



THE INVESTMENT CASE FOR BIOCHAR:

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A JOURNEY TOWARDS ENHANCED
SUSTAINABILITY & NET-ZERO EMISSIONS

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INTRODUCTION

Biochar is a traditional material that has been used for thousands of years. Due to its ability to store carbon and to contribute to mitigate climate change it has been recently rediscovered and it is gaining growing interest worldwide.

Biochar is increasingly seen as a promising investment for organisations to attain their net-zero commitments. The Intergovernmental Panel on Climate Change (IPCC) (1), Project Drawdown (2), The Royal Society (3) and The Exponential Roadmap Initiative (4) all consider biochar as a means to reach net-zero emissions.

Moreover, companies like Microsoft and Shopify are investing in biochar carbon credits to compensate their carbon emissions (5) (6). And, in June 2021, Nasdaq became a majority investor in Puro.earth, a market platform that sells carbon credits from engineered carbon removal methods, including biochar (7).

For other organisations biochar represents a solution to their biomass disposal and a means to enhance the sustainability and circularity of their operations. For instance, Suez Group and Airex Energy have formed a partnership this year, by which Suez will use the CarbonFX™ torrefaction technology developed by Airex Energy for the global deployment of industrial-scale production plants that transform biomass residues into biochar (8).

Furthermore, Germany's Tierpark in Berlin, one of the largest landscaped animal gardens in Europe, is running a project supported by the European Commission, which invests in biochar technology to improve the zoo's CO2 footprint of the zoo's waste management system (9). Other municipalities in Europe, like Lund in Sweden, are investing in biochar projects as part of their organic waste management system, and utilising the biochar produced as a soil amendment material for the municipality's trees and landscaped areas.

Biochar is a nascent industry that looks very promising from the point of view of advancing towards a net-zero global economy and for enhancing organisations' waste management systems and their circular and sustainable practices. It also presents ample opportunities to invest in R&D of new product uses and applications catered to different industries.

In this report we develop a deeper understanding of the biochar business case and explore different opportunities and approaches to invest sustainably in biochar. The methodology utilised is based on research and analysis of industry news and reports, on personal interviews with industry experts and on our elaboration of industry insights and main conclusions.

WHAT DO WE UNDERSTAND BY BIOCHAR?

Biochar is a stable, carbon-rich solid material that is primarily used as a natural soil amendment, while other uses are proliferating in construction materials, water filtration, food additives for livestock, odor absorbent, etc.

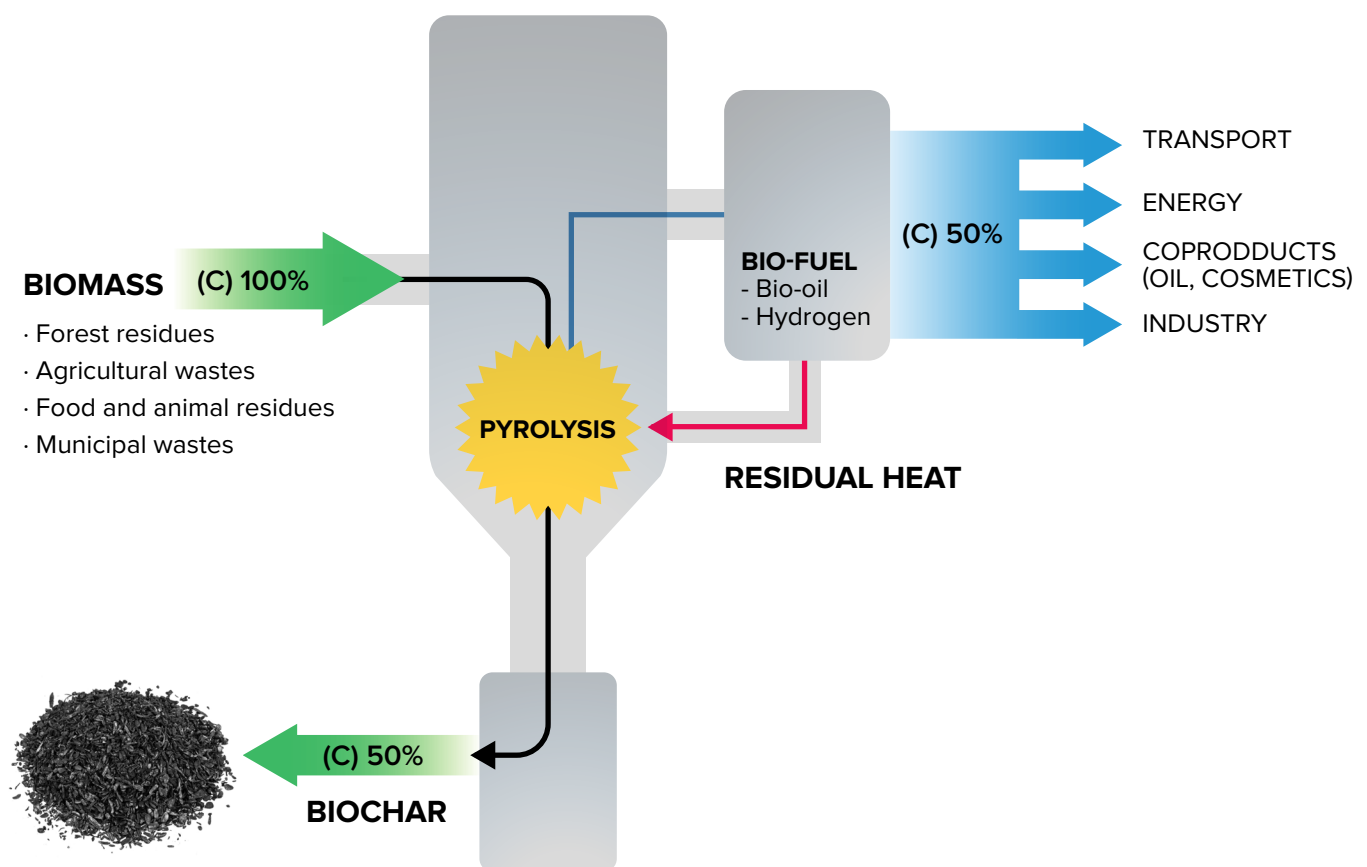
It is generally produced through a process called pyrolysis which performs the thermal decomposition of biomass under limited supply of oxygen. The result is a biochar that contains more than 65% of carbon, depending on the feedstock and on pyrolysis conditions.

The biomass utilised as feedstock includes forest residues, agricultural waste, food and animal residues or municipal waste.

Biochar is found naturally in soils around the world as a result of vegetation fires (10). It has also been used to improve soil fertility for thousands of years in the Brazilian Amazon, where it has been found in a dark nutrient rich soil called “terra preta”, which is different from nearby soils that have a lighter colour and lower carbon content and fertility.

Chart 01:

Biochar production diagram.



Source: International Biochar Initiative, Johannes Lehmann and Valoral Advisors.

THE EVOLUTION OF BIOCHAR IN RECENT YEARS

This technology has recently reappeared and is being rediscovered. It is gaining increasing interest and attention as biochar production is a means to capture carbon dioxide from the atmosphere and store it in the char, contributing to mitigate climate change.

Biochar is currently produced in an environmentally friendly and closed loop system, compared to traditional production methods that released smoke and carbon dioxide to the atmosphere.

The biomass used to produce biochar has a large carbon content that has been captured and stored in plants and trees through photosynthesis, and if they were left to decay and decompose naturally, in some years this carbon would return to the atmosphere through the natural carbon cycle.

However, when this biomass is converted into biochar via pyrolysis, around 50% of the original carbon in the biomass can be captured and stored in the char for hundreds of years. This is possible because biochar is highly resistant to decay, becoming effectively a long-lasting carbon sink from a climate perspective.

For this reason, biochar production is considered a negative emission technology ("NET"), which refers to the removal of carbon dioxide from the atmosphere and its storage in a permanent, long-term basis, in this case in the char (11).

It is important to note that for biochar to be carbon negative the whole biochar production process -from feedstock supply, to production, commercialisation, and distribution - must be sustainable and attain a lower carbon footprint than the carbon content that has been captured in the char.

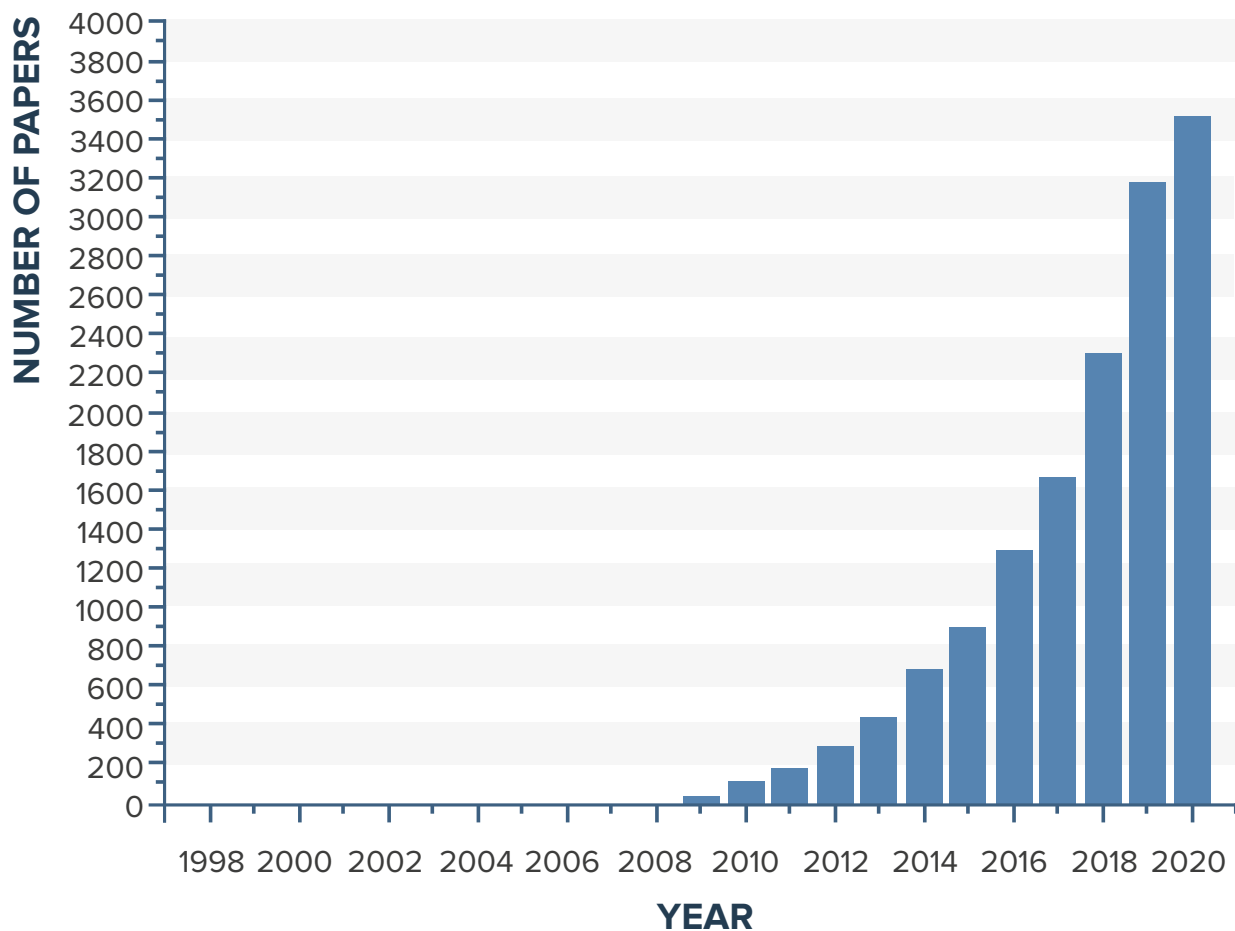
The good news is that the production of biochar has recently been included as a promising negative emission technology (NET) in the Intergovernmental Panel on Climate Change (IPCC) special report published on 8th October 2018 (1). Because of this, it can be expected that there will be more funding directed by the EU to biochar R&D, as the EU needs to channel funds to research in negative emission technologies as part of its commitment with the Paris Agreement.

In this context, during the last decade there has been a large increase in the appearance of the biochar topic in scientific papers and reports, which confirms the growing interest in biochar and its potential impact on helping to slow climate change and on its capacity to restore degraded soils.

Figure 1 below shows how the number of scientific papers containing the word biochar has increased from less than 50 in 2000 to more than 3500 papers in 2020 (12).

Figure 1:

Number of scientific papers published that contain the word biochar.

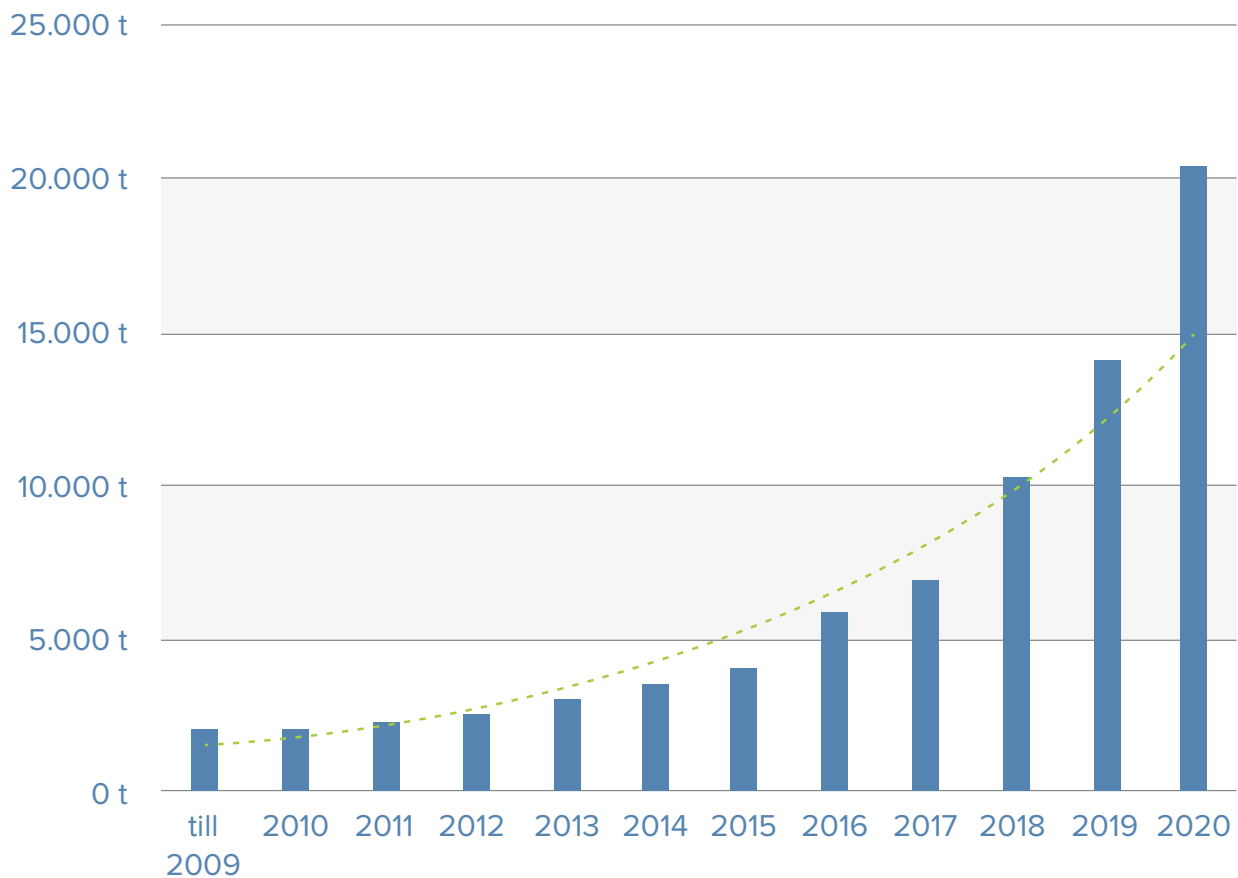


Source: Conte, P.; Bertani, R.; Sgarbossa, P.; Bambina, P.; Schmidt, H.-P.; Raga, R.; Lo Papa, G.; Chillura Martino, D.F.; Lo Meo, P. Recent Developments in Understanding Biochar Physical-Chemistry. Agronomy 2021, 11, 615.
<https://doi.org/10.3390/agronomy11040615>.

At the same time, an analysis from The European Biochar Industry Consortium illustrated in Figure 2 shows a spectacular growth of biochar production capacity in Europe in the last decade. By the end of 2020, the biochar production capacity in Europe reached over 20.000 metric tons, growing fourfold from less than 5.000 metric tons in 2015, and doubling from 2018 to 2020.

Figure 02:

Cumulative biochar production capacity in Europe (Metric Tons).



Source: European Biochar Industry Consortium, February 2021. European Biochar Market Report 2020. Retrieved from: https://www.biochar-industry.com/wp-content/uploads/2021/02/Market-Overview_public_2021-02-17_V1.01.pdf

According to The European Biochar Industry Consortium, four European countries - Germany, Sweden, Switzerland and Austria - concentrate 69% of European biochar production (13). This shows that there is vast space to continue growing and expanding biochar production capacity in other countries in Europe and around the world.

BIOCHAR REVENUE STREAMS

The production of biochar offers four main revenue streams:

- First, from the biochar product itself which can have different uses and applications;
- Second, from bio-oil and heat - which are two additional outputs from biochar production -. The heat is normally used in pyrolysis of biochar with the purpose of maintaining a closed loop system, while the bio-oil is generally sold as an additional product.
- A third possible revenue source would come from the lower cost of biomass supply, due to savings made from the reduced cost of biomass disposal.
- And finally, the fourth revenue stream comes from the carbon credits that account for the carbon captured and stored in the char.

To sell carbon credits from biochar, the producer needs to show that the production of biochar is absorbing more carbon dioxide than what it is generating, so it needs to have high traceability standards and present relevant evidence.

For instance, Puro.earth demands its suppliers to present a Lifecycle Assessment (LCA) or Environmental Product Declaration (EPD) to demonstrate that the product has absorbed more CO₂ that it has emitted. In addition to that, if the producer is sourcing forestry biomass as feedstock, this biomass needs to be certified by the Forest Stewardship Council (FSC) to ensure it is sustainable.

It is also desirable that biochar companies have a sustainability certification, like, the European Biochar Certificate (EBC), which guarantees sustainable biochar production process. All these standards and processes are key to ensure the credibility of the carbon credits and the sustainability of the companies' operations.



The biochar product itself offers the possibility to be used in several different products and applications as can be observed in the following table.

Table 01:

Biochar uses and applications.

| BIOCHAR USE | DESCRIPTION |
|---|---|
| SOIL IMPROVEMENT | <p>The use of biochar as soil amendment presents several benefits: it increases soil's water holding capacity and nutrient retention, improves soil aeration and drainage, increases microbial activity, and enhances carbon sequestration in the soil.</p> <p>It is currently the most used form of biochar, and it is generally applied to the following activities:</p> <ul style="list-style-type: none">— Forestry.— Traditional agriculture, organic agriculture & horticulture.— Gardening and landscaping of private gardens and of green spaces and trees in cities.— Green-waste composting. |
| FEED ADDITIVES FOR LIVESTOCK | <p>The addition of biochar to animal feed may have several potential benefits, like improved digestion, increased immunity, and reduced methane production.</p> |
| OTHER USES FOR LIVESTOCK | <p>Biochar is also used for stable bedding and litter amendment, slurry treatment, smells absorption, etc.</p> |
| CONSTRUCTION MATERIALS | <p>Companies are exploring biochar use in building façades and its addition to concrete and to road materials.</p> |
| WATER FILTRATION | <p>Biochar removes impurities from water and can be used in water filtration.</p> |
| DECONTAMINATION | <p>Biochar can be used for water and sewage treatment.</p> |
| OTHER POSSIBLE USES | <p>Companies are also exploring other biochar uses, such as:</p> <ul style="list-style-type: none">— Cosmetics industry.— Graphite and graphene.— 3D printing and electronic devices.— Football fields, to strengthen natural grass and increase the use of natural grass fields. |
| PERSONALISED OR DESIGNER BIOCHAR | <p>Biochar can be designed to fit different end-uses according to specific client needs.</p> |

Source: Valoral Advisors

While biochar is currently used predominantly as soil amendment, there are multiple uses that are being developed and that will stimulate market growth. Investments in R&D will be very helpful to continue developing new biochar products tailored to different industries like cosmetics, apparel, construction, etc.

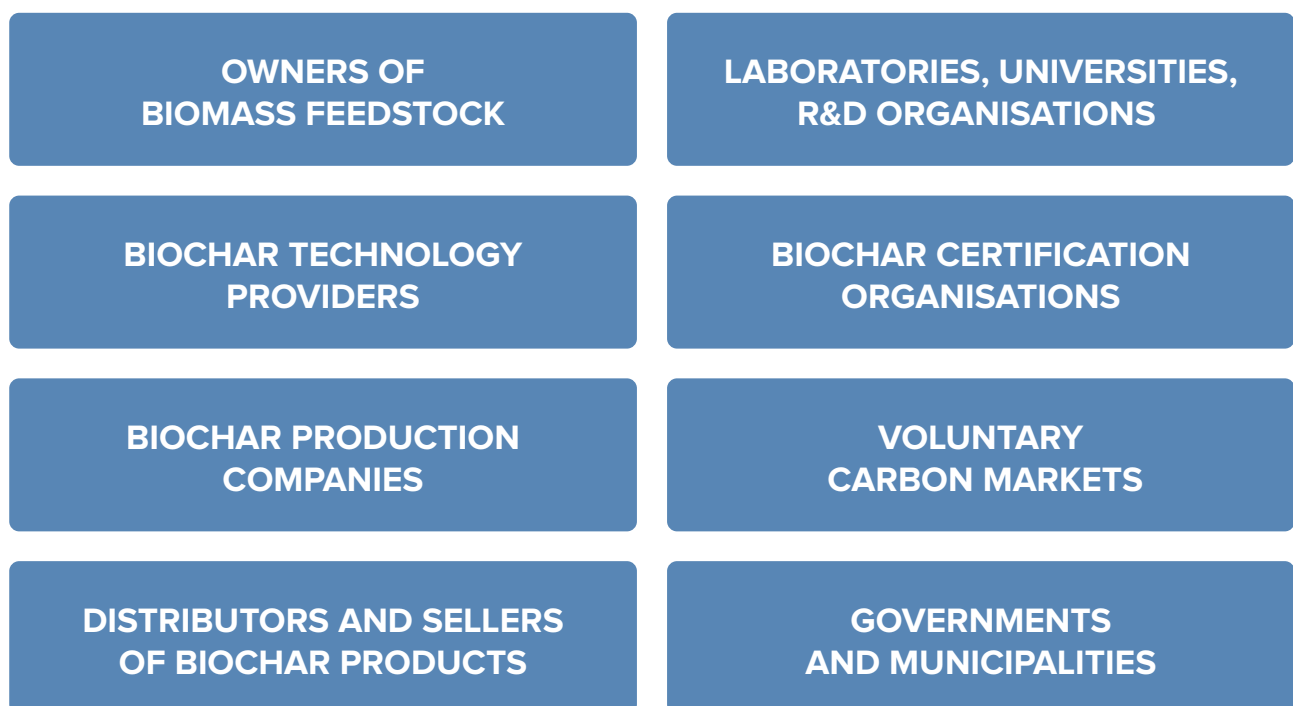
It is especially important to understand that there is not one biochar but many different biochar with varied characteristics which makes it more suitable for different uses. The combination of different types of biomass and different biochar technologies leads to a product with distinct attributes. This brings the possibility to innovate and produce a more personalised biochar, designed for specific end-uses.

BIOCHAR INDUSTRY PARTICIPANTS

The biochar industry combines a wide array of companies and organisations that make biochar production possible and that provide diverse investment possibilities for investors interested in this industry.

Figure 03:

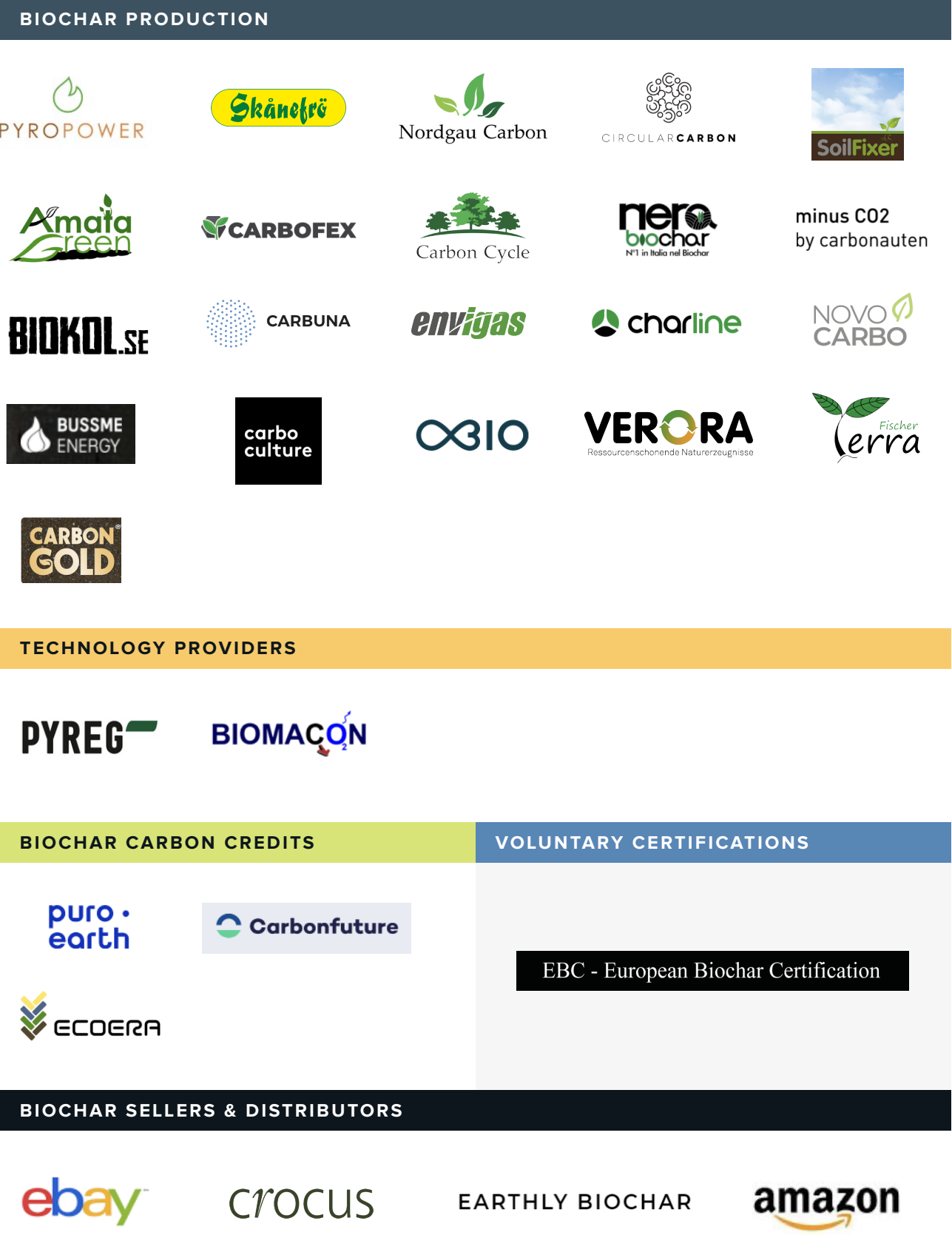
Categorisation of biochar industry participants.



Source: Valoral Advisors

The following figure provides a preliminary, non-exhaustive view of the biochar ecosystem in Europe, with companies that are currently most active in this space.

Figure 04:
Illustration of main biochar companies and industry participants in Europe.



Source: Valoral Advisors

MAIN CHALLENGES FACED BY THE BIOCHAR INDUSTRY

Although the biochar industry is gaining attention and interest and has sizable potential to develop and grow, it is still a nascent industry that faces several challenges. The industry needs to gain maturity in terms of regulations, knowledge and education, technological advancement, cost of biochar production technology and scale, and the development of markets and commercialisation.

The development of a supportive policy framework regarding biochar production and consumption as well as policy that includes financial rewards for greenhouse gas removal from the atmosphere will be very helpful for the biochar industry to grow (14).

For instance, Sweden has a highly developed biochar industry compared to other European countries, which has indirectly benefited from the Swedish carbon tax adoption since 1991 (15). This tax follows the 'polluters pay' principle, and it has been proved rather successful as Sweden's greenhouse gas emissions have fallen by 26% since the introduction of the carbon tax (16). Moreover, Sweden is considering the implementation of a reverse carbon tax for negative emissions that could prove positive for the evolution of biochar investments (17).

Likewise, the growth of voluntary carbon markets and the expected increase in carbon price may further promote the biochar industry. This goes hand in hand with the need to increase biochar educational efforts and the awareness of biochar's beneficial properties to make biochar better known among investors, corporates and other organisations, and be increasingly considered an investment option to attain net-zero targets.

The biochar industry may also profit from innovation in the development of improved sustainable biochar production technologies, especially for medium-scale pyrolysis operations, as well as portable, small to medium-scale pyrolysis technology, to make its use more widespread.

A further challenge relates to the development of distribution channels for biochar. Online sales of biochar are growing, especially for biochar products for retail consumers (e.g. gardening products). Going forward, it is expected that new traders and distributors of biochar will emerge in some of the main geographical markets.

Here again, the role that education plays among traders, distributors and end-users, and the knowledge and clarity of biochar's attributes and benefits are key to the development of commercial markets and the increase in demand by end-users, including farmers, gardeners, municipalities, among others.

BIOCHAR INDUSTRY INVESTMENT OPPORTUNITIES

The biochar industry is young and has great potential to develop and grow, due to its environmental benefits and to its contribution to mitigate climate change. Investors with interest in this sector can explore four alternative ways to invest in this industry:

1. Investments in biochar technology: Investors can pursue opportunities in new technologies and equipment used to manufacture biochar.

- **Rationale:** Given the expected growth in this sector, more biochar plants will be built in the coming decade which will require a significant scale up in technology and equipment manufacturing. Moreover, we can expect new technological innovations that may improve the process and allow the production of more specialised types of biochar tailored to specific applications.
- **Available opportunities:** We see opportunities in the venture capital space, as a new wave of biochar technology companies emerge, mostly across Europe.
- **Key value drivers:** An investment in emerging technology can be risky but entails a higher potential reward if the innovations developed can be scaled up in the market.

2. Investments in biochar manufacturing: Investors can pursue opportunities in the setup and operation of biochar manufacturing plants.

- **Rationale:** The market outlook for biochar is very promising and we expect production volumes and demand to grow in the coming decade. The existing production capacity may have to increase significantly, which brings opportunities for investors who want to invest in manufacturing platforms to gain scale in certain geographies.
- **Available opportunities:** We see Private Equity style opportunities either as a greenfield investment or through an investment in an existing manufacturer. There is an emerging field of “pre-credits” being developed to finance biochar production facilities upfront through the sale of carbon removal rights. This kind of financing may be combined with traditional equity and debt funding. In all cases, securing competitive raw material, achieving the right scale, and having a solid go-to-market strategy is critical.
- **Key value drivers:** Value from an investment in biochar manufacturing is likely to be driven by the scale, cost competitiveness and a solid commercialisation strategy.

3. Investments in integrated biochar supply chains: Alternatively, investors can focus on participating in integrated biochar supply chain models, which offer other value drivers.

- **Rationale:** As discussed throughout this report, biomass suppliers play a significant role in the biochar market, as they can be relevant stakeholders in the development of biochar manufacturing assets. From forestry companies, through horticultural companies to local municipalities, these biomass suppliers can have an interest to partner with biochar operators and investors to integrate their biomass resources into the biochar supply chain. In some cases, even a closed loop system can be developed, in which the same biomass suppliers use the biochar end product within their operations.
- **Available opportunities:** We see Private Equity style opportunities through the setup of joint ventures with relevant stakeholders.
- **Key value drivers:** The main value driver in this opportunity is based on the strategic value that each partner is bringing to the business in the form of biomass supply, manufacturing capabilities, or a secured market for the production.

4. Investments in biochar applications: Investors can pursue opportunities in the design, engineering, and manufacturing of biochar applications:

- **Rationale:** It can be expected that the range of applications for biochar will expand considerably in the coming years, as industry players explore new potential uses of biochar in different sectors and industries. There may be an opportunity to invest in the development of these new applications.
- **Available opportunities:** We see opportunities in the venture capital space, as entrepreneurs launch new applications and look to scale up them in the market.
- **Key value drivers:** Innovation is the key value driver. Those new applications which can be competitive vis a vis existing solutions or materials and can find traction in the market, have a potential to grow significantly.

While this set of opportunities is already broad, we expect that as more investors and companies commit to transition to a net zero future to tackle climate change, the range of investment opportunities around biochar will expand in multiple ways.

CONCLUDING REMARKS

From our previous analysis we can conclude that biochar production is a young and promising industry which presents several positive environmental benefits, such as contributing to climate change mitigation through carbon sequestration, promoting soil improvement, being a source of renewable energy, providing waste management solutions and being a means to environmental remediation.

For all these reasons, in recent years biochar has been rediscovered and is becoming increasingly attractive to different stakeholders: for some organisations as a means to achieve their net-zero targets, while for others as a solution to their biomass disposal and to enhance the sustainability and circularity of their operations.

Although the biochar industry has grown substantially in the last decade, it is still in its infancy and faces several challenges, but at the same time, these challenges present opportunities for the industry to develop and grow.

We foresee the development of new regulations that could promote the industry further, more widespread knowledge and education of biochar's attributes, further development of biochar technology and of novel product applications, and the development of new biochar markets and improved commercialisation.

From an investor's perspective, and for all the reasons previously mentioned, we believe biochar represents an attractive space for venture capital, private equity and impact investors. At present, we highlight four main investment areas which can be considered, and that relate to (i) the development of biochar technology, (ii) biochar manufacturing, (iii) integration of biochar production in supply chains, and (iv) the development of new biochar product applications.

Eventually, the future development of the biochar industry will represent a positive contribution in the pathway to net-zero carbon dioxide (CO₂) emissions by 2050.

We look forward to exploring with you the growing opportunities in biochar investments and more broadly in the global food and agriculture investment space.



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