European Biochar
Market Report 2022 | 2023

March 2023
Outline Introduction

a. Impressions from recent installations
b. Thoughts on Biochar Carbon Removal (BCR)
c. EBI members and activities
Biochar Carbon Removal (BCR) captures carbon, using, and storing it.

Carbon capture transforms biomass into a stable form & tailored to application. The result is carbon storage by use of Biochar.
Biomass to carbon & energy and then?

A conversion of 50% of the carbon is representative for plants optimized on biochar yield, not on energy.
Carbon preserving application

• Emissions avoided: 0,0 t CO$_2$
• Carbon removal: 2,5 – 3,0 t CO$_2$

Metallurgy

• Emissions avoided: 2,5 – 3,0 t CO$_2$
• Carbon removal: 0,0 t CO$_2$

Energy

• Emissions avoided: < 1,0 t CO$_2$
• Carbon removal: 0,0 t CO$_2$ per t of Biochar
The problem is with $\text{CO}_2$

1 t C pure carbon

$= 3.66$ t CO$_2$

C is not a problem

O$_2$ is not a problem

dealing with C is more to the point than dealing with CO$_2$
Tackling the problem at its root means preventing carbon atoms from becoming CO$_2$-molecules.
Carbon contents

30 - 50% C in biomass

4,4% C in exhaust gas

0,01% C in atmosphere

80% C in Biochar
Avoiding combustion prevents dilution of carbon by 10x and up to 4,000x.

Carbonizing biomass instead concentrates carbon up by 2x.
Six highly relevant carbon removal options

1. Afforestation/Reforestation
2. Biochar Carbon Removal (BCR)
3. Build-up of soil organic matter
4. Enhanced Weathering
5. BECCS
6. DACCS
Multiple synergies between different CDR options
Different CDR technologies will have different growth trajectories. Only a portfolio approach can deliver the required amounts of carbon removal.
Broad range of biomass suitable for carbonization
Broad range of applications of Biochar

Urban Applications

Agriculture

- Stable climate (+)
- Animal welfare (+)
- CH₄ (-)
- Process stability (+)
- Gas yield (+)
- Livestock
- Biogas
- Humus formation (+)
- Water holding capacity (+)
- Nutrient buffering (+)
- NO₂-Leaching (-)
- Compost quality (+)
- N₂O (-)
- CH₄ (-)
- NO₃ (-)
- Root growth (+)
- Yield (+)
- Stress Tolerance (+)

Construction materials
EBI Members by type of business

- **Manufacturer of Equipment**, mostly pyrolysis/gasification (25%)
- **Plant Operators** including members that intend to build a plant (33%)
- Members w/o own pyrolysis plant, creating **biochar products** or trading or using them (14%)
- **Service companies**, most of them in the field of consultancy, certification and CO₂-certificates (20%)

Status: 28. Feb 2023
Activities of EBI to support the Biochar industry

**Policy**
Support/initiate adaptation of legal regulations regarding production & usage of biochar

**Market Intelligence**
Provide relevant market information for members and for publications

**Communication**
Increase the level of awareness of biochar and its commercial and environmental benefits

**Industry Standards**
Develop & establish standards for a broad set of applications

*Subject of this report*
Outline Market Report

1. Motivation, scope and methodology
2. Biochar manufacturing equipment
3. European Biochar Market 2022/2023
4. Scaling BCR to climate relevance
European Biochar Market Report
2022/2023

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• The Nordic Biochar Network
• The Equipment Manufactures and Plant Operators for Biochar production
• EBI Policy Working Group
• And many other EBI Members, Biochar experts and stakeholders

12. March 2023
Thanks for sponsoring the Market Report 2022/2023
Carbonfuture

Carbon removal you can trust.

Carbonfuture is your platform for high-quality and impactful carbon removal credits.
South Pole helps clients address climate change impacts, while mitigating risk and creating value on their sustainability journeys.

**Innovative solutions**
An award winning, 17-year history of providing sustainability solutions

**Diverse expertise**
Based in 37 offices and representations globally, our team of +1200 sustainability advisors, scientists, and engineers are leading experts in their fields

**Project developer**
Largest developer of climate action projects globally
Motivation, scope, and methodology
Motivation
Why we created this market report

- High-quality market information is key to take the right decisions (business, investment, regulatory and political decisions)

- Market information in growing industries is difficult to gather and is often outdated; standardized reports from market research firms, are (i) expensive and (ii) have limited relevance and (iii) they often don’t get the complexity

- We want to share the insight that Biochar Carbon Removal (BCR) is a key solution to mitigate climate change, is real today, and is scaling very fast
Scope of the European Biochar Market Report 2022/2023

• We look at Biochar production plants **installed in Europe until 2022** and **installations** that will be **commissioned in 2023**

• We look at carbonized biomass suitable for **application in soils and materials**, that is produced in
  – **dedicated Biochar production** plants as well as in
  – **charcoal production plants** and **plants for production of carbon for the metallurgic industry** with dedicated production for carbon-preserving applications (counting only the carbon-preserving part)

• Definition of **categories** in terms of production volume

<table>
<thead>
<tr>
<th>equipment category</th>
<th>method for calculating production capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Small (100 - 199 t)</td>
<td>full Biochar production dedicated to carbon preserving applications</td>
</tr>
<tr>
<td>Medium (200 - 499 t)</td>
<td>individual split btw. (i) BBQ/energy, (ii) metallurgy and (iii) Biochar</td>
</tr>
<tr>
<td>Large (500 - 1.999 t)</td>
<td></td>
</tr>
<tr>
<td>Very large (2.000 t - 4.999 t)</td>
<td></td>
</tr>
<tr>
<td>Industrial (≥ 5.000 t)</td>
<td></td>
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Methodology
How we approached this

• Interviews
  - We gathered information from various stakeholders in the Biochar sector
  - Partially this information was provided on a confidential basis (requires adequate handling)

• Information from equipment manufacturers
  - We verified the gathered information with key equipment manufacturers
  - Some equipment manufacturers provided confidential information on projects that are (i) under construction or under contract or (ii) in their planning (requires adequate handling)

• Internet research
  - Reference lists from equipment suppliers
  - Published information from biochar producers
  - EBC website

• Trustful handling of provided information
  - Confidently provided information will only be reported in a consolidated way, so that the confidential information cannot be deducted from the report
  - Respecting confidentiality is the basis for collection of data in the future
Biochar manufacturing equipment
Equipment manufacturers
Examples for industrial equipment producing Biochar

- Biomacon
- SYNCR AFT®
- PYREG
- VOW
Equipment manufacturers
Examples for industrial equipment producing Biochar
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Equipment manufacturers
Examples for industrial equipment producing Biochar

PyroCore

PERPETUAL NEXT

XYLERGY

minus CO2
by carbonauten

Stiesdal

CARBODFORCE

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Equipment manufacturers
Examples for industrial equipment producing Biochar
European Biochar Market 2022/2023
Biochar market growth
Annually installed Biochar production plants in Europe

- 28 Biochar production plants have been installed and commissioned in 2022
- In last year’s EBI Market Report, we had 44 projects on our radar for 2022 completion
  - For 15 of them commissioning moved to 2023
  - 4 projects slipped even beyond 2023 or have been canceled
  - 3 projects completed in 2022 were previously not on our radar screen
Biochar market growth
Annually installed Biochar production plants in Europe

- EBI is currently aware of 51 projects under construction or under contract for 2023 commissioning

[Graph showing annual installation of Biochar production plants from 2013 to 2023]

www.biochar-industry.com/market-overview/ © EBI 2023
By end of 2022, the cumulative number of production plants in Europe has grown to 130 installations.

Until the end of 2023, the cumulative number of production plants in Europe is expected to grow to 180 installations.

Many further projects (some of them quite large) are in an advanced planning and permitting process for commissioning in 2024.
Biochar market growth and growth rates
Cumulative Biochar production capacity in Europe

- Biochar production capacity continues to show **strong growth**. In 2022 it **grew by 52% to 53,000 t** Biochar
- **3y CAGR** was **56%** (2019 - 2022)
- For 2023 we expect the **production capacity** to **grow to > 90,000 t**, equivalent to above **80% growth rate**
- **3y CAGR** is expected to grow to **68%** (2020 - 2023)
From production capacity to actual Biochar production

- Assumptions to calculate actual Biochar production
  - 6 months operation and 60% uptime in the commissioning year
  - 12 months operation and 80% uptime in following years

- This leads to **33,500 t of Biochar** production in **2022**, equivalent to more than **90,000 t of CO₂e**

- **BCR** is by far today's **most relevant** industrial **carbon removal technology**

- For **2023**, we expect **>50,000 t of Biochar** equivalent to up to **150,000 t of CO₂e**
Biochar production by size of equipment
Cumulative Biochar production capacity in Europe end of 2022

- **80%** of the **production 2022 capacity** is in the equipment categories **medium, large** and **very large**
- **very large** and **industrial**, where only part of the production is dedicated to carbon preserving applications, make **37% of the capacity**

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<th>capacity range</th>
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Biochar production by regions/countries
Cumulative Biochar production capacity in Europe end of 2022

- Basis is the cumulative production capacity end of 2022, 53,000 tons
- About three quarters is distributed among three dominating regions/countries:
  - Germany
  - Nordics
  - Austria and Switzerland
Carbon Removal Standards for Biochar Carbon Removal
Standards for usage of Biochar as a material and its production
Certification of Biochar is becoming more and more relevant

- Certification of the **Biochar material** is becoming **increasingly relevant**
  - The EBC is today by far the most relevant certificate
  - For Biochar application in established markets additionally/alternatively other certification schemes are required by customers

- From the total production capacity available by **end of 2023**, almost **70%** is product **certified** (in 2018 this was below 50%)
Market observations and trends beyond the general growth

• Today there are at least ten companies that have been operating commercial plants since several years, with an installed base of several to many systems, up 30+ installations

• Beyond the established equipment manufacturers, several new industrial players are entering the market, some with relevant experience from installations outside Europe

• **Replacement of fossil carbon in metallurgy** is becoming a relevant application for biogenic carbon (*not* Carbon Removal)

• Feedstocks other than woody biomass is becoming more relevant
Market observations and trends beyond the general growth

- **CO$_2$-Certificates** for valorisation of the climate service have become an important commercial element for the industry.

- The offtake and use of biochar is increasing in various applications, with the material offering significant added value, but it remains a challenge and requires political and regulatory support to develop offtake markets in parallel with increasing production.
Summary

• Biochar production **technology is mature** with at least **ten** experienced EU technology providers, from which at least **four** are at **TRL9** level, the others at least **TRL8**

• The European Biochar market **has grown strongly** and will **continue to grow**
  – end of **2022** the **Biochar production capacity** was **53.000 t** and **production of Biochar** was about **33.500 t** (equivalent to over **90.000 t CO_{2e}**)  
  – **3y CAGR was 56% (2019 - 2022)**  
  – Until the end of **2023** the **Biochar production capacity in Europe** will grow to **90.000 t** and **production in 2023** is expected to exceed **50.000 t** (equivalent to almost **150.000 t CO_{2e}**)  

• **Biochar** production & **BCR** are “easy” to **scale** to relevant volumes **near term**
European Biochar Market 2022/2023

Reference Projects
Criteria for selecting Reference Projects

• The equipment supplier has already realized multiple projects that are up and running with an operational experience of several years and the equipment has proven to be capable of producing certified Biochar

• The Reference Project itself is either operational or in construction and has a smart energy utilisation concept

• We want to show a representative split on countries/regions and system size

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For each of the most relevant equipment categories we show at least one example
Auen Pflege Dienst – Flaach
Reference Project (“Small”)

- Customer: Auen Pflege Dienst AG (CH)
- Equipment: Biomacon C400-I
- Commissioning: 2019
- Feedstock: Natural wood (forest and landscape management)
- Energy utilization: Feeding up to 400 kWth into the local district heating network and an own district heating network for industry
- Biochar production: up to 360 t/yr of Biochar
NGE – Offenhausen
Reference Project (“Medium”)

- Customer: Ökologische Klärschlamm-trocknung Offenhausen GmbH (GER)
- Equipment: NGE T:CRACKER_DH 5000 & NGE T:CRACKER_DH 3000
- Commissioning: 2022
- Feedstock: Residual forest wood
- Energy utilization: sewage sludge drying
- Biochar production: overall 500 t/yr
Nawaro – Perg  
Reference Project (“Large”)  

- Customer: NAWARO ENERGIE Betrieb (AT)  
- Equipment: 2 x CW1800-500  
- Commissioning: 2022  
- Feedstock: Residual forest wood  
- Energy utilization:  
  - 11 GWh/yr renewable heat for the local district heating network  
  - 7,5 GWh/yr electricity (8,000 households)  
- Biochar production: 1,000 t/yr Biochar up to 3,000 t CO2e
Thyssenkrupp Lippstadt
Reference Project (“Large”)

- Customer: thyssenkrupp (Germany)
- Equipment: PYREG PX1500
- Commissioning: 2022
- Feedstock: Residual forest wood
- Energy utilization: Feeding up to 750 kWth into the company’s heating network
- Biochar production: 700 t/yr of Biochar corresponding to 1,500 t CO₂
Vow Green Metals – Follum plant
Reference Project (“Industrial”)

- Customer: Vow Green Metals (NOR)
- Equipment: 6 x Vow BGR750x6
- Commissioning: 2024 (under construction)
- Feedstock: Demolition wood
- Energy utilization: 50 - 60 GWh/yr renewable heat for the local district heating network
- Biochar: 10,000 t/yr Biochar for Solar Silicon Production saving 30,000 t CO$_{2e}$
Fårevejle Reference Project ("Medium")

- **Customer:** Odsherred Utility Company (DK)
- **Equipment:** Hecla® Setores 1.000
- **Commissioning:** in process
- **Feedstock:** Sewage sludge 4.000 t/yr
- **Energy utilization:**
  - sewage sludge drying without use of external energy
  - 2 GWh/yr excess heat for the district heating network
- **Biochar production:** 400 t/yr Biochar with up to 35% carbon used as soil improver under Danish law
Scaling BCR to climate relevance
BCR plays a vital role in the portfolio of the Carbon Removal Technologies
Growing by 70% will bring BCR to 6 megatons by 2030

- Starting point is the **historic production** of Biochar
- A **conversion rate** of 2.8 t CO$_2$ per t Biochar was used to convert the amount of Biochar produced to CO$_2$
- To extrapolate from 2022/2023 a **growth rate of 70%** was modeled
Growing by 70% will bring BCR to 6 megatons by 2030

- Maintaining growth rates of 70% until 2030 is challenging but feasible
- At 70% growth, BCR will sequester 120% of the Commission’s current target for industrial CDR
Number of new installations required to meet the 6 megatons

- **New installations** will have to grow to above **1,000 plants** by 2030, **cumulative** installed fleet would then be just over **3,000 plants**

- In comparison: around 143,000 medium-sized combustion plants (1 - 50 MW) are installed in the EU

- Required **growth rate until 2030 for new installations** will be **55%** (lower than the 70% modeled for production growth rate, as average system size is expected to further grow)
100 megatons of carbon removal by 2040

- Assuming **10 years** of high growth at **70%** and then declining growth rates would bring BCR to well above **100 Mt** by **2040**

- **Short term** challenge is to maintain high growth rates for installation of new plants and find commercially interesting application for the produced Biochar

- **Long term** challenge will be the availability of biomass with smart allocation and cascaded use
Smart biomass allocation is key to reach 100 megatons by 2040

- **Biomass is a limited resource**
  - Smart use of **thermal energy** from the process avoids conflicts over biomass resources
  - **Cascaded use** of biomass with pyrolysis as final step optimizes the use of biomass
  - Pyrolysis permits usage of hardly valorized **residual biomass**

- For the **6 megatons CO₂** projected for BCR by 2030, **1%** of the **biomass** is required

- In order to achieve **100 megatons CO₂** by **2040**, **19%** of the **biomass** would be required

*Estimated total sustainable biomass potentials (RED II Annex IX A and B) in 2030 and 2050 for all markets (in million dry tonnes) as estimated in this Imperial College London study.*
BCR is capable of delivering carbon removal at climate relevant volumes within 15 years.