Sinkit

Biochar explainer

April 2023

What is biochar?

Introduction

Biochar is a carbon rich, charcoal like material produced from biomass. It's been used for thousands of years as a soil conditioner and is now re-emerging as a useful material for environmental remediation and carbon storage.

Production

Biochar is produced by thermally decomposing biomass in a low-oxygen environment. This process, known as pyrolysis, converts the carbon stored in materials to a stable form resistant to degradation. Pyrolysis is flexible as it can be used to treat a wide variety of feedstocks using machinery of various scales; from very simple backyard kilns to complex industrial facilities. It does however require a dry feedstock, meaning moisture levels must be reduced under 20% for efficient conversion.

Feedstocks

Biochar can be produced from any organic biomass source. Wood residues and similar lignocellulosic feedstocks are preferred due to their relatively high carbon and low ash content, which yield a better product with desirable physio-chemical properties. In general, the input and output quality are closely correlated.

Characterization

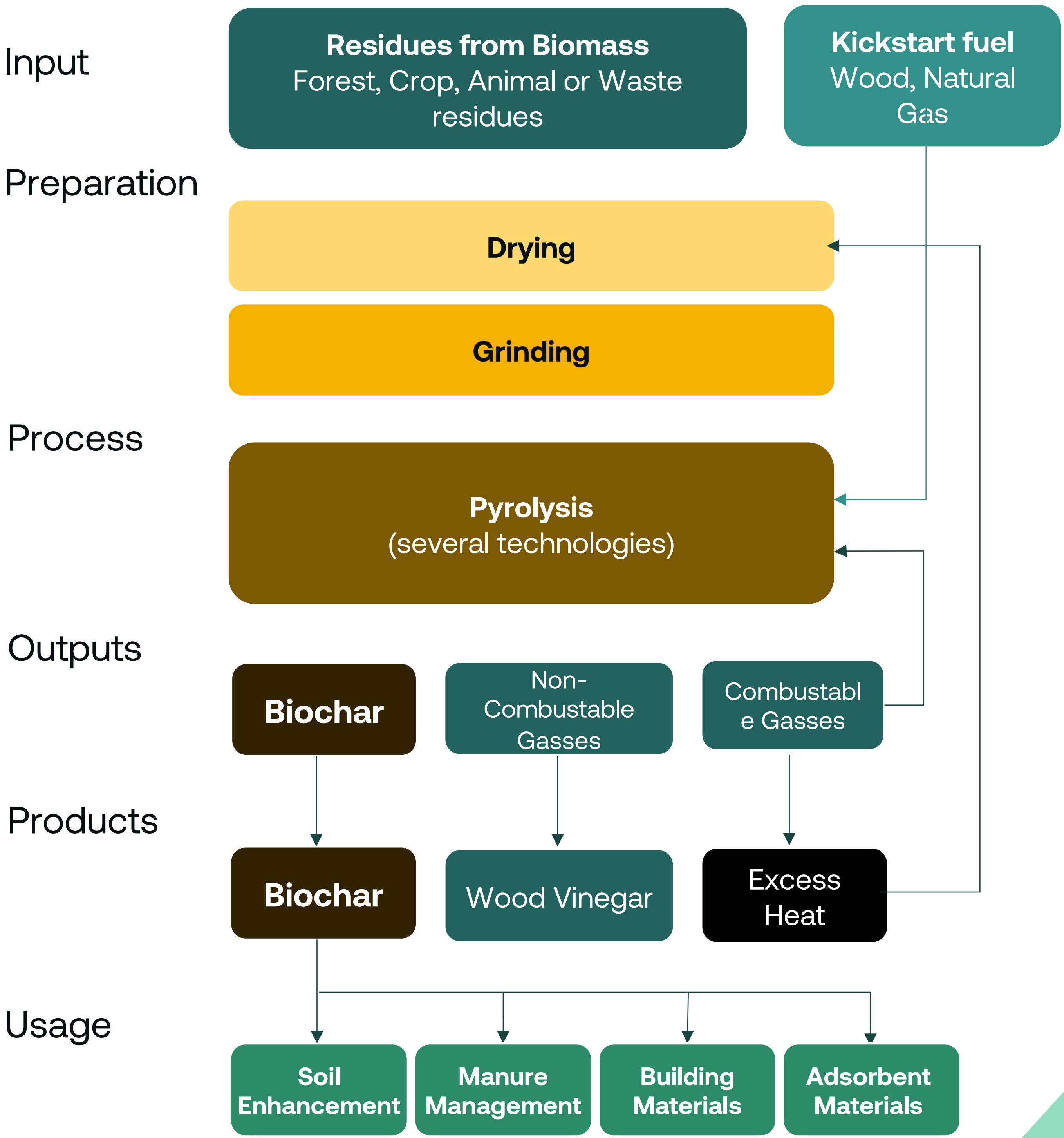
Not all biochar is created equal. The feedstock type and production parameters including temperature and reaction duration are all critical parameters which influence product properties. Longer reaction times and higher temperatures remove more impurities and promote the formation of more complex surface morphologies with a higher porosity and larger surface area.

Benefits

- **Improved soil quality:** In agriculture, biochar can help restore degraded soils by improving both biotic and abiotic characteristics. Adding it to soils at rates as low as 1 ton per hectare can help stimulate the soil microbiome and increase cation exchange capacity while retaining both water and valuable nutrients.
- **Carbon Storage:** High quality biochar is composed of aromatic carbon structures that are recalcitrant to microbial decomposition, meaning the stored carbon won't be released back in the atmosphere. This can be measured through the H:C ratio, where lower values correspond to increased stability.
- **Reduced fertilizer dependence**: Biochar contains many macro/micro-nutrients that become available to plants upon soil application. Its high porosity and surface area promote adsorption and therefore minimize nutrient loss after fertilizer application. While biochar cannot replace fertilizers, it can act as a powerful co-product to increase use efficiency.
- **Activation potential:** Biochar can be further refined into activated carbon for higher value industrial applications including flue gas scrubbing or catalyst supports.

Fibre Waste Biochar

Production process



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Biochar Carbon Removal (BCR)

The Shift

Agricultural crops store around 30 Gt of carbon per year - all of which is re-released into the atmosphere when decomposed within the various cycles of life. By turning the carbon from organic waste residues into stable biochar, short cyclic carbon is moved into the long cycle where carbon will remain out of the atmosphere for hundreds to thousands of years depending on its application.

With the growing need for durable carbon dioxide removal, biochar production has been identified as one of the most promising and scalable methods. Widespread recognition by the scientific community coupled with certification labels and the emergence of methodologies from carbon credit issuing platforms has opened the way for biochar projects of various scales around the world. Previously unsuccessful business models surrounding biochar production are becoming viable partially due to the supplementation by carbon credits.

Technological Readiness

Biochar is a mature product that has been used for millennia in the agricultural setting. Today, its additional use for large scale carbon removal is mainly limited by feedstock availability, supply chain uncertainties, processing costs, and/or underdeveloped policies and regulations. Still, additional research is needed to optimize pyrolysis parameters, better monitor carbon removal permanence per application type, and to understand various co-benefits from its application in different products or soil types.

Scale and Costs

The potential and cost of using biochar at large scale remain unclear. A literature review of 20 academic papers reporting on the global potential of BCR display removal estimates ranging between 0.1 - 1.3 $GtCO_2$ per year with an average removal of 0.51 $GtCO_2$.

The price per ton of carbon associated with BCR also has a wide range with estimates between $10 to $500 per ton CO_2. However, key European industry experts and current large scale biochar producers report biochar sales in the range of $200-700 per ton, indicating that credit sales can substantially add to production viability. Biochar price is largely determined by output quality, application type, feedstock costs, and the region of production and sales.

Typical biochar technology options and volumes

Type	Stoves (Small)	Batch Kiln (Medium)	Continuous Reactors (Large)	Industrial (Very Large)
Annual production capacity	**100-200 t**	**200 – 1.000 t**	**1.000-5.000 t**	**5.000+ t**

Increasing costs, complexity, volumes, quality, and lifespan

Minimize Flue Gas Emissions

Biochar market in Europe

Market Growth in Europe

Biochar is easier to scale rapidly than other permanent CDR technologies given its mature production process. In the last decade, we have witnessed an accelerated deployment of facilities in Europe. The European Biochar Industry reports 51 projects under construction or under contract for 2023 commissioning.

Market Geolocation

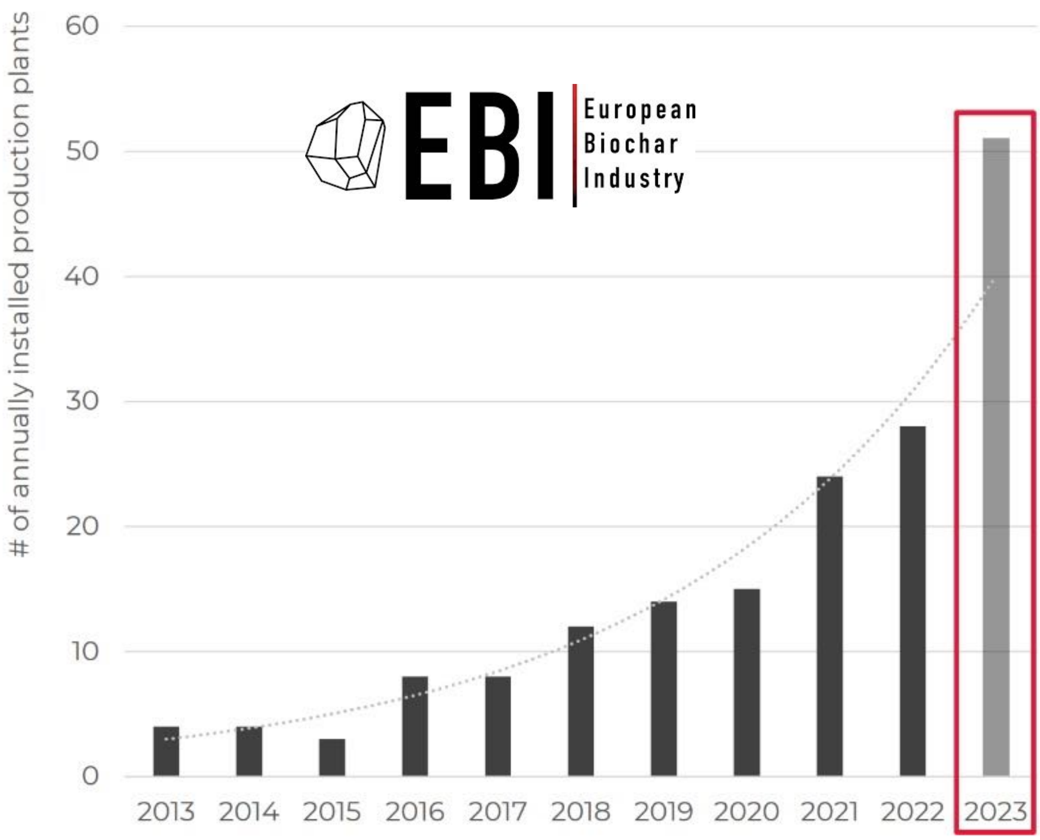
About three quarters of European production is shared between Germany, the Nordics, Austria & Switzerland. For countries like France, Italy, Belgium, the Netherlands, and eastern European countries, there are major growth opportunities.

Future Market Opportunities

Biochar production also yields valuable coproducts. At the industrial scale, excess process heat can be used in local heating networks or for renewable electricity. As we shift towards renewable energy generation, pyrolysis heat can supplement this transition.

Growth projection 2023

In 2023, the cumulative biochar production capacity is expected to grow to over 90.000 tons from the current amount of 53.000 tons supplied in 2022, equivalent to a 70% growth rate in the last year. Annually installed Biochar production plants in Europe have been recorded by the EBI over the last decade as can be seen in the figure below.



BCR Credits

Certifications systems

With the resurgence of biochar production, certifications and associated methodologies gain importance to ensure production quality. According to the 2023 EBI Market Report, biochar certification will rise to 70% of the total supply compared to just 50% in 2018.

Among the current certification labels, the most widespread and recognized continues to be the European Biochar Certificate (EBC). Through independent certification, customers are guaranteed a quality product with transparent carbon accounting.

EBC roadmap for calculation of net carbon sequestered

I. Determine carbon content of biochar in percentage of weight on dry matter basis.

II. Determine all GHG emissions caused by production and processing of biomass per batch

III. Transform all GHG emissions per batch recorded in previous step to CO2 equivalent

IV. Determine 'carbon expenditure' by multiplying CO_2 equivalent with 0.2727 (ratio of the atomic mass of carbon and the molecular mass of CO_2). The carbon expenditure amount indicates the carbon costs, i.e. the amount of carbon emitted to produce the batch of biochar.

V. Express carbon expenditure as a percentage of dry weight of the total amount of biochar produced per batch.

VI. The carbon expenditure percentage of weight can now be subtracted from the carbon content percentage to come to actual carbon sink potential of specific batch.

Key Considerations

Production

Biomass availability

Given the seasonal nature of biomass availability, supply chain management and processing flexibility is of key importance. Storing residues could ensure year-round feedstock availability, or pyrolysis plants could operate seasonally depending on the operation.

Drying

Biomass has a high moisture content that needs to be reduced below 20% for the pyrolysis process. On-site dewatering or heat recycling within the pyrolysis process should be integrated to minimize energy requirements for feedstock preparation.

Technologies

Pyrolysis can be performed using many technologies with various complexities. Larger scale operations should include drying integration and complete flue gas combustion. Smaller scale or modular reactors may be more decentralized and flexible but with less capacity and higher emissions per production unit.

Parameters

Temperature and residence time present a trade-off between maximum biochar yield or product stability and can be tuned accordingly. The generation of condensable and non-condensable (combustible) gasses will be produced in various fractions and can also be collected separately.

Unwanted substances

Heavy metals may accumulate within biochar if a feedstock contains high metal concentrations. Additionally, toxic and persistent polycyclic aromatic hydrocarbons (PAH's) may be formed if there is incomplete combustion within the pyrolizer, which should be carefully monitored and regularly evaluated.

Use

Location

Biochar should ideally be used as close to the source of production as possible. Additionally, soil benefits and positive effects on productivity will be lower in temperate climates compared to tropical climates. European applications may therefore be better suited for higher end uses.

Storage

Biochar, especially when grinded for increased surface area, is combustible and should be stored and transported with care.

Application

Application rates have been studied between 0.5 and 80 tons applies per hectare with various results. European soils need significantly higher loading rates compared to tropical soils for similar increases in crop productivity, while use for wastewater treatment requires similar volumes.

Monitoring

In addition to calculating the total carbon footprint of production, carbon storage must also be monitored for leakage post application to ensure carbon reduction claims are upheld.

Governance

- **Encouraging adoption**: good agricultural extension efforts and incentives are needed to encourage widespread adoption, especially on small farms.
- **Monitoring, verification, and reporting**: processes, standards, and technologies need to be developed to reliably measure carbon sequestration.
- **Sustainable biochar production**: policies would be needed to promote and ensure that biomass is sourced and processed sustainably.

Project options

Tropical, Sub-Tropical, and Sub-Saharan Areas

Feedstocks

Typical feedstocks suitable for biochar production in countries such as Uganda or India will likely come from crop residues. Common sources include cassava, maize, sorghum, coffee, cacao, groundnuts, rice, and millet which constitute most farming output and thus have high volumes of residues.

Processing

Biochar production can be implemented alongside the wide array of smallholder farms which account for an estimated 80% of food production in this part of the world. This calls for many small-medium scale pyrolyzers capable of processing feedstock from local operations compared to the large-scale centralized facilities needed for the European context. The costs of individual units, maintenance requirements, and the distances to areas where the biochar will be used must be considered when evaluating potential projects and applications.

Applications

Agriculture

Biochar is most suitable for agricultural applications due to the expansive agrarian economies found in many of these regions.

Studies undertaken in Uganda found significant improvements in soil bulk density, porosity, and water retention. Other studies highlight the importance of increasing the alkalinity of acidic soils which dominate similar regions, while stimulating microbial activity and increasing the cation exchange capacity.

In this way, biochar can help in restoring marginalized lands, increasing, crop productivity, and minimizing water and fertilizer uses –all with application rates that are a magnitude of 10x lower than that in European soils. This means that farmers can derive great value from processing their feedstocks into biochar.

However, introducing new technology and changing the ways in which traditional farmers operate is no easy task and may require significant time in the building of trust and relationships.

Water Treatment

Biochar can also be utilized as a sorbent for contaminants to filter out various organic and inorganic impurities from water. Small to intermediate scale systems could be used in developing areas as an alternative or supplement to current practices.

Project options

The Netherlands and Greater Europe

Feedstocks

Waste residues in Europe are relatively well managed, although there is still much room for improvement. In countries with a larger timber industry, wood residues could be obtained from refused fractions and waste scraps which typically make up 25-50% of processed volumes. In agriculturally dominated regions, crop residues with large lignin or hemicellulose components may be utilized as they are indigestible to humans and are more difficult to break down biologically. Other feedstocks such as dewatered manure from farms, or pulp and papermill sludge from wastewater treatment may provide interesting alternative options as feedstocks for processing.

Processing

Biochar can be produced via pyrolysis, gasification, or hydrothermal carbonization. Each of these methods can be implemented on a per-project basis to best suit the feedstock type and desirable output. Drying integration using process heat and flue gas combustion should be implemented as part of these systems to minimize process emissions. Residual heat may also be produced and could be utilized for nearby industrial applications. Postprocessing of biochar may also be considered to produce activated carbon or specialised adsorption materials for the chemical industry.

Applications

Soil improvement

Biochar can be directly added to soils by farmers to increase organic carbon content, reduce ammonia leaching, and promote microbial activity.

Manure Management

Biochar can be added to dry manure stockpiles as a management strategy to reduce methane emissions, minimize nitrogen loss, eliminate odours, and speed up processing times. This can be seen as an added value step prior to soil application.

Built environment

Biochar can be added to a range of materials including concrete or plaster and has the potential to replace various fillers/polymers in composite manufacturing.

Chemical Industry

Biochar has a high surface area that can be exploited for its adsorption capabilities, particularly when upgraded into activated carbon. It can be used to scrub industrial flue gas emissions, adsorb harmful and/or persistent chemicals from solutions, or retain heavy metals from various sources.

Water treatment

The same adsorption capabilities can be used within the treatment of wastewater to remove a spectrum of organic, inorganic, and microbial contaminants from process waters.

Biogas Production

Biochar can be added into existing anaerobic digestion plants to stimulate methanogenic bacteria and regulate pH. Studies show biochar integration with biogas production can significantly increase biogas yields.

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Carbon Removal Cooperative

Sinkit is a carbon removal accelerator. We are a cooperative with experienced employees with a proven track record in carbon technology, project management and marketing & communication.

Carbon removal & storage is a new and growing market. Technologies, policies, frameworks, and markets are all in development.

Sinkit works with various stakeholders to create more awareness and action within the carbon removal market. We work with multiple technology providers to accelerate and execute carbon removal projects.

We have a cooperative approach in which everyone can participate and invest. The profits will be shared among our members and other stakeholders.

We currently have three concrete projects in our portfolio and are in touch with multiple organizations to accelerate carbon removal solutions.

Sinkit launched in early **2023**.
Are you ready to sink it?

Projects

At Sinkit we see a huge untapped potential in turning waste residues into long term carbon sinks through biochar production. That is why we set out to support upcoming biochar projects and are launching several projects of our own.

Coffee Husks – Uganda 2023

Working with coffee farmers in Uganda to convert the waste stream from Robusta coffee beans into char. Here we hope to improve local soil and enable farmers to earn additional income while fixing carbon.

Sargassum Seaweed – Caribbean 2024

By turning readily available Sargassum into biochar, we ensure carbon is permanently locked away, while preserving sensitive nearshore ecosystems and local community functioning in the Dominican Republic.

Wood Residues – Netherlands 2024

Engaging with municipalities to collect residual wood waste from regular land maintenance and produce biochar for urban applications.

Sinkit has the mission to initiate and accelerate carbon removal and storage projects and deliver **55** projects by 2030.

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More information?
Questions?

www.sinkit.org
info@sinkit.org