Emissions should be minimal, if not neutral, and always discounted from the final estimate of emissions removed.

However, since carbon accounting methodologies only enable the issuance of carbon credits for the carbon (already in the atmosphere) sequestered, as opposed to the carbon avoided (from being emitted in the future due to biochar displacing a more carbon-intensive product), baseline emissions are set to zero. All standards require a complete set of data and documentation to inform and justify emissions estimated for each stage of the biochar production process, and each standard requires a third-party auditing of emissions calculation.



Variability of Biochar



Biochar has the potential to remove 6% of global carbon emissions annually (Lefebvre et al. 2023), but not all biochar is created equal.

The carbon sequestration potential of biochar can vary significantly according to both feedstock and production parameters, as well as the environmental conditions of the end use application.

Biomass feedstock	Carbon content (wt%, dry basis)
Wood mixture	50
Maize	48
Meadow grass	49
Food waste	41

Table 1: Comparison of carbon content from different biomass feedstock type (Břendová et al. 2012, Seow et al 2022).

Feedstock Variability

For example, in one meta-analysis, biochar carbon content ranged from as little as 10% (gasified sewage sludge) to 81% (high temperature pyrolysis of wood) by mass (Woolfe et al. 2021).

Other biochar characteristics such as nutrient availability, pH, and specific surface area are similarly influenced by the feedstock used. The amount of energy produced in the production process is also affected, with high carbon feedstocks typically also providing more energy which can be utilised.

Different feedstocks require different preparation processes. Feedstock needs to be relatively dry (~20% moisture content) and homogenous in size, content, and shape, meaning a combination of grinding, drying, sorting, and pelletising may be necessary depending on the type of feedstock utilised.

Carbon standards and biochar quality standards also have rules about the kind of feedstock that is eligible for certification, meaning that choosing the correct feedstock for a biochar production project is of the utmost importance.

Available Biochar Production Technologies

Biochar production technologies vary widely, from small-scale artisanal kilns to large, industrial pyrolysis plants. These technologies will have different temperatures, residence times, and throughputs. The most common biochar production technologies are pyrolysis and gasification systems:

- **Pyrolysis systems:** biomass is heated under anaerobic conditions or a limited supply of oxygen, producing gases, bio-oil, and biochar. Two main types of pyrolysis:
  - Slow pyrolysis (produce more oils and liquids)
  - Fast pyrolysis (produces more syngas)
- **Gasification systems:** biomass is heated in a directly heated reaction vessel with introduced oxygen under higher temperatures, producing smaller quantities of biochar and a higher calorie syngas.

The cost of production varies significantly depending on the methods of production. Traditional artisanal methods that involve small-scale kiln technologies tend to be cheaper. For instance, a low-technology pyrolysis, using a soil pit and the artisan's own residues, will have little to no production costs.

On the other hand, large-scale, industrial pyrolysis/gasification plants are more expensive, but have a higher biochar-producing capacity. Production cost can vary from US$220 to US$580 per tonne of biochar produced (Xiao et al. 2020). Moreover, not all feedstocks are usable with every technology. A flame curtain kiln such as the Kon-Tiki will never work using rice husk alone as a feedstock, for instance.

High technology pyrolysis systems are usually fairly modular, and can be built to specifications. Peripherals like dryers and pelletisers are normally added separately, however some units will include integrated dryers or integrated electricity production modules.

Eligibility of End-use Applications and Their Impact on Carbon Storage

Both production processes and feedstock used affect biochar characteristics, including:

- Concentrations of different elements (for example carbon and nitrogen)
- Density
- Water holding capacity
- Cation exchange capacity
- Porosity
- Water holding capacity
- Specific surface area
- pH

Because of these differences in properties, some biochars will be more appropriate for certain applications. For example, biochar with a high pH is useful as a soil amendment in acidic soils, and biochar with high specific surface area is effective in purification systems.

Carbon standards and biochar quality standards have rules about the end use of biochar.

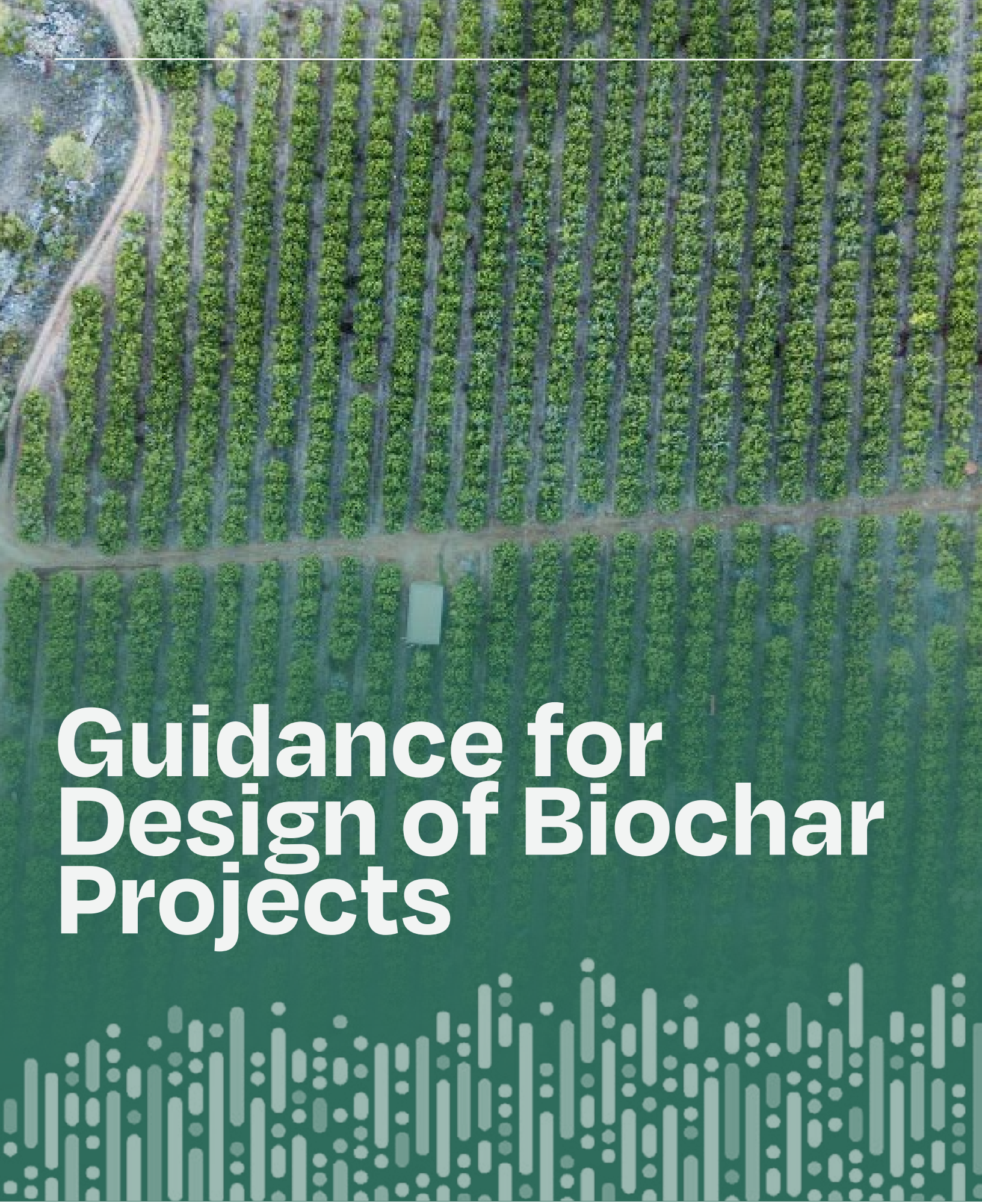
Carbon standards forbid the use of biochar as a fuel, or as a reductant, as the carbon sequestered within the biochar is released.

Meanwhile biochar quality standards dictate which biochars can be used for which application. These standards are designed to prevent biochars with high levels of heavy metals being used in soil, or as animal feed.

Examples of applications for biochar include:

- In soil as an additive
- In animal feed
- In construction as an aggregate
- In purification and filtration systems

Whatever the end use, project developers must prove that the carbon sequestered within the biochar is preserved over 100 years before they can earn removal credits from their project.



Guidance for Design of Biochar Projects



There is a lot to consider when designing a biochar project. Here are some of the main considerations that will feed into your biochar carbon removal project design and can help you formulate a concept note.

1. CONSIDER THE SCALE OF YOUR PROJECT

Who will be the biochar producer? How much resource do you already have? How much will you need? Who else will be included and impacted by the project? How much biochar are you aiming to produce? Map out the different actors as well as your targeted objectives.

2. DETERMINE THE BIOMASS FEEDSTOCK TO BE USED

What feedstock do I have access to? What kind of biochar will it produce? What would happen to it in the absence of the project? What processing requirements does it have? Is there a constant supply? These are important questions which are crucial to figure out to get going on the certification process.

3. WHAT IS OR WILL BE YOUR BIOCHAR PRODUCTION FACILITY?

Is the project high or low technology? What coproducts are produced? Is there energy produced as well? Is there a way to use the energy produced? Where is it located and who will be the producers? Is any training required for production? Will feedstock be brought to the plant or will the plant need to move around where feedstock is?

4. CONSIDER THE END-USE BIOCHAR APPLICATION

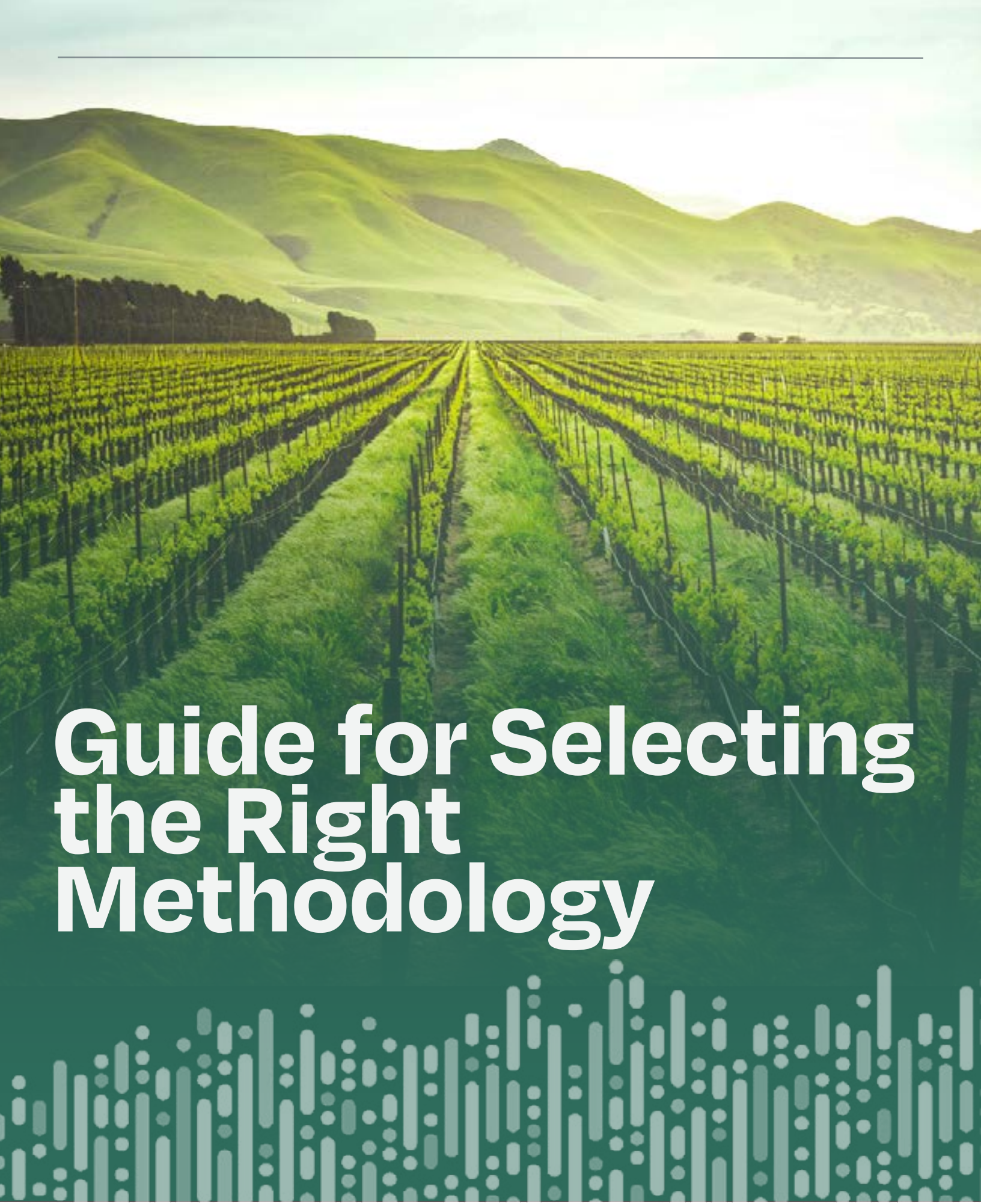
What will be the end use application of your biochar? This can be soil or non-soil. The biochar application will need to be into a stable matrix where its carbon will remain durably stored. Can it be used locally? Applied to agriculture? Can it be integrated as part of a wider circular organic waste economy? Have you targeted an interest buyer or user?

5. WHAT CARBON CERTIFICATION STANDARDS IS THE BEST SUITED FOR MY CARBON REMOVAL?

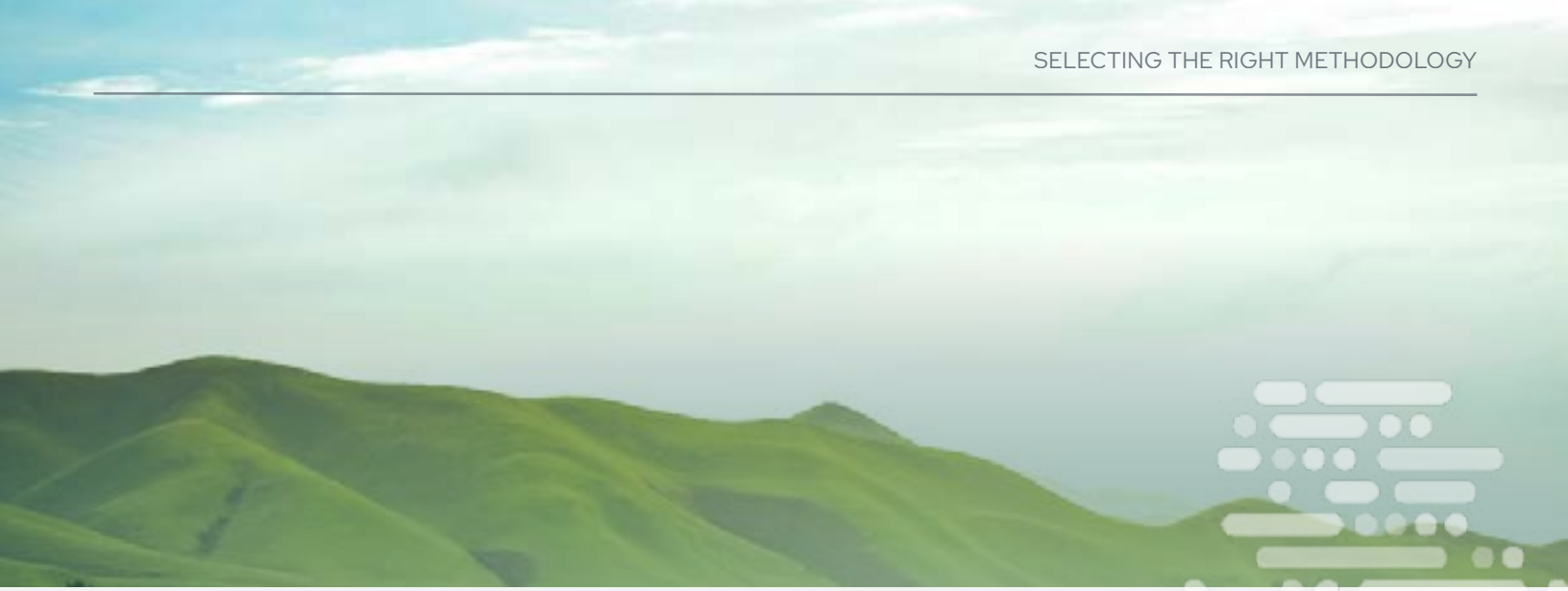
Partner up with a carbon specialist to help you estimate the carbon content of your biochar and how many credits your biochar activities could generate. This is an exciting step which will show you concretely the impact of your project. It will also help you understand how much income can be obtained, to fund your activities. Calculations of your project's carbon removal capacity will be made by considering all the previous steps of the project, thus highlighting the importance of your project design.

6. GET YOUR PROJECT CERTIFIED!

Now that you have all your project steps in mind, and all the keys to a successful biochar project, you should be ready to go through certification and make it a reality! Whilst the certification process will require your attention and your time, you should carefully approach it for the long-term results of your projects and its successful implementation. The first step will be to target a specific standard with the right methodology for your project. Use this guidance document to guide you through the different certifications available.



Guide for Selecting the Right Methodology



Because biochar is highly variable, each carbon certification standard has designed their methodologies with specific guidelines to meet the wide range of pathways for carbon sequestration by biochar.

This section outlines major characteristics for biochar methodologies, defined here by the standard they belong to. **Each criteria characteristic below is further described in the following section, titled: "Defining a Project's Characteristics"**.

	Puro Standard	VCS	Global Biochar C-Sink	Global Artisan C-Sink	CAR	Riverse Standard
Project emissions boundary[1]	Biomass production → biochar application	Biomass sourcing → biochar application	Biomass sourcing → biochar application	Biomass sourcing → biochar application	Biomass production → biochar transportation	Biomass sourcing → biochar application *(if applied to soil, application-related losses accounted for in LCA)*
Requires external/ prior certification of biochar production[2]	**No** Strongly recommends biochar to align with WBC or EBC guidelines	**No** Requires feedstock source to align with IBI Biochar Testing Guidelines or EBC production guidelines	**Yes** Only biochar certified under the EBC or the WBC is entitled to Global Biochar C-Sink certification	**Yes** The use of low-tech system must comply at least with WBC Agro class limits	**No**	**No** But prior EBC certification accepted

	Puro Standard	VCS	Global Biochar C-Sink	Global Artisan C-Sink	CAR	Riverse Standard
Eligible feedstock[3]	Biomass feedstock listed on the EBC/ WBC positive list Biomass from forestry must come from sustainably certified forestry	Waste biomass only Feedstock must be purely biogenic waste biomass and not purposefully grown	Only carbon neutral biomass* *(Biomass feed-stock listed on the EBC/ WBC positive list)* Biomass from forestry must come from sustainably certified forestry	Only carbon neutral biomass* *(Biochar made from feedstock that originated from the artisan's farm (e.g., cocoa mills, coffee pealing, rice thrashing, sawmills, and comparable industries). Biomass may also come from disaster debris, main-tenance of fallow fields, or dedicated biomass production like bamboo or switch grass plantations* Forest residues may be used only for cooking in TLUDS within C-Sink Villages	Waste biomass and non-waste purposefully grown biomass meeting environmental safeguard criteria	Biomass feedstock listed on the EBC/ WBC positive list
Additionality[4]	**Proof required** 1) Demonstrate CO_2 removal is a result of carbon finance 2) Provide full project financials and counterfactual analysis based on baseline	**Proof required** 1) Pass regulatory surplus (project activities are not mandated by law) 2) Meet appliability con-ditions ('positive list') on section 4 of the methodology	If there is no legal requirement for biochar production and carbon preserving application and if all permits are met, a project is considered additional	**No demonstration required** Guaranteed by the standard and allowed use cases itself	**Proof required** 1) Pass performance standard test 2) Pass regulatory surplus test *Proof required of no double counting re-quired if the biochar activity overlaps with other carbon or GHG mitigation activities*	**Proof required** 1) Pass regulatory surplus 2) Show financial additionality 3) Show prevalence ad-ditionality (must not be a norm or market practice)
Already existing processing plant accepted	**Yes**	**No** Biochar production facility must be new	**Yes**	**Yes** Proof of successful training for the appropriate technology is required	**Yes**	**Yes**

*Carbon neutral biomass: agricultural biomass, biomass waste from forest management, municipal waste, other biogenic residues.

	Puro Standard	VCS	Global Biochar C-Sink	Global Artisan C-Sink	CAR	Riverse Standard
Production technology allowed[5]	Pyrolysis Gasification Biomass boilers *Pyrolysis gases and tars must be combusted or adequately recovered, resulting in negligible GHG*	Pyrolysis Gasification Biomass boilers *GHG quantification is differentiated for each technology type*	Pyrolysis Gasification Biomass boilers	Pyrolysis Gasification *Low technology* OR *Pyrolysis cookstoves* *Others must go through a system endorsement*	Pyrolysis Gasification Biomass boilers	Pyrolysis Gasification
Biochar end use[6]	Soil + non-soil applications	Soil + non-soil applications	soils, animal farming, construction & composite materials, storage	Soil + non-soil applications	Soil + non-soil applications	Soil applications + incorporation in construction materials
Biochar tracking requirements	Proof that biochar end-use does not cause CO_2 returning to the atmosphere must be kept in records and submitted for auditing	Tracking records must be provided throughout the entire chain of custody from sourcing to the end-use application. *Any tracking software is allowed*	Tracking records must be provided throughout the entire chain of custody from sourcing to the end-use application. *dMRV system required, and must be endorsed by CSI annually*	Tracking records must be provided throughout the entire chain of custody from sourcing to the end-use application. *dMRV system required, and must be endorsed by CSI annually* *Pictures required with date/time stamp & geolocation.*	Tracking records must be provided throughout the entire chain of custody from sourcing to the end-use application. *Tracking software, third-party tracking, or paper bills of lading is allowed*	Tracking records must be provided throughout the entire chain of custody from sourcing to the end-use application. *Tracking software, third-party tracking, or paper bills of lading is allowed*

	Puro Standard	VCS	Global Biochar C-Sink	Global Artisan C-Sink	CAR	Riverse Standard
Requirements for end-use applications[7]	Biochar environmental quality must be assessed & demonstrated to meet certain benchmarks for use *(e.g. in soils, see rule 1.1.7 in the methodology)*	Biochar must be utilized within 1 year of production If applied to soil: 1) must be mixed with other substrates 2) must comply with IBI testing guidelines or EBC production Non-soil end-use application requires sequestered carbon is preserved long-term	Positive list of permissible matrices for the establishment of biochar C-sinks in soils, non-soil applications and geological storage	Biochar is preferentially used on the farm of artisan biochar producers Biochar can be sold, often in cases of Artisan Pro's If biochar is applied/ sold outside of the farm, the biochar trader needs to become certified as trader to track the biochar with dMRV tool	End-use application requires sequestered carbon is preserved long-term Biochar cannot be used for energy production Only use in soil applications where the biochar sample analysis meet standard rules If sold/ transferred to an external party, must trace and report final end use & must comply with methodology	Must specify location of end-use application sites
Leakage & uncertainties	All upstream & downstream emission sources must be included in the LCA via use of adequate emission factors (e.g. transport is not considered leakage, but direct project emissions) *Additional leakage penalties may be applied depending on project specifics (land use change, energy leakage, etc.)*	Leakage emissions are part of the net GHG quantification *Leakage emissions are primarily attributed to transport at various stages of the biochar life cycle*	All upstream & downstream emission sources plus a margin of safety of 20kg CO_2e applied per dry tonne of biochar produced	Margin of safety of 20kg CO_2e applied per tonne of biochar produced *Potential emissions for transporting of biochar to the field site (up to 100 km), milling, blending with other substrates, and applications are included in the margin*	Leakage considered if biomass is diverted from bioenergy production - specific leakage calculation required for such instance *Leakage is also addressed for purpose-grown biomass by limiting types of crops allowed & source locations (marginal lands, reclaimed mining sites)*	No direct measurement of leakage. All emissions related to transport or other losses are accounted for within the LCA

	Puro Standard	VCS	Global Biochar C-Sink	Global Artisan C-Sink	CAR	Riverse Standard
Biochar sample testing[8]	**Required** Frequency decided by supplier *Must appropriately reflect variability & seasonality in biomass feedstock & production conditions*	**Required** Each reporting period	**Required** Annually as part of the EBC/WBC certification	**Required** Annually for Artisan Pro producers *Not required for C-Sink Farmer Network, analysis required if biomass is not in the database; recommended in any case*	**Required** Each reporting period	**Required** Each reporting period
Stability criterion H:C (organic)[9]	< 0.7	< 0.7	.4 (PAC) and .7 (SPC)	< 0.4	< 0.7	< 0.7
Permanence factor application	Calculators provided to the project Calculations based on molar H/Corg ratio determined by laboratory analysis & average soil temperature in area in region where biochar is used	For high technology: pyrolysis temperature used to determine conservative value of permanence adjusted factor[‡]	Biochars with H/Corg ration < 0.40 have 75% PAC when applied to soils; biochars with H/Corg > 0.40 < 0.70 applied to soils are registered as 100% SPC	Persistence factor of 75% over 1000 years applied	Default permanence factor applied based on biochar end-use list	Calculates the percent of biochar carbon remaining after 100 years, using a regression equation for a given soil temperature and H/Corg ratio
Upstream biomass tracking	Yes	Yes	Yes	No	Yes	No
Geographical restrictions	No	No	No	Low-Income, Lower Middle Income and Higher Middle-Income countries only	US & Canada only	Europe only

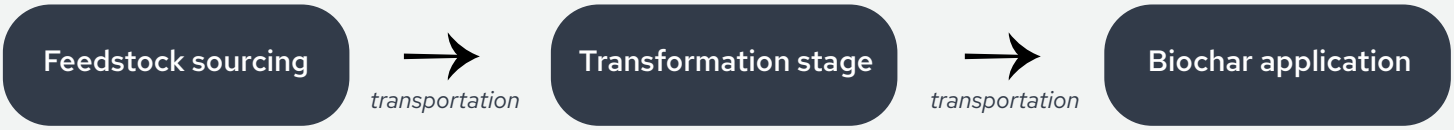
[‡]A different value can be proposed given the adequate and approved forms of evidence are provided. These must comply with VCS established methodology requirements. For low-technology: a default value is given if production facilities do not measure temperature.

Defining a Project's Characteristics

Because the characteristics of biochar can vary significantly based on feedstock, production method and cost, composition, end-use application, carbon accounting, and monitoring considerations are multifold.

Life cycle analysis (LCA) & project boundary[1]

All methodologies apart from the Global Artisan C-Sink require a complete step-by-step analysis approach, considering all stages of the biochar lifecycle (from cradle to grave). While the Global Artisan C-Sink does not require a third party LCA to be conducted, the CSI Biochar Tool provides an automated way for producers to calculate all emissions. The main stages considered are biomass sourcing, biochar production, and application stage/storage. The aim is to assess its carbon footprint and discount it from the estimated CO_2 stored by the final biochar product.



GHGs considered

CO_2, CH_4 and N_2O emissions rising from project activity are considered. CH_4 and N_2O emissions can result from the pyrolysis or thermochemical conversion processes, and thus need to be accounted for when estimating the total project emissions. Carbon Standards International (Global Biochar C-Sink and Global Artisan C-Sink) requires that any methane emission occurring from biochar production must be compensated for.

Calculations of emission reduction

All standards share a common approach to estimating CO_2 removed with biochar. "E" stands for emissions in the following:

Net CO_2 removed (tCO_2e) = E stored in biochar – E from biomass production and supply – E from biochar production – E from biochar end-use (transformation+transport)

Net CO_2 removed (tCO_2e) = Carbon stored in biochar for 100-year time horizon – E from biomass production and supply – E from biochar production – E from biochar end-use (transformation+transport) – E from indirect leakage

Estimations of emissions at each stage are made through a LCA. Additionally, to account for emissions that have been omitted from these calculations, and for uncertainties, standards require accounting for a margin of safety to be removed from overall GHGs calculations. The Global Biochar C-Sink and the Global Artisan C-Sink require adding a safety margin of 20kg of CO_2e per tonne of biochar produced. Leakage, referring to the unintended GHG effects resulting from the project activity, is also accounted for within protocols/methodologies. Leakage is attributed to transport emissions at the various stages of the biochar life cycle. The VCS integrates leakage calculation to the net GHG removal quantification. The Puro Standard and Riverse Standard's BECCS & Biochar methodology do not specifically require accounting for leakage but a thorough LCA which is expected to cover all potential emissions. CAR bases leakage on the potential diversion of the feedstock biomass from bioenergy production.

External certification[2]

Some standards require certifications from biochar "material standards" (for example, WBC) which validate characteristics of the biochar itself.

Eligible feedstock[3]

All methodologies require that the biochar is produced from a sustainable feedstock:

- Puro requires that forest biomass be externally certified as sustainable (e.g. FSC, SFI, PEFC); all other feedstock needs to be a waste biomass (agricultural waste, biodegradable waste, urban wood waste or food waste).
- VCS requires biomass to come from waste only (thus excluding biomass from purposely grown feedstock).
- CAR mainly allows for waste biomass feedstock. However, purposefully-grown biomass can be accepted under highly limited conditions. In this case, biomass must come from non-woody perennial species that are either native species or sterile hybrid non-native species. They also have to be cultivated on marginal lands and not involve tillage.
- Similarly, CSI's Global Biochar C-sink requires feedstocks to be carbon neutral, where biomass is sourced from waste only, and is not specifically grown for biochar production. Moreover, CSI requires that biomass coming from forestry should come from certified forestry (FSC or PEFC certified). A positive list of allowed feedstock is provided by CSI (Global Biochar C-sink and WBC).
- Riverse Standard requires feedstock to align with Global Biochar C-sink guidelines.
- Due to its more specialised nature, the Global Artisan C-Sink methodology assumes that the biochar is made from biomass feedstock that originated from the artisan's farm or from biomass processing industries and may also come from disaster debris, maintenance of fallow fields, or dedicated biomass production like bamboo or switch grass plantations. It is not permitted to use forest wood and to slash forest trees (except for C-Sink cookstoves).

Additionality[4]

All standards request a demonstration of additionality, proving that biochar production and its long-term disposal would not have taken place without the prospective sale of carbon credits. Both regulatory and financial additionality must be demonstrated. Additionally, Global Biochar C-Sink and VCS both specify feedstock additionality, thus making sure that biomass was not diverted from other uses (e.g. construction wood, bioenergy, etc.). Global Artisan does not specifically require any additional proof of additionality than stated already in the standard itself.

Production technology[5]

Treatment of waste heat and gas from pyrolysis: fuel gas is produced from the condensation stage of the pyrolysis. To ensure the net negativity of the pyrolysis plant, Puro requires these gases to be re-utilised within the pyrolysis process, by feeding the gas back into the reactor where biomass is processed. Other methodologies tolerate waste gas, but most require the use of excess heat and compliance with nationally defined emission limits. All emissions from pyrolysis should be accounted for and deducted from total emission removal estimates.

(See table on next page)

Production technology[5]

Standard	Technology Allowed			Additional Requirements
	Pyrolysis	Gasification	Boiler	
Puro Standard	✓	✓	✓	Combustion of syngas and/or oil must minimize CH_4 emissions. Any residual emissions are accounted for in the LCA. Design of reactor is vetted during certification, if not from known technology partner. Production facility must be validated by the Production Facility Audit.
VCS	✓	✓	✓	Pyrolysis plant needs to be new (invested as result of carbon finance). High and low technology allowed.
Global Biochar C-Sink	✓	✓	✓	The energy efficiency requirement is 60% for all certified technologies.
Global Artisan C-Sink	✓	✓ Pyrolysis Cookstoves (TLUD micro gasifier).	✗	CH_4 emissions occurring during biochar production must be fully compensated within 20 years after emission (e.g., can be by growing additional biomass). Does not exclude any particular (low) technology but requires that no un-combusted pyrolysis gases are emitted from the device. Technology often used in this context: flame curtain pyrolysis (e.g., in Kon-Tiki type pyrolysis kilns). For pyrolysis cookstove technologies, CH_4 emissions related to cooking versus biochar production are separated on a pro rata basis. Only CH_4 emissions released from the pyrolysis of the feedstock carbon contained in the biochar must be compensated. Biochar from traditional charcoal piles and retorts where pyrolysis gases are released not passing a combustion zone or burning chamber cannot be certified.
CAR	✓	✓	✓	No specific requirements as long as produced biochar meets standard criteria.
Riverse Standard	✓	✓	✗	All external energy needed to start the process (e.g. natural gas, wood combustion, electricity) needs to be included within LCA.

The size of activities covered under Global Artisan C-Sink certification is limited to small-scale production. An Artisan Biochar Producer must produce a maximum of 1,500 m^3 of biochar per year. Individual C-Sink farmers producing less than 100 m^3 of biochar per year can be grouped into C-Sink Networks of up to 1,000 farms to facilitate certification.

Biochar end use[6]
All methodologies apply to projects where biochar is stored in the environment in soil and non-soil application. The end-use application of biochar needs to preserve its full carbon storage. For instance, VCS's methodology requires biochar to be utilized within one year of production and proponents to track its final geographical location (in the case of soil applications).

Requirements for end-use applications[7]
Regarding CSI's Global Biochar C-Sink and Artisan Biochar C-sink, differentiation between Geological C-sink (long-term) and Temporal C-sink (short-term) depends on the application.

Biochar sample testing[8]
All standards require the analysis of biochar samples to measure the carbon content of biomass. In the case of the Global Biochar C-Sink and Global Artisan C-Sink, analytical biochar samples are sent to an endorsed EBC/WBC laboratory. Other parameters measured include metal content, and the hydrogen to carbon (H:C) ratio, which is used as a proxy for estimating biochar permanence.

Stability criterion H:C (organic)[9]
To estimate the rate of biochar degradation when applied to soil, a stability factor is applied, based on the hydrogen to carbon (H:C) organic ratio of the biochar. The H:C ratio is a proxy for estimating biochar permanence. The lower the ratio, the more permanent the carbon storage of the biochar is. Various research studies are ongoing, with the objective of better estimating the carbon storage permanence of biochar. CSI Global Biochar C-Sink and Global Artisan C-Sink methodologies require this ratio to be lower than 0.4, whilst Puro Standard, the VCS, CAR, and Riverse allow for a less conservative approach with a ratio lower than 0.7. Regarding CSI's Global Biochar C-Sink, biochar with >0.4 can be accounted for but only as semi-persistent carbon (SPC) fraction with lower sequestration capacity, rather than as persistent aromatic carbon (PAC).

Additional Notes on Selecting a Methodology

Monitoring: the VCS and CAR require a detailed monitoring plan, covering the quantification of GHGs emissions at each project stage: sourcing, production, and application. However, to ensure and track the end-product of the biochar produced, all methodologies require tracking and documenting the end buyer and the final application of the biochar. This information should be accessible by the auditing unit to monitor the created biochar and its associated carbon stock. Puro requires invoices of biochar to be kept, and certificates of biomass if it is not a waste biomass. Both Global Biochar C-Sink and Global Artisan C-Sink require monitoring via dMRV systems. All methodologies require activities to go through auditing to verify emissions throughout the project.

Global Artisan C-Sink, a more targeted standard: the Global Artisan C-sink is targeted towards biochar producers with less resources and smaller scale production. The aim is to make biochar production (an expensive and technical process) more accessible to small-scale farmers and encourage more sustainable practices than slashing and burning crop residues, which causes significant GHG emissions as well as air pollution.

The flame curtain type of pyrolysis kilns (e.g., Kon-Tiki) used in this context have a much lower

infrastructure requirement, making it a more easily used and accessible method. The flame curtain pyrolysis technique involves burning biomass layer by layer to create a smokeless fire where gases emitted are consumed by the fire instead of being released into the air. In such a process, the oxygen cannot access the biomass layer underneath the fire, thus achieving pyrolysis. The layering up of the biomass feedstock is required to maintain a fire which is strong enough, and yet controlled enough to prevent the emission of gases. Therefore, the methodology can thus be used on artisanal farms and provides a way to develop biochar at a scale smaller than industrial scale plants. The standard is specifically made for projects located in low income, lower middle income and higher middle-income countries.

The methodology also includes biochar produced under pyrolysis cookstoves technology (TLUD micro gasifier). This allows projects distributing cleaner and safer cooking technologies to get certified for the biochar co-product and the associated carbon sink created.

The main difference with other certification approaches is that the Artisan Biochar Producer will enter necessary data into the dMRV application, gathering all data needed for reduction-sink calculations and project details. The production of the biochar and the final biochar produced will then be validated by an Artisan C-Sink 'Manager' before the data is sent for verification to the CSI. Artisan C-Sink Managers are required to carry out annual visits and internal inspections of their Artisan Biochar Producers and check the data entered in the application. This methodology is thus made to facilitate the certification process to small-scale farmers.

The Future of Biochar

Today, discussions about biochar and its many applications are multiplying. With concerns about rising temperatures and global GHGs emission reduction targets, this simple material has potential to provide huge benefits to the planet, as well as creating a new pathway for circular waste economy.

Researchers are increasingly studying the material's physical properties, and its applications could be more wide-ranging than previously thought. Engineers are creating roads using biochar-based asphalt, insulating houses with biochar-based insulation materials, and farmers are switching to regenerative organic farming with the help of biochar-based fertilizer.

Whilst there is still so much to learn about biochar, one thing is certain: the future of the biochar economy looks promising.



Appendix

Cost Comparison by Standard

Payment to standard | Payment to third party auditors | Payment to consultant

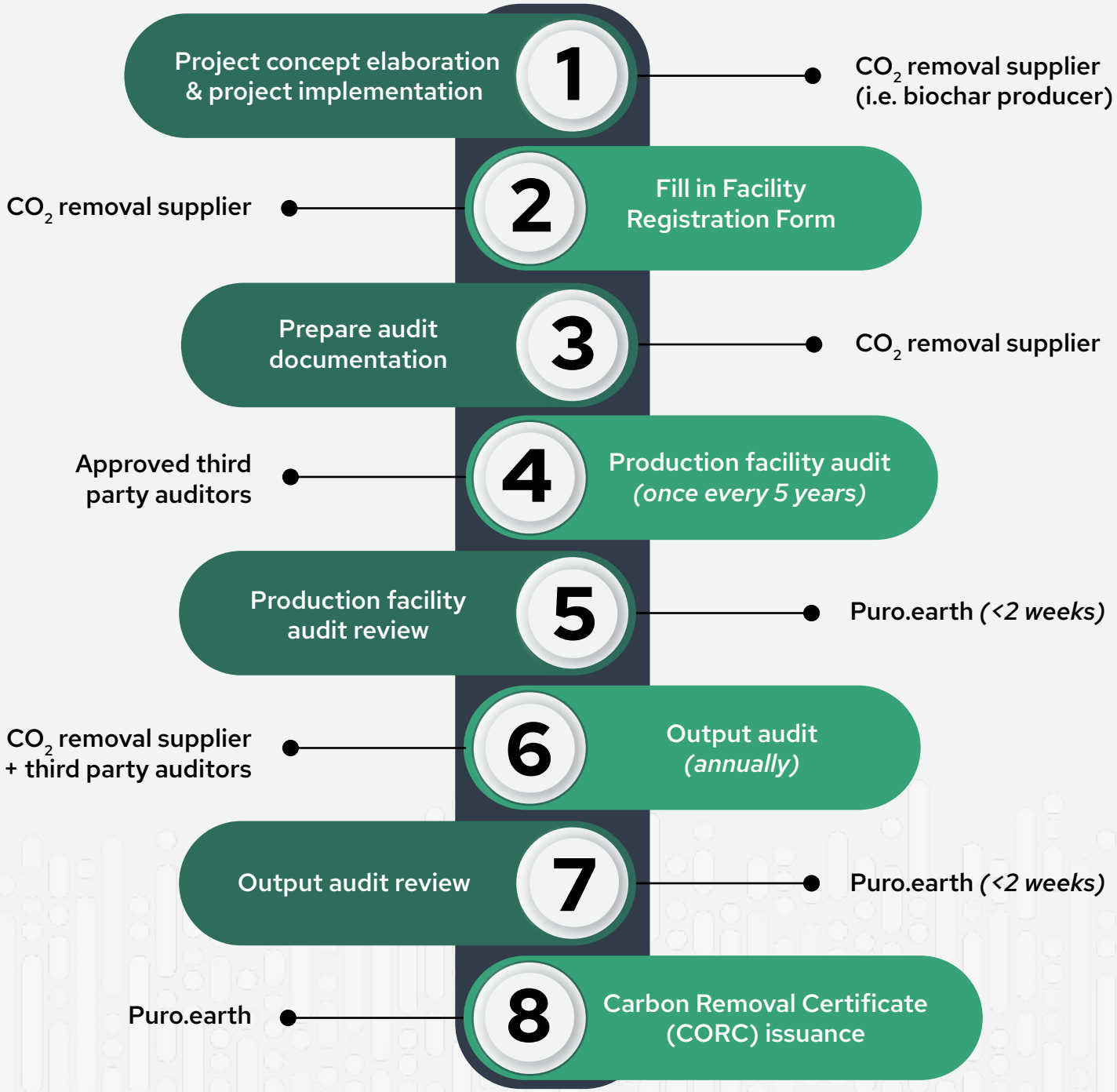
Disclaimer: Payments to standards are valid at the time this manual is published; payments to third party / auditors are indicative and based on the complexity of the underlying activity and location; payments to consultants are indicative estimation based on intensity of the work and internal experience team. Standards do not require project developers to work with consultants, if not necessary.

	Puro Pathway	VCS Pathway	CSI Pathway	CAR Pathway	Riverse Pathway
Registration & initial fees	Platform membership fee: 1.4k € *(annual)*	Registration fee: $500 *(annual)* Maintenance fee: $500 *(annual)* Pipeline listing: $1k *(once)* Project registration: $2.5k *(once)*	Registration fee: 300€ *(per company)* Annual fee: 300€ Global Artisan C-Sink: annual fee per Artisan Pro *or* C-Sink Network: 200€	Account set up: $500 Maintenance fee: $500 *(annual)* Project submittal fee: $500	*(included in monitoring fee, with third party auditors)*
Credit issuance fees	Volume-based fee: 0.2%-20%	$0.20 per credit	2€ per credit	$0.19 per credit	5€ per credit
PDD crafting	0–5k € *(including LCA & project document drafting)*	$15–50k *(including emission calculation & project document drafting)*	3k € *(project document drafting)*	$15–40k *(including emission calculation & project document drafting)*	— *(done by Riverse team & platform)*
Validation	Included in package	$7–15k *(once)*	Global Biochar C-Sink: included in certification for the EBC/WBC Global Artisan C-Sink: audit per country of activity, small & midsize projects: 3–5k € *(annual)*	$7–15k *(once)*	3–7k € *(once)*
Monitoring	Lab analysis: 1–5k € *(annual)*	$1–5k *(for each issuance)*	Global Biochar C-Sink: annual lab analysis already covered by EBC/WBC certification (900–1.2k €)	$1–5k *(for each issuance)*	7.5k€ *(annual fee covering standard support & verification)*
Verification	Included in package	$7–15k *(per issuance)*	—	$7–15k *(per issuance)*	— *(included in monitoring fee, with third party auditors)*

Main Steps for Certification by Standard

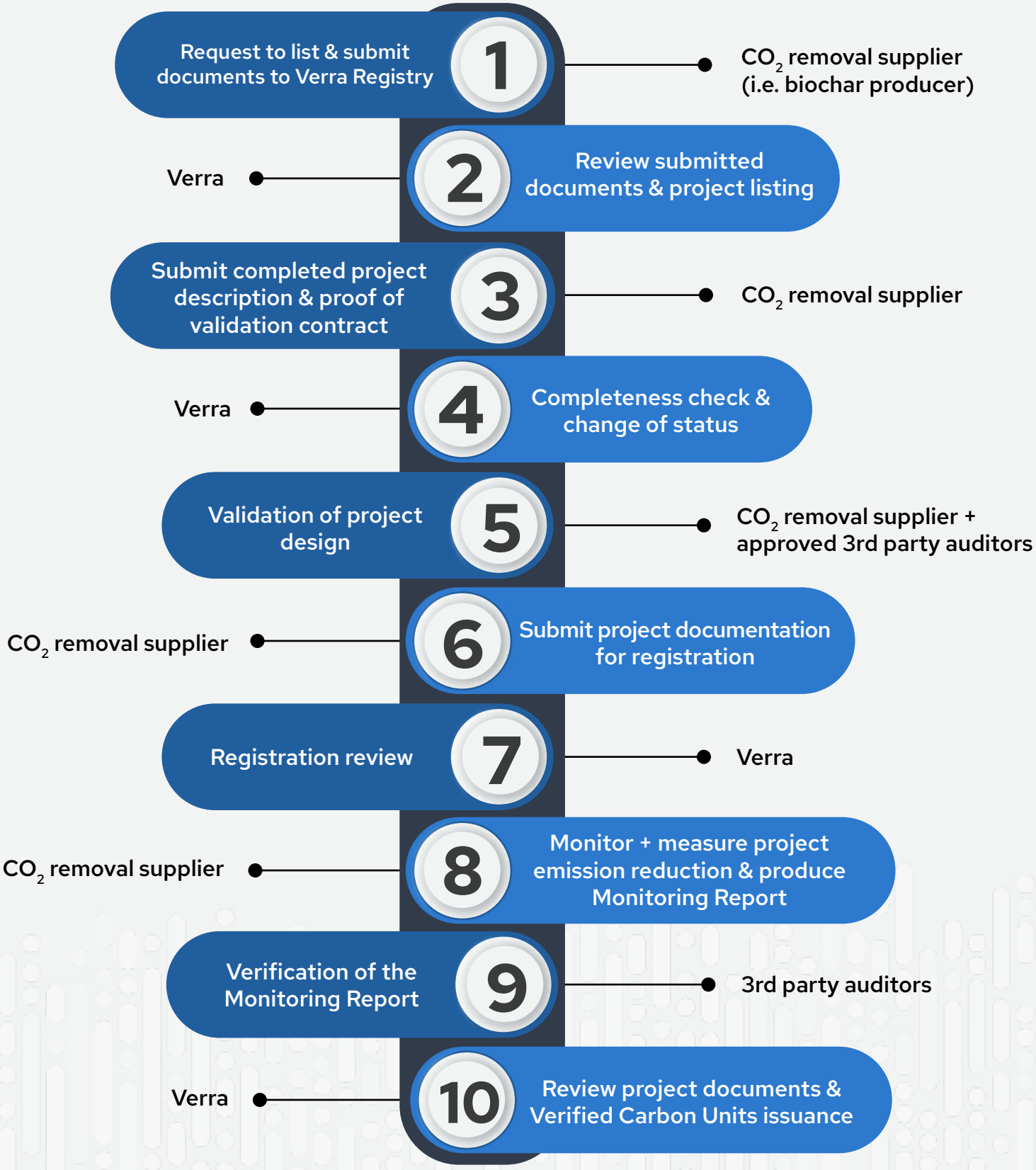
Puro Standard

Puro.earth holds the Puro Standard. Puro was the first carbon credit issuer for biochar production activities and thus was the first to come up with a methodology to quantify biochar carbon removal capacities in line with the expectation of the carbon markets.



Verified Carbon Standard (VCS)

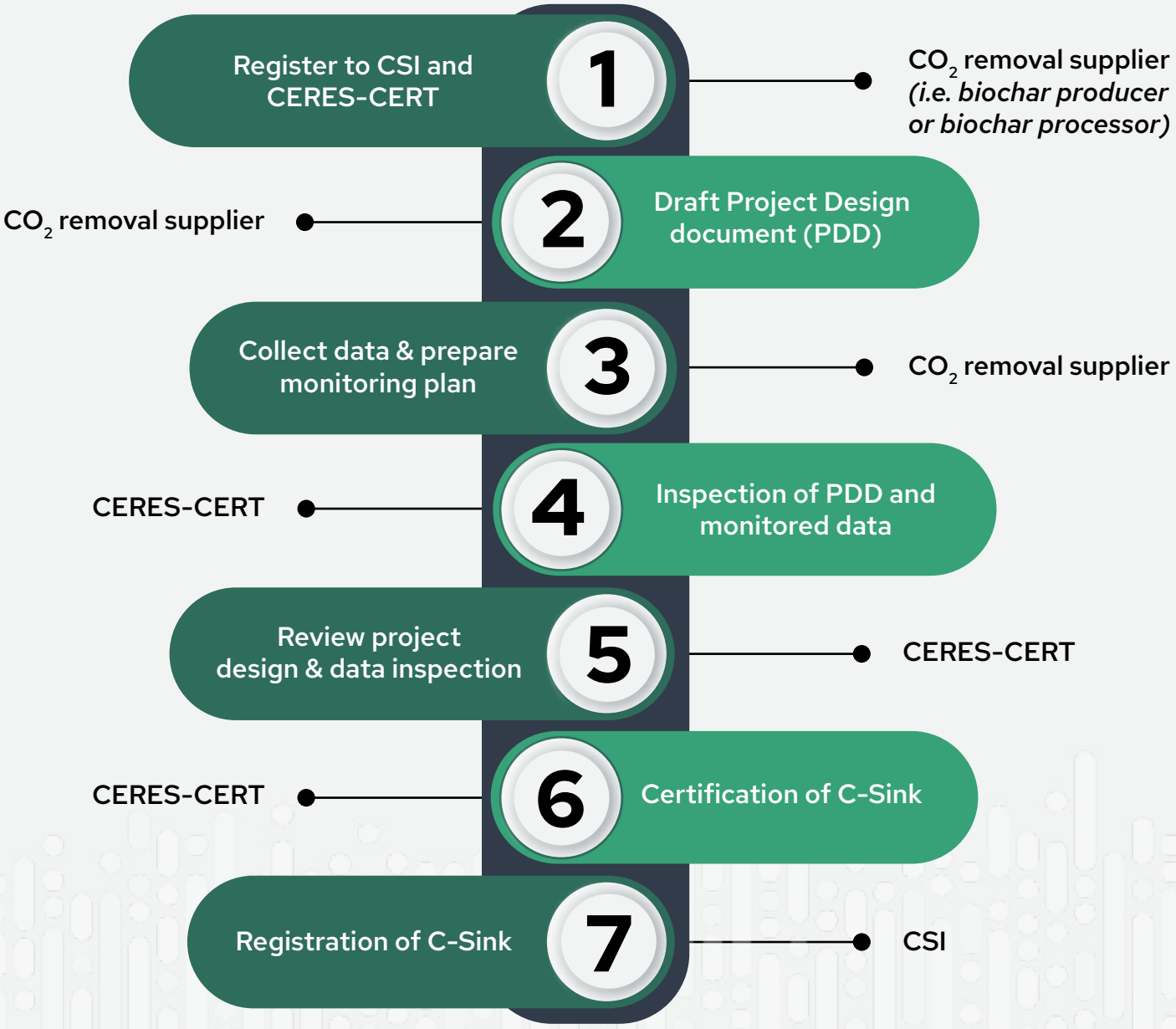
The VCS is one of the largest carbon certification standards on the market and is administered by Verra.



Carbon Standards International (CSI)
Global Biochar C-Sink

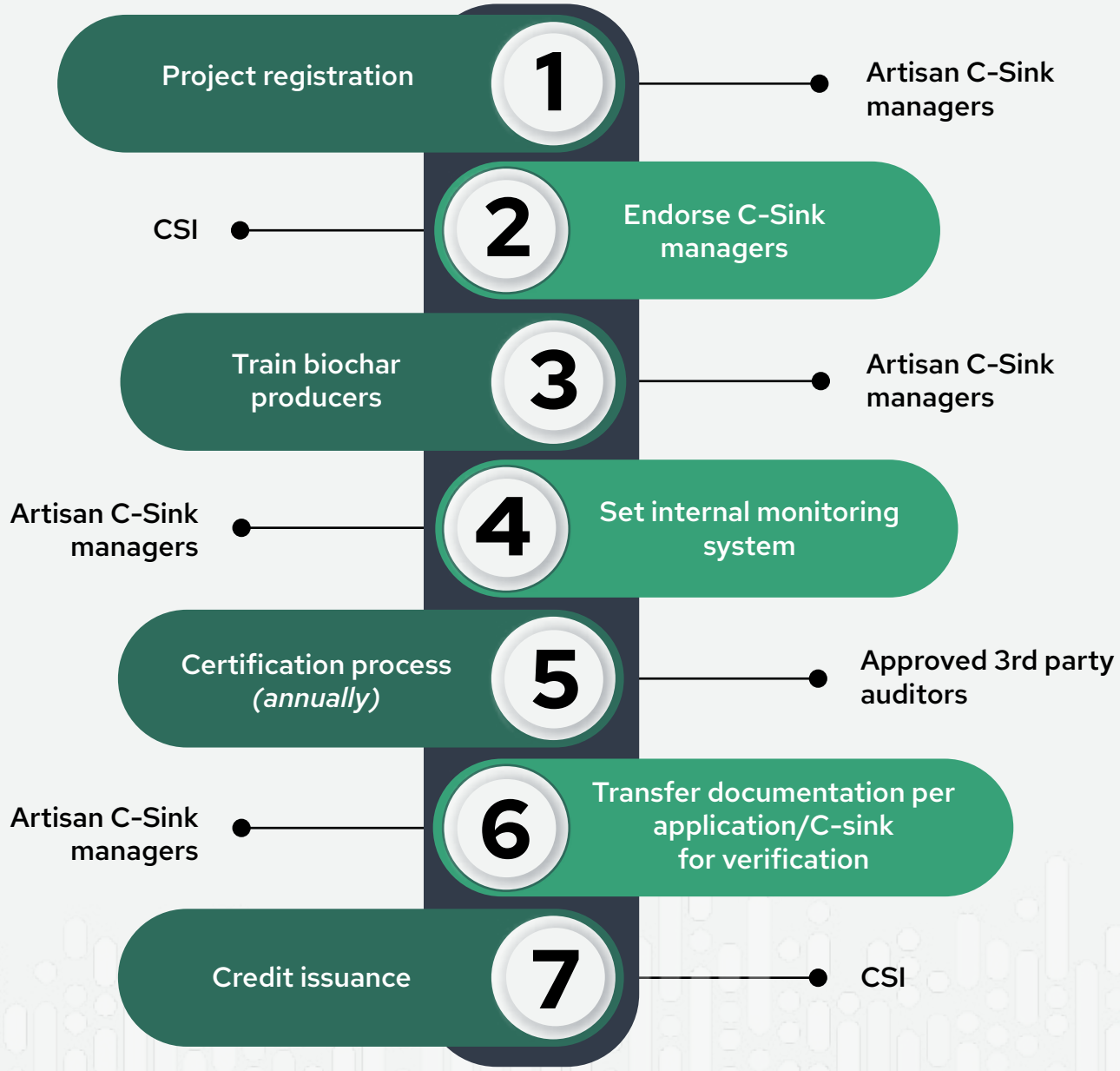
CSI was the first standard to distribute a certificate which provides independent assurance of quality within the biochar production process. The organisation has now developed two biochar methodologies: the Global Biochar C-sink methodology to quantify emissions removal of a broad range of biochar activities; and the Global Artisan C-Sink methodology, targeting the artisanal production of biochar most notably by small-scale farmers located in lower income countries.

Note: Biochar must also be certified under EBC/WBC to be certified as C-sink.



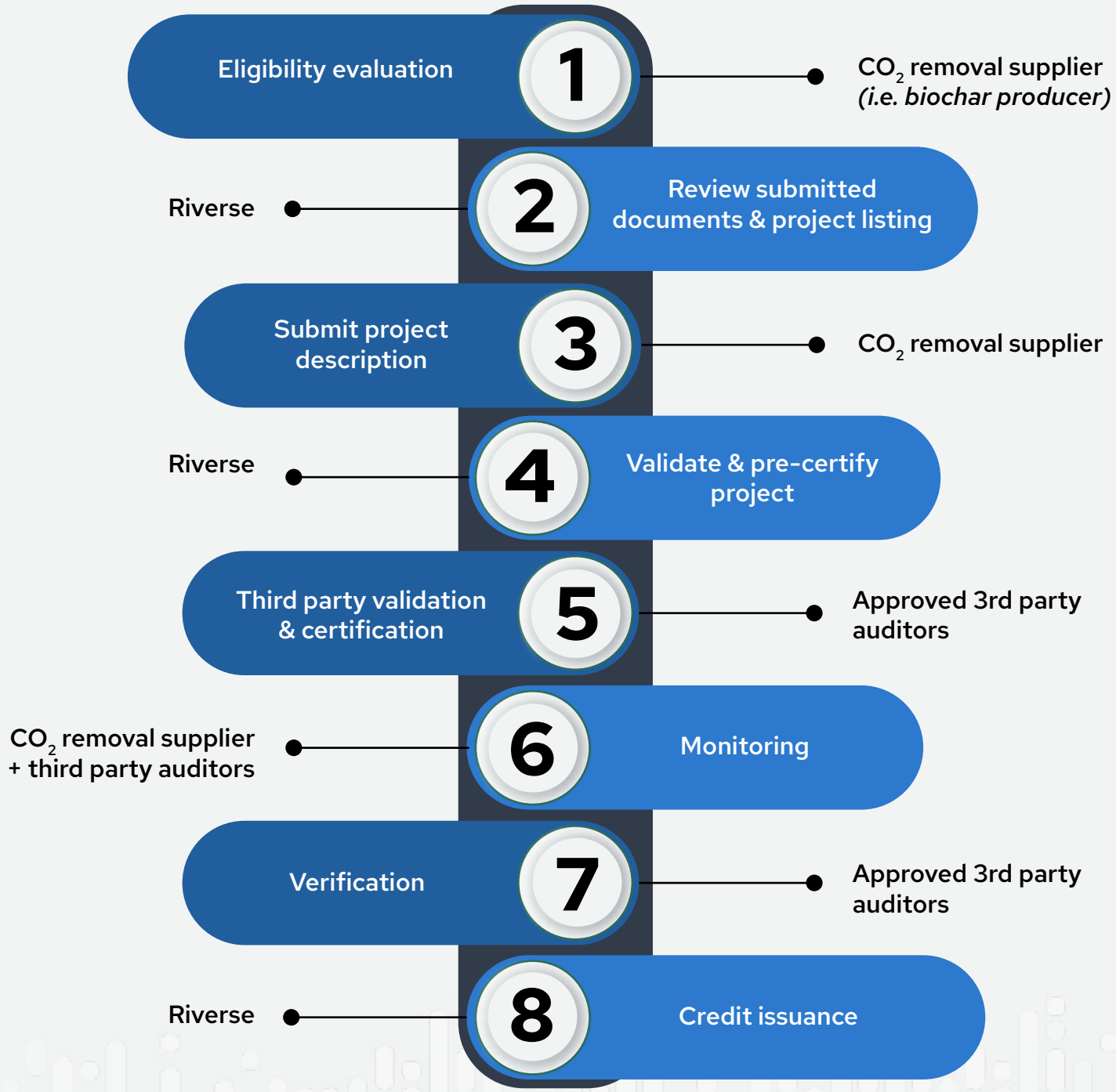
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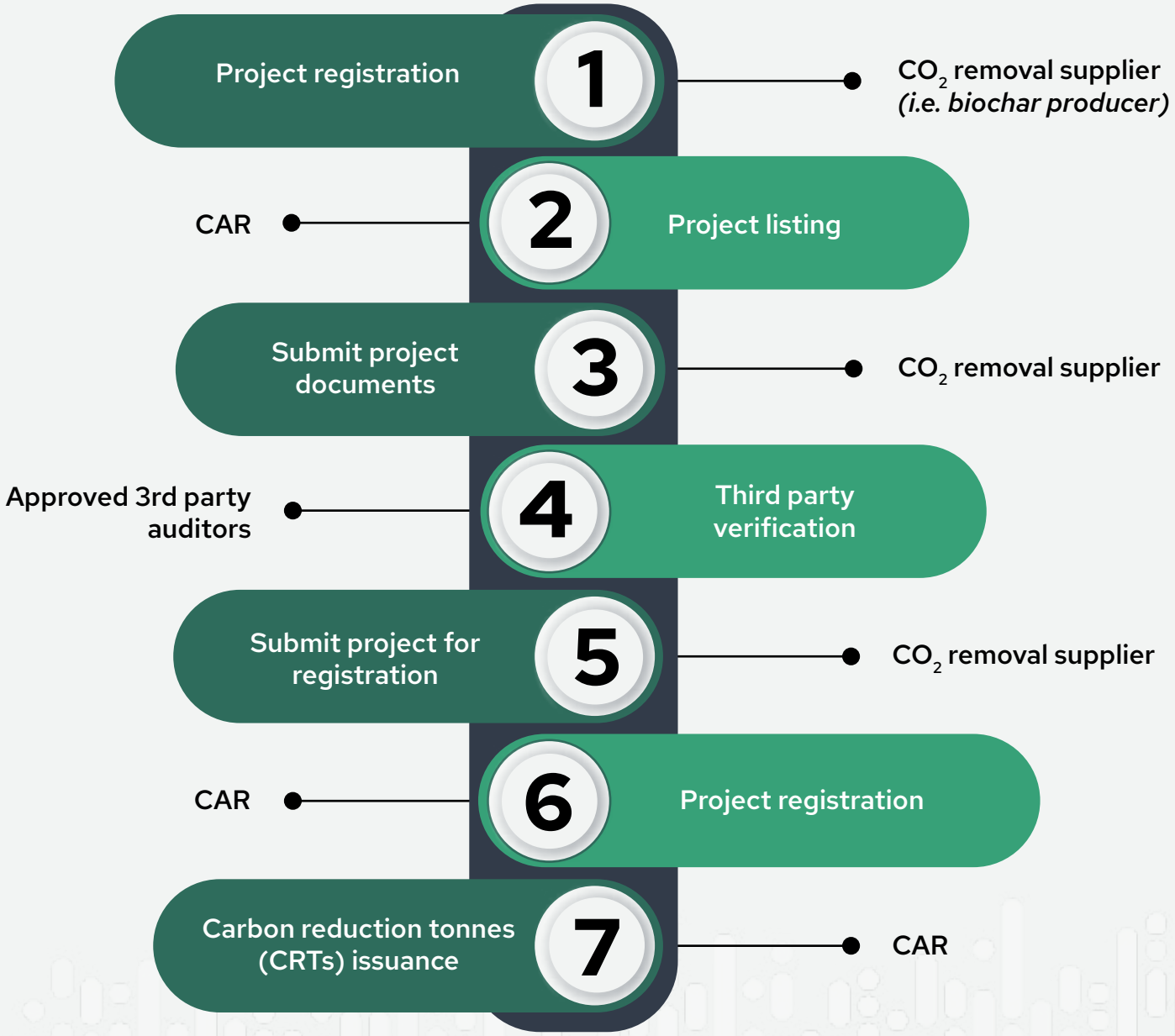
Riverse Standard

Riverse is a pan-European certification standard which targets carbon projects developing green technologies at industrial scale. Their BECCS & Biochar methodology was created to certify biochar & bio-oil production.



Climate Action Reserve (CAR)

CAR is a recognized carbon standard targeting carbon projects across North America. They recently released the U.S. and Canada Biochar Protocol to start certifying biochar projects in the U.S. and Canada.





Glossary

Glossary

Biomass: organic matter, usually used as fuel; carbon-based material that is alive or once-living.

Biomass boiler: biomass boilers are designed to burn biomass materials to produce heat or steam for various applications, such as heating buildings or generating electricity. In some contexts, biomass boilers may produce biochar as a co-product.

Bio-oil: biomass-based oil that can be gasified into syngas and combusted for fuel.

Carbon neutral: the net release of carbon dioxide (CO_2) emissions into the atmosphere is balanced by the absorption or removal of an equivalent amount of CO_2.

End-use applications: where and how the final biochar product is stored or used. The produced biochar can either be stored in soil as an amendment, stored in other materials such as building materials (asphalt, concrete), or used in waste management (Wang et al. 2019) and filtration.

Feedstock: fuel for a pyrolyzer; eligible feedstock may include biomass generated through forestry activities, agricultural waste, urban food waste, etc. Each methodology specifies the eligible source of feedstock, since it significantly influences the total environmental impact of the process. In most cases, feedstock should be sourced from organic waste.

Gasification: a thermochemical process that converts biomass feedstocks into a gaseous mixture primarily composed of carbon monoxide (CO), hydrogen (H_2), and methane (CH_4), along with other trace gases. During gasification, biomass undergoes several chemical reactions, including pyrolysis. In the context of biochar production, gasification can be employed as a means to produce both syngas for energy purposes and biochar as a valuable co-product.

Permanence: the long-term stability or durability of biochar carbon in soil or other storage environments.

Production facility: technology used to convert the biomass into biochar. Each methodology has unique requirements for the production technology used.

Project developers: an individual, organization, or company responsible for planning, coordinating, and implementing biochar-related initiatives or projects, often in the context of carbon removal and certification.

Syngas: short for synthesis gas, can be combusted and used as fuel.

Voluntary carbon market: regulated or compliance carbon markets are trading mechanisms created by national or regional jurisdiction to meet their climate objectives under international treaty (e.g. Kyoto Protocol and then Paris Agreement) and requires carbon intensive sectors to reduce their GHG emissions or buy carbon reduction units. The voluntary carbon market (referred to as VCM) emerged in parallel and offers sectors without obligation to reduce their emissions with the possibility to voluntarily offset their emissions through the purchase and cancellation of emission reduction units from project activities (e.g. biochar carbon credits).

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Additional Note

Carbon Standards International and the International Biochar Initiative announced a new partnership in 2024 to create stronger standards and certifications to meet the needs of a rapidly scaling biochar industry. As the core part of this partnership, the IBI Biochar Standard – the industry's first material standard – merged with CSI's World Biochar Certificate. In disclosing this business relationship as a co-author of this manual, IBI is not endorsing or recommending any particular biochar carbon sequestration methodology.

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HAMERKOP
CLIMATE CHANGE & FINANCE

Founded in 2018 in the UK, HAMERKOP specializes in climate and carbon finance (covering energy, forestry, and agriculture), aiming to maximize social and environmental impacts.

Operating mainly in developing countries, HAMERKOP offers its technical expertise based on three pillars:

- **Project:** supporting the certification and implementation of climate mitigation activities, including biochar, supported by the carbon markets, and impact assessment.
- **Market:** advising on carbon market strategies, asset transactions, fundraising, and legislation.
- **Policy:** supporting Global South countries in developing and implementing climate strategies and evaluating programmes for climate finance.

Based in the UK and Singapore, HAMERKOP has completed over 100 assignments in 45+ countries, working with governments, international organizations, NGOs, and private companies. Their extensive carbon market knowledge makes them an independent and trusted technical partner for NGOs and the private sector.

hamerkop.co

International Biochar Initiative

Founded in 2006, the International Biochar Initiative (IBI) provides a platform for fostering stakeholder collaboration, good industry practices, and environmental and ethical standards to support biochar systems that are safe and economically viable.

As the global network for a rapidly-scaling biochar industry, IBI supports its 600+ members across 70 countries through networking, education, and demonstration initiatives.

biochar-international.org