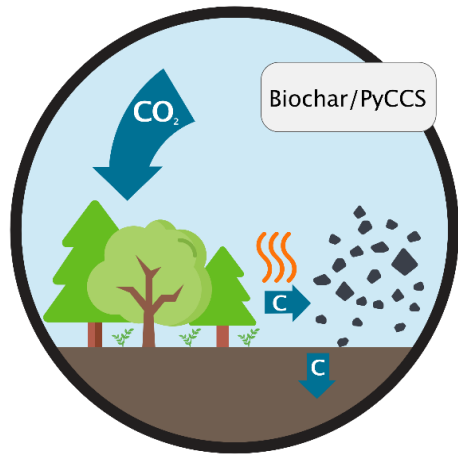




European Biochar Market Report 2021/2022

March 2022

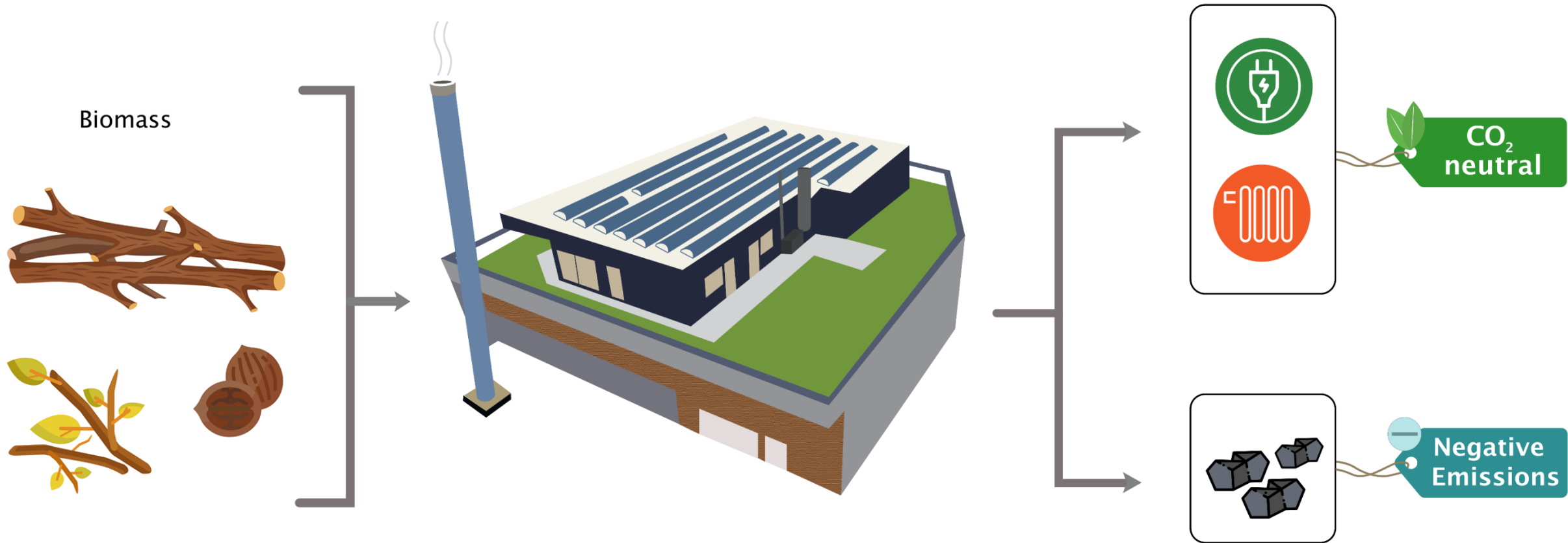
What is Biochar, what is PyCCS?



- **Biochar** is a **stable form of carbon**, obtained from biomass **pyrolysis**
- Biochar is a **highly versatile material** used in **agriculture** and in **construction materials**
- Pyrogenic Carbon Capture and Storage (**PyCCS**) enables the **capture & sequestration** of atmospheric carbon through the **carbonization of biomass**
- CO₂ is **captured** by plants through photosynthesis, their biomass is **transformed** into stable carbon through the technical process of pyrolysis and **stored** by the use of Biochar
- Since 2019 **Biochar** is highlighted in the reports of the **IPCC** as material for **carbon sequestration**

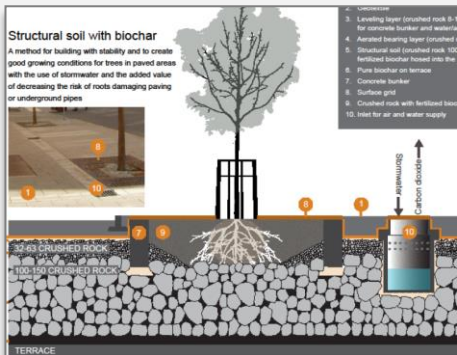
PyCCS/Biochar goes hand-in-hand with bioenergy

Up to fourfold value creation: electricity, heat, biochar and negative emissions

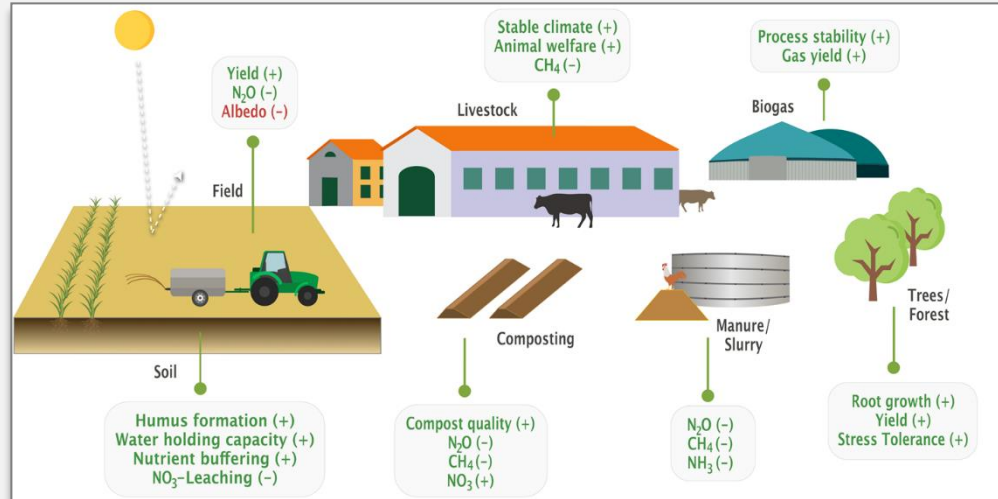


Broad range of applications of Biochar

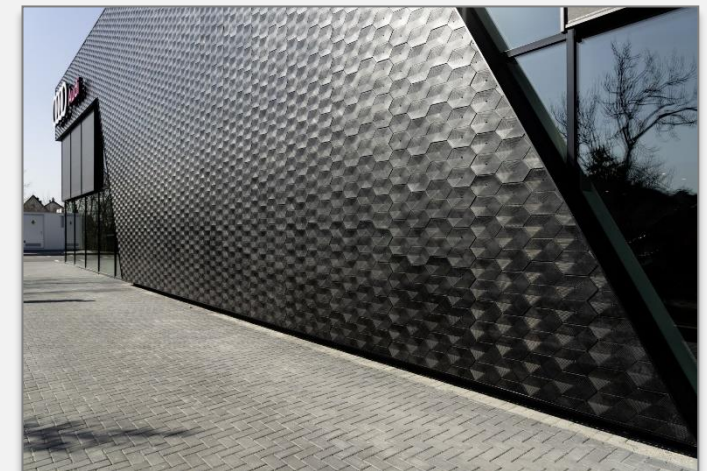
Urban Applications



Agriculture



Construction materials



Members of the Industry Consortium

The EBI membership base is growing constantly



Key Activities of the EBI Consortium

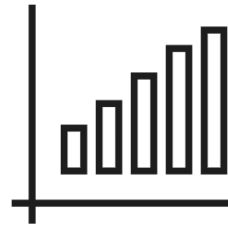
It is all about eliminating/alleviating market entry barriers

Policy



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

Market Intelligence



Provide relevant market information for members and for publications

Subject of this report

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 (based on EBC)

Agenda

1. Motivation, scope and methodology

2. Biochar manufacturing equipment

3. European Biochar Market 2021/2022

4. Biochar/PyCCS – Scaling to climate relevance

5. Further market insight for EBI Members

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 actuality
- We want to share the insight that **Biochar**, as a **key solution to mitigate climate change**, is **real today** and it is **scaling very fast**
- ... and we want to give our **EBI-members** a **head start** through further in-depth market information

Scope of this European Biochar Market Report 2021/2022

What we look at

- We look at **Biochar** production plants **installed in Europe until 2021** and **installations** that will be **commissioned in 2022**
- We exclusively look at **Biochar in EBC quality grade**, it 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 **six categories** in terms of production volume

equipment category	research approach
Micro (<100 t)	considered if they came across
Small (100 - 199 t)	mostly considered
Medium (200 - 499 t)	intense research to include all plants
Large (500 - 1.999 t)	intense research to include all plants
Very large (2.000 t - 4.999 t)	intense research to include all plants
Industrial (≥ 5.000 t)	intense research to include all plants

Newly created class

Methodology

How we approached this

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

Trustful handling of provided information

Trust and confidentiality is key

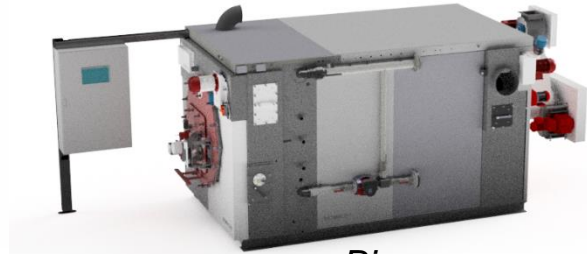
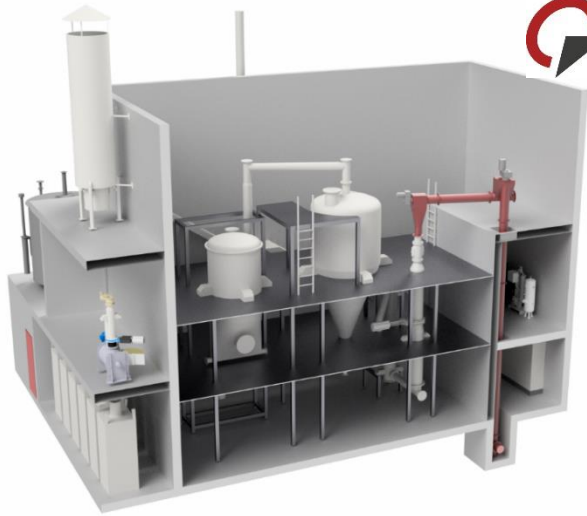
- Respecting confidentially provided information
 - Confidentially provided information will only be reported in a consolidated way, so that the confidential information cannot be deducted from the report
 - Respecting confidentiality is the basis for collection of data in the future
- We will share market information at two levels
 - **General public** (e.g. production capacity in Europe, growth rates, ...)
 - **EBI Members** will get some further in-depth insights

A scanning electron microscope (SEM) image showing the intricate, porous, and layered structure of biochar. The image displays a complex network of interconnected, thin, and sometimes curved layers, creating a highly porous and textured surface. The lighting highlights the three-dimensional nature of the structure, with deep shadows and bright highlights on the edges of the layers.

Biochar manufacturing equipment

Biochar manufacturing equipment

Examples for industrial equipment producing Biochar in EBC quality

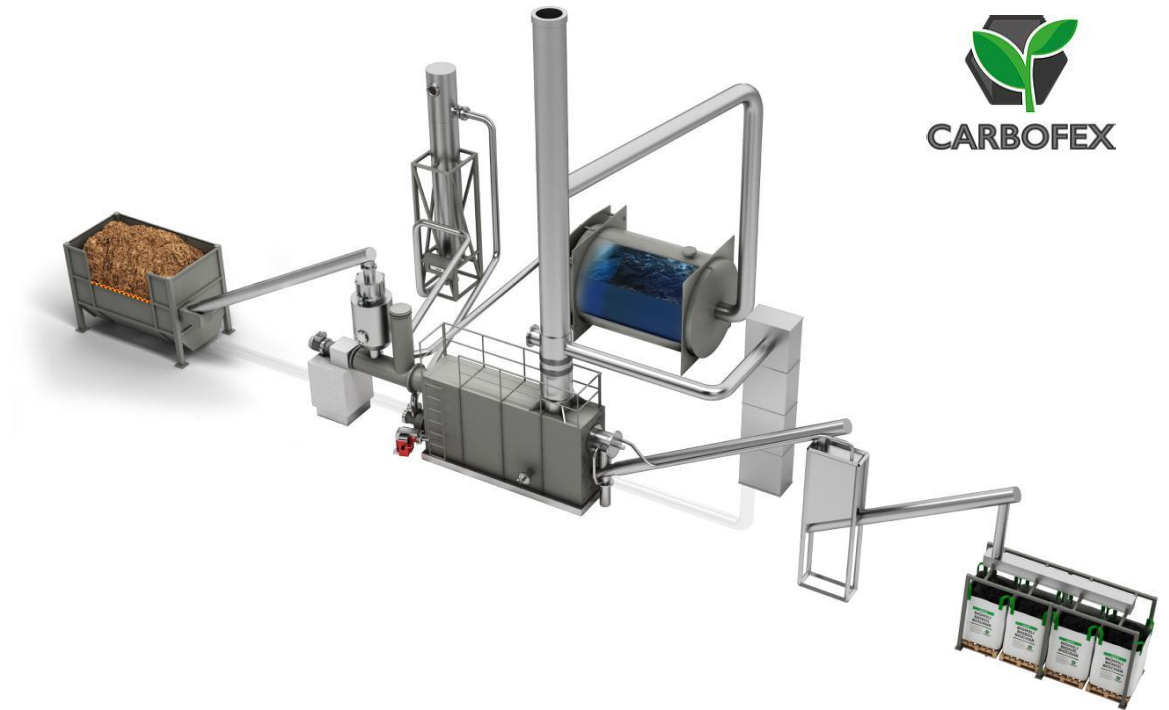


Biomacon



Biochar manufacturing equipment

Further examples for industrial equipment producing Biochar in EBC quality



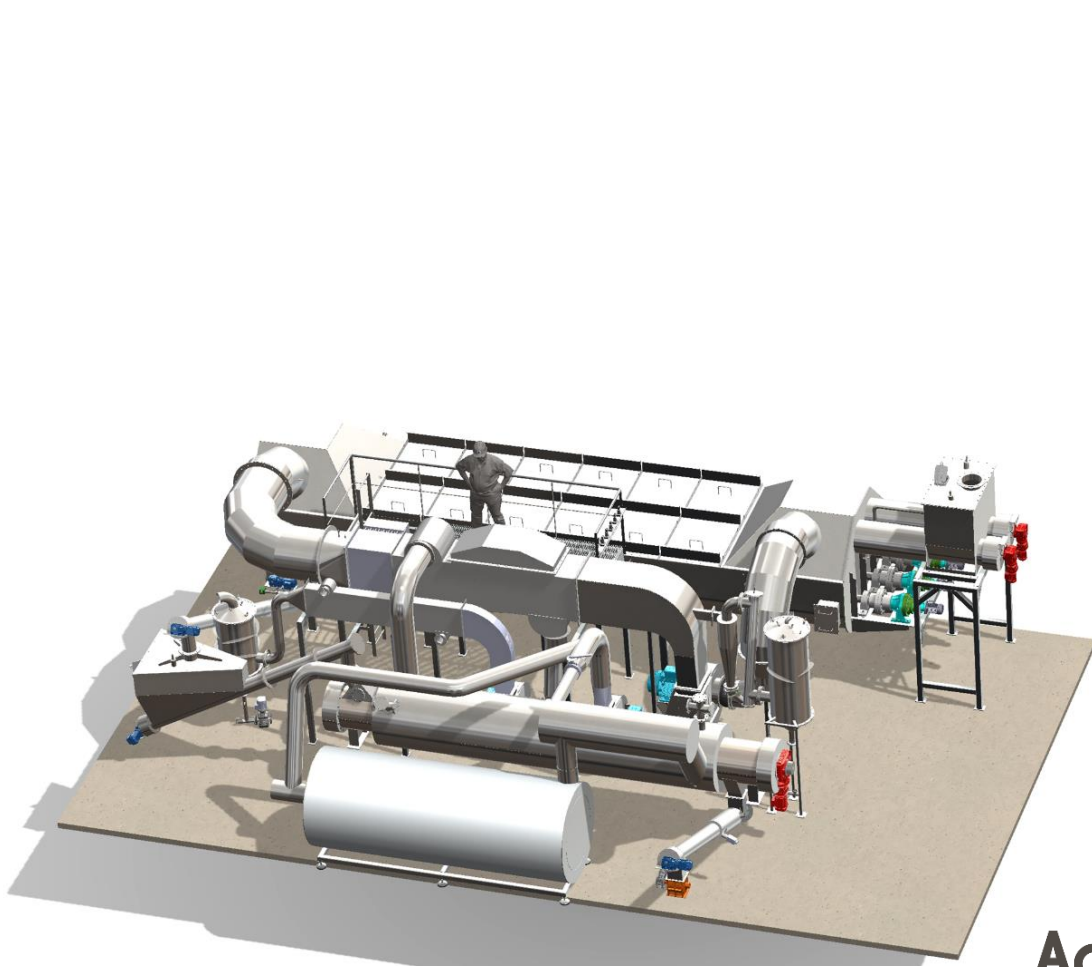
Biochar manufacturing equipment

Further examples for industrial equipment

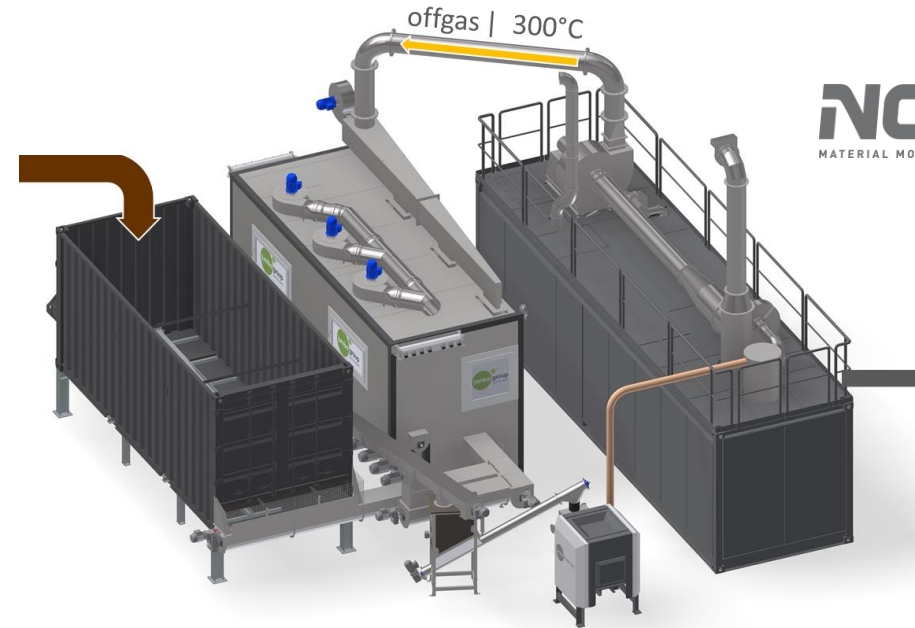


Biochar manufacturing equipment

Examples for industrial equipment with a focus on sewage sludge



AquaGreen



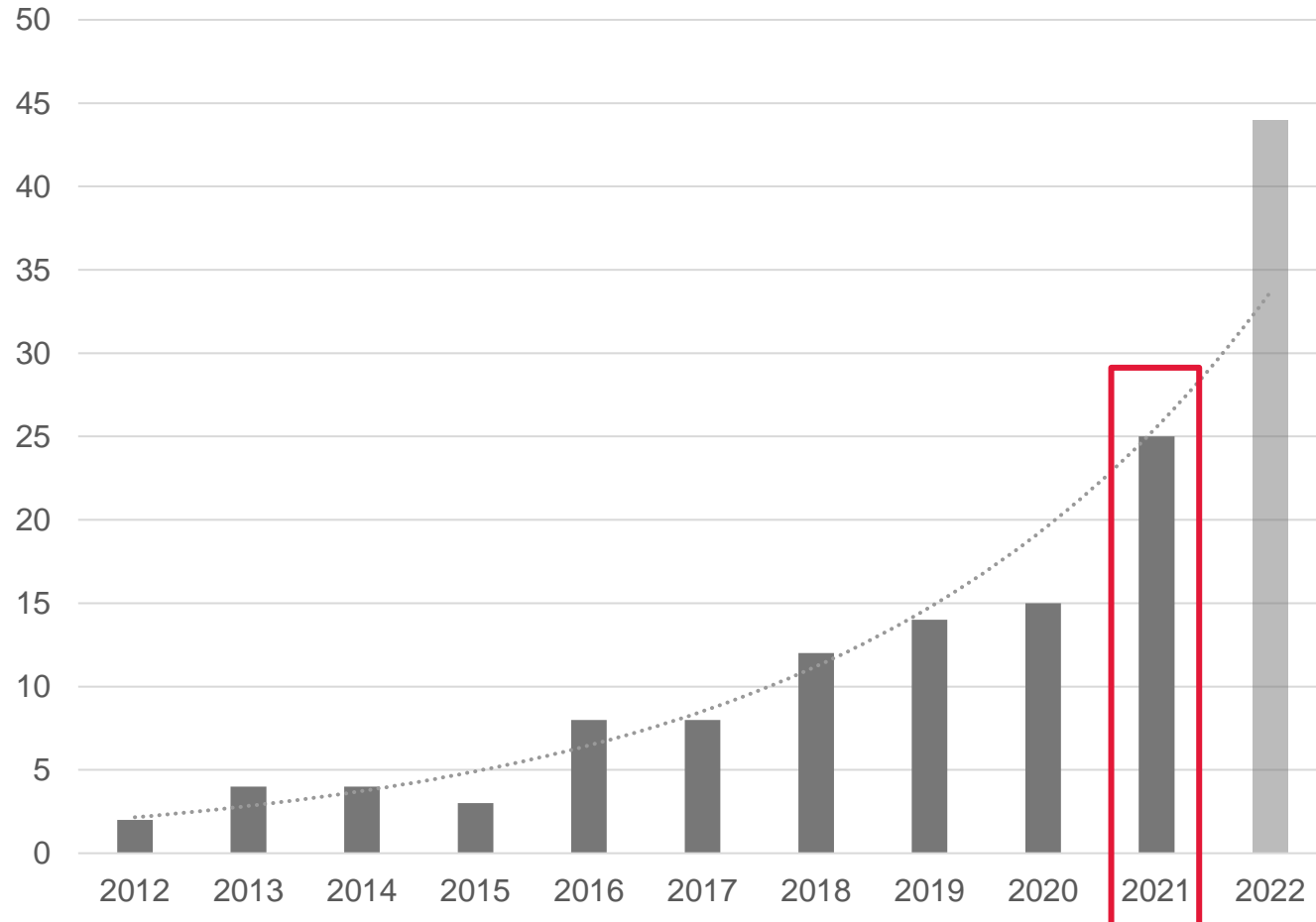
NGE
MATERIAL MORPHING TECHNOLOGY

A scanning electron microscope (SEM) image showing the intricate, porous, and layered structure of biochar. The image displays a complex network of interconnected, thin, and slightly curved layers, creating a highly porous and textured surface. The lighting highlights the three-dimensional nature of the structure, with some areas appearing more prominent than others.

European Biochar Market 2021/2022

Biochar market growth

Number of Biochar production plants installed in Europe

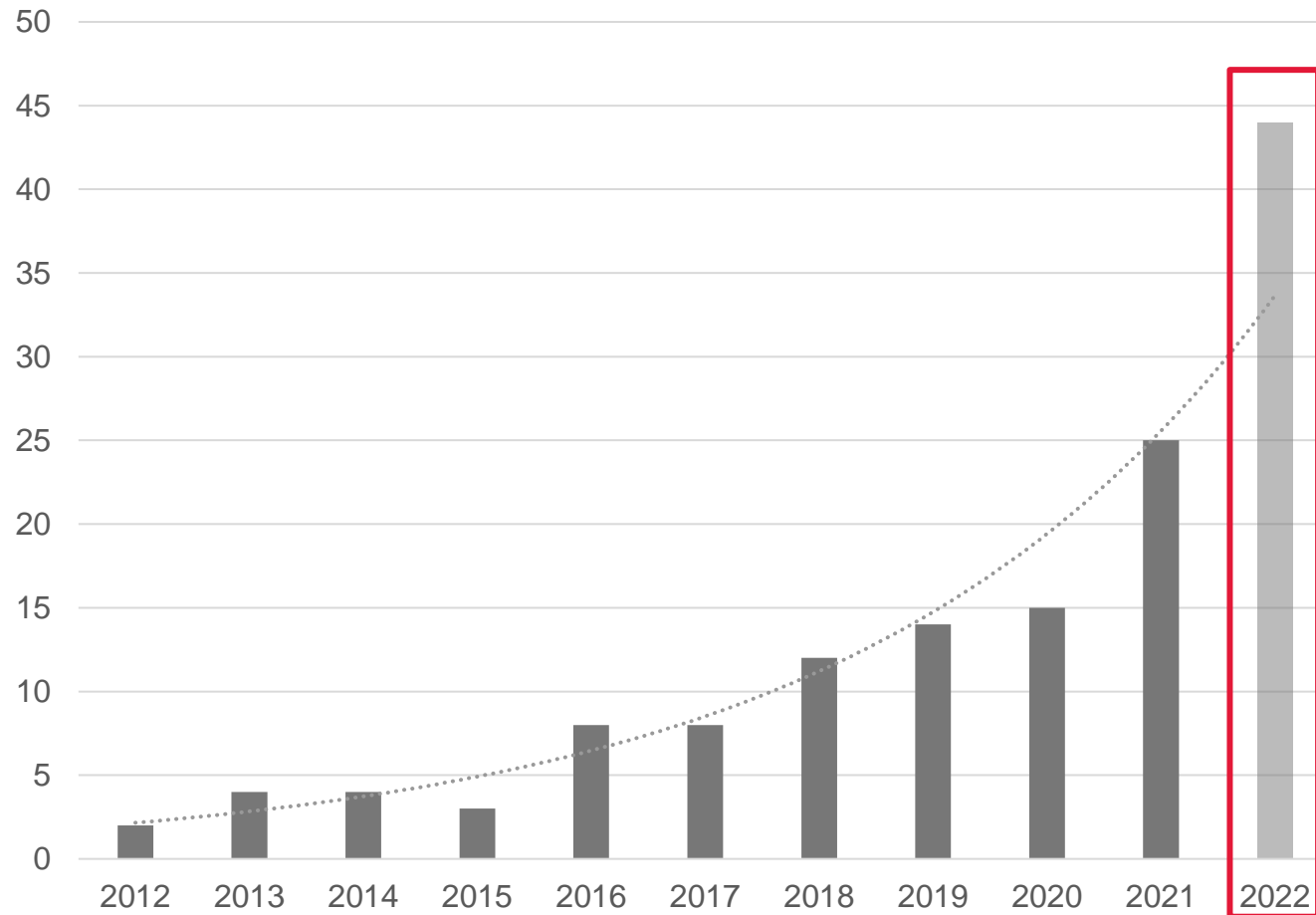


www.biochar-industry.com/market-overview/ © EBI 2022

- **25 Biochar production plants had been installed in 2021**
 - In Feb '21 EBI had 32 projects on the radar screen for 2021 completion
 - 12 of them were delayed (Covid, permitting, material shortage, ...)
 - 5 project completed in 2021 were previously not on our radar screen
- The **cumulative number** of installed Biochar production plants has grown to more than **100 installations**, **almost 80** of them with a **production capacity ≥ 200 t/a**

Biochar market growth

Number of Biochar production plants installed in Europe

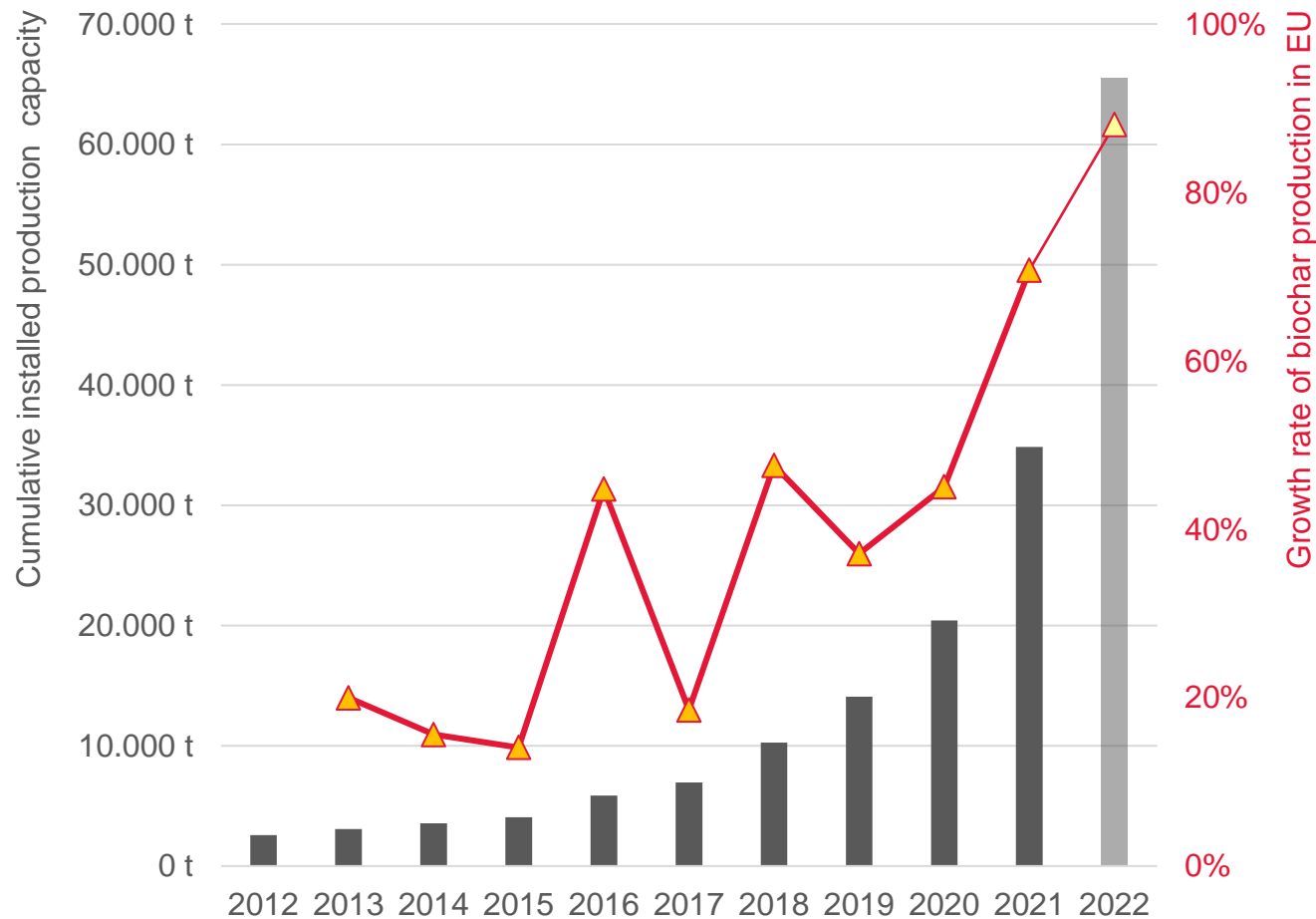


- EBI is currently aware of **44 projects under construction or under contract** for 2022 commissioning
- **Many further projects** (some of them quite large) are **in an advanced planning and permitting process** but will likely be commissioned in 2023ff
- There are certainly a few **projects** that are **not on our radar screen yet**

www.biochar-industry.com/market-overview/ © EBI 2022

Biochar market growth and growth rates

Cumulative Biochar production capacity in Europe

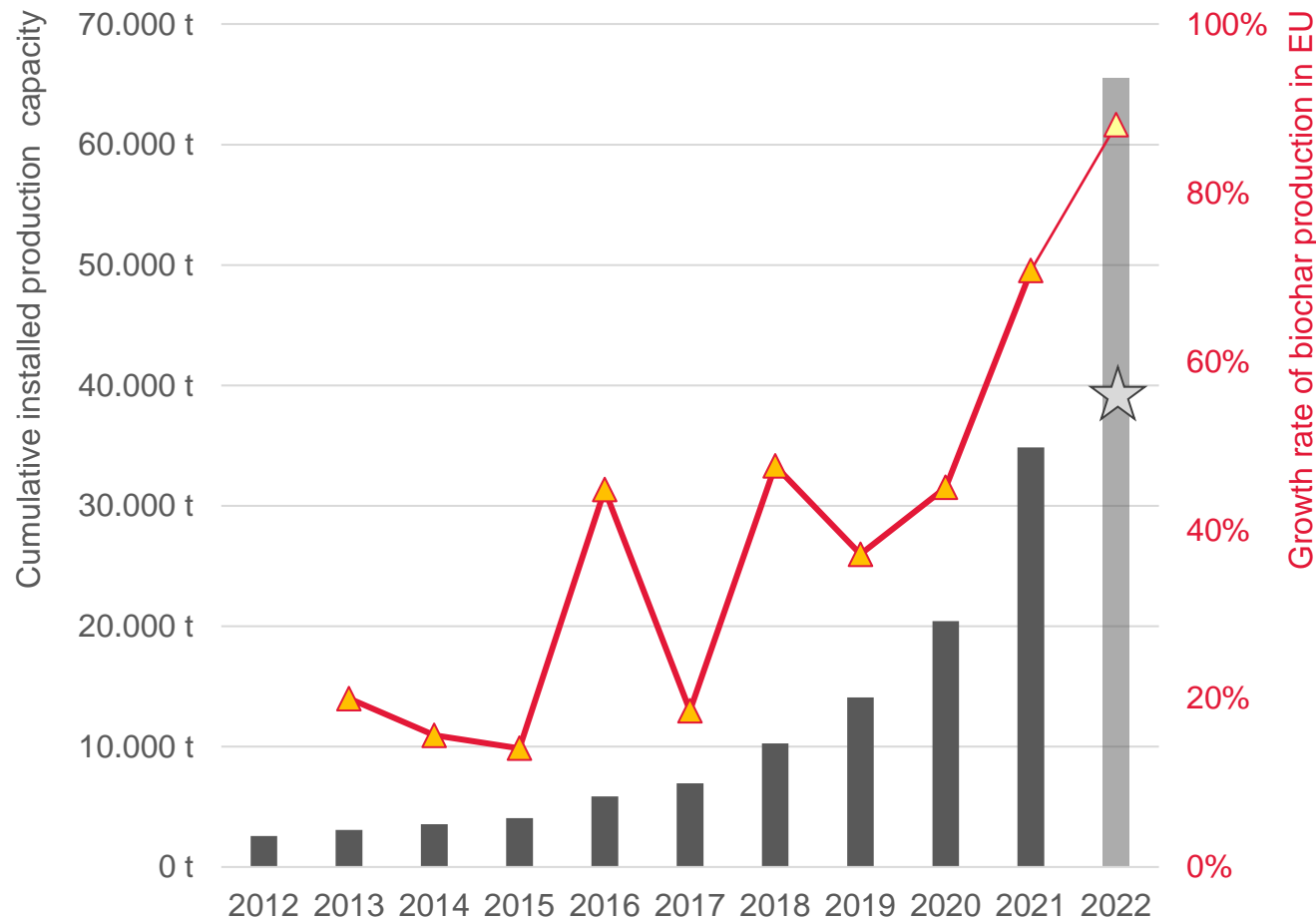


- The Biochar production capacity shows **very strong growth**, with consistently **high** and even accelerating **growth rates**
- **Growth rate 2021** was **71%**, **2022 growth** expected to be **> 85%**
- **Average growth rates**
 - **3y CAGR** was **50%** (2018 - 2021),
 - **3y CAGR** expected to grow to **67%** (2019 - 2022)

www.biochar-industry.com/market-overview/ © EBI 2022

Biochar market growth and growth rates

Actual Biochar production in Europe



- Assumptions for assessment of **actual Biochar production 2022**

- 70% uptime in commissioning year and 6 months operations calculates actual production to 35%
- 80% uptime for plants commissioned in previous years

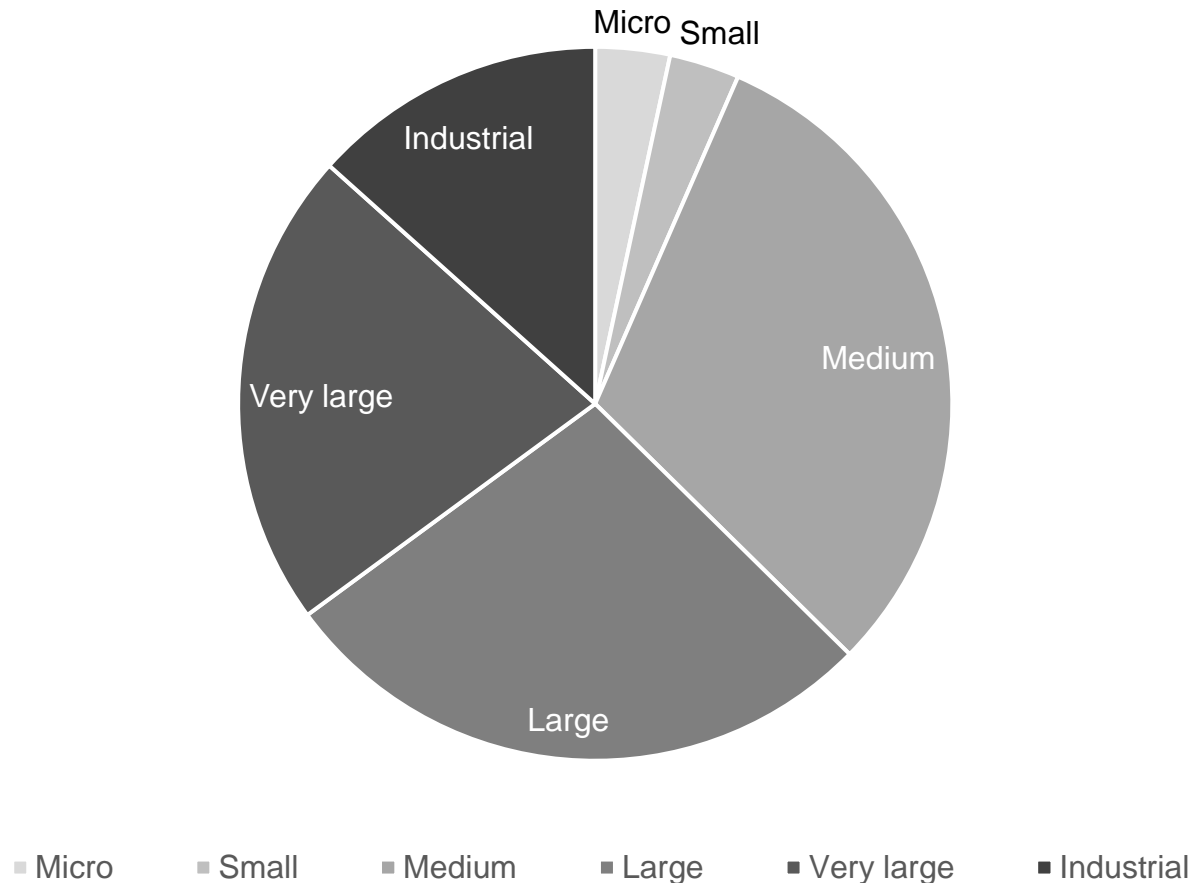
- This leads to **almost 40.000 t** of actual Biochar production in 2022, equivalent to about **100.000 t of CO_{2e}**

- This makes **Biochar/PyCCS** by far today's **most relevant industrial NET**

www.biochar-industry.com/market-overview/ © EBI 2022

Biochar production by size of equipment

Cumulative Biochar production capacity in Europe end of 2021

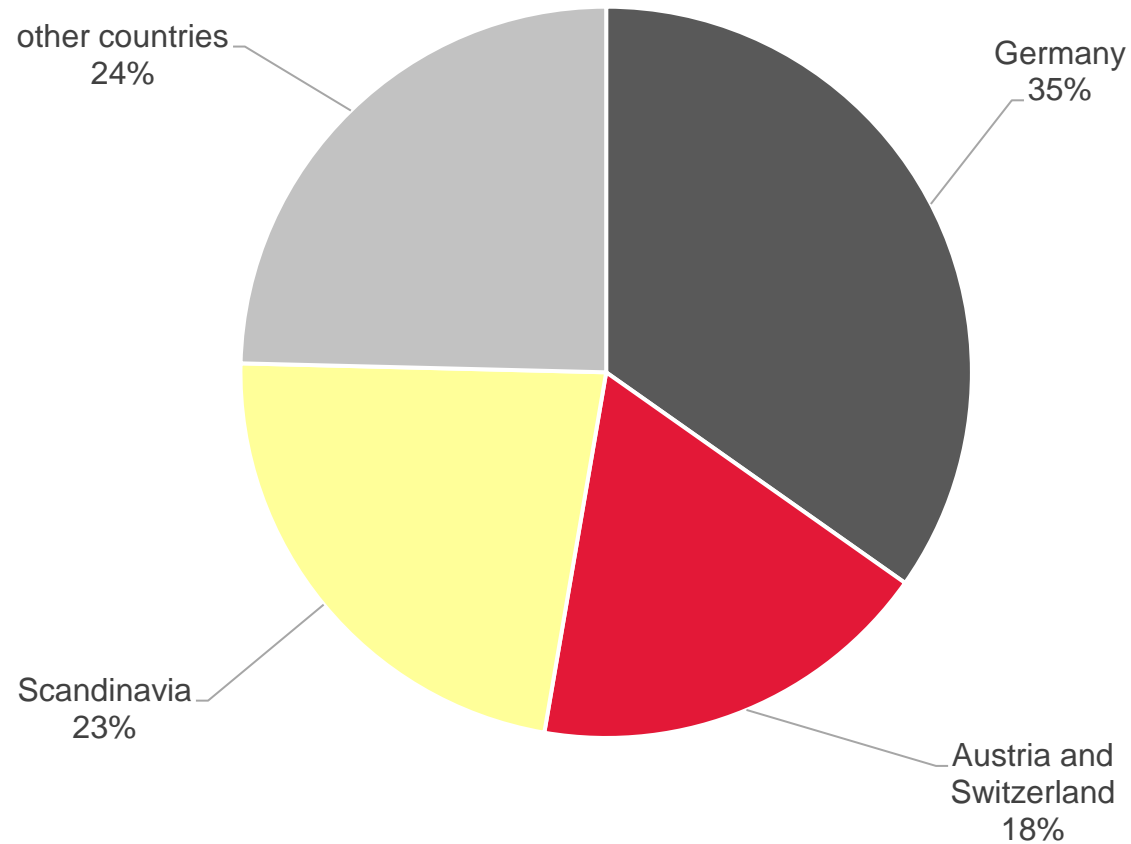


- More than **60%** of the **production capacity 2021** is in the equipment category **Large** and above (≥ 500 t/a)
- Over **90%** is in the equipment category **Medium** and above (≥ 200 t/a)

equipment category	
Micro	(<100 t)
Small	(100 - 199 t)
Medium	(200 - 499 t)
Large	(500 - 1.999 t)
Very large	(2.000 t - 4.999 t)
Industrial	(≥ 5.000 t)

Biochar production by regions/countries

Cumulative Biochar production capacity in Europe end of 2022



- The **production capacity end of 2022**, expected to be 65.000 t/a, will have **three dominating regions/countries**
- **D-A-CH and Scandinavia** together will represent about **75%** of the production capacity 2022
- Within Scandinavia, **Sweden** represents the most relevant country

The European Biochar Certificate (EBC)

Standards and regulations are key for large-scale roll-out



deutsch EBC - European Biochar Certification

Home EBC Guidelines C-Sink EBC Producer Laboratories Register your company login

THE EUROPEAN BIOCHAR CERTIFICATE (EBC)

The EBC was developed to limit the risks of biochar usages to the best of our scientific knowledge and to help the users and producers of biochar to prevent or at least to reduce any hazard for the health and for the environment while producing and using biochar.

For thousands of years, charcoal has been one of civilisation's basic materials. By far the most common use of charcoal was for cooking, for heating and for smouldering when producing metal tools. However, for centuries charcoal and biochar have also been used for conditioning soils, or as litter (bedding) materials, as medicine and also as a feed additive. Over the course of the last century most of this traditional knowledge has been lost yet is being rediscovered since 2010.

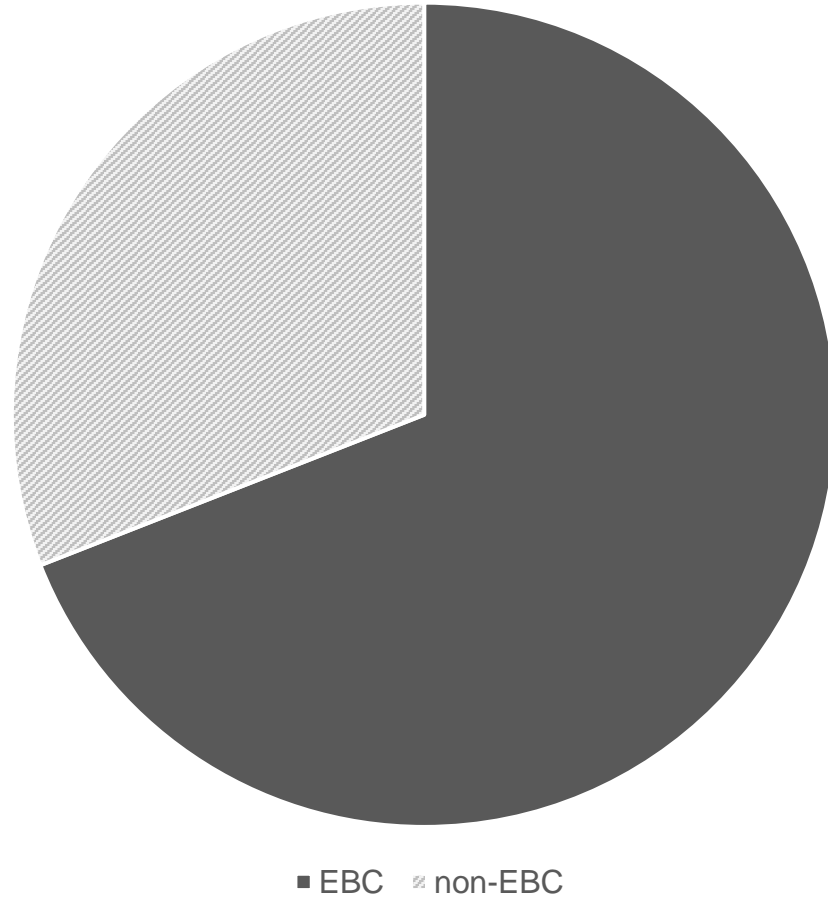
Thanks to wide-ranging multidisciplinary research and field trials, the understanding of the biological and physico-chemical processes involved in the production and use of biochar has made great progress. A significant increase in the agricultural use of biochar has already been recorded since 2015. From 2020 onwards, a further acceleration in both agricultural and industrial use of biochar is expected. Agricultural applications range from soil conditioners, composting additives and carriers for fertilisers to manure treatment and stable bedding, silage additives and feed additives. Industrial applications are particularly relevant to the construction, plastics, paper and textile industries.

<https://www.european-biochar.org>

- EBC Classes
 - EBC-Agro, EBC-AgroOrganic
 - EBC-Feed
 - EBC-ConsumerMaterials, EBC-BasicMaterials
 - EBC-Urban
 - **EBC-Sink (since 2020)**
- Production
 - Permitted feedstock
 - Energy efficient production
 - Calculation of carbon sink potential
- Characteristics
 - C-content
 - H/C, O/C
 - pH
 - heavy metals
 - PAH

Biochar production with and w/o EBC

The EBC Certificate is becoming more and more widespread



- In **2018** about **50%** of the total production capacity has been **EBC certified**, since then it is becoming **increasingly relevant**
- Of the total production capacity available by **end of 2022**, almost **70%** is either already **EBC certified**, in process for certification or under planning for certification
- **EBC-Sink** has been identified as a **key driver** for the increased relevance of EBC

Trends beyond the general growth

- Beyond the **established equipment manufacturers** several **new industrial players** are entering the market
- Today there are at least seven companies that have been **operating commercial plants** for **several years**, most of them with an installed number of systems in the low to mid double-digit range
- There is a clear trend in the market for **growing system sizes**
- **Replacement of fossil carbon in metallurgy** as well as for **activated carbon** is becoming a relevant application for biogenic carbon (no Negative Emissions though)
- The **EBC Certificate** is becoming more and more widespread and is clearly **the established quality-standard for Biochar**
- **EBC-Sink**, which enables **valorisation of the climate service**, has become an important element for the industry. Today only one C-sink trader is accredited (Carbonfuture), further traders are in the process for accreditation.

Summary

- The **strong market growth** has even accelerated compared to previous years, **3yCAGR** will be **67%** (2019 – 2022)
 - End of **2021** Biochar **production capacity** was **35.000 t**, actual **production** was about **20.000 t**
 - End of **2022** Biochar **production capacity in Europe** will grow to **65.000 t**, **production** in **2022** will be almost **40.000 t** (equivalent to **100.000 t CO₂**)
- Biochar production **technology is mature** with at least ten serious EU technology providers, from which at least five are at TRL8+ levels
- With **EBC-Sink** a mature and trusted methodology for **CO₂ accounting and certification** is in place
- Among the industrial **NET** solutions, **Biochar/PyCCS** is easiest to **scale** to significant volumes in the **near term**

A scanning electron microscope (SEM) image showing the intricate, porous, and layered structure of biochar. The image displays a complex network of interconnected, thin, and sometimes curved layers, creating a highly porous and textured surface. The lighting highlights the three-dimensional nature of the structure, with some areas appearing more prominent than others.

European Biochar Market 2021/2022

Appendix – Reference Projects

Selection Criteria for 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 **EBC certified Biochar**
- The Reference Project itself is either **operational** or **in commissioning** and has a **smart energy utilisation concept**

equipment category	
Micro	(<100 t)
Small	(100 - 199 t)
Medium	(200 - 499 t)
Large	(500 - 1.999 t)
Very large	(2.000 t - 4.999 t)
Industrial	(≥ 5.000 t)

*For each of the **most relevant equipment categories** we show at least one example*

Stadtwerke Groß-Gerau

Reference Project (“Medium”)



- Customer: **Stadtwerke Groß-Gerau (GER)**
- Equipment: **Biomacon C400-I**
- Commissioning: **2020**
- Feedstock: **Municipal green waste**
- Energy utilization: **Feeding up to 400 kW_{th} into the local district heating network**
- Biochar production: up to **360 t/a of Biochar**

IWB Basel

Reference Project (“Large”)



- Customer: **IWB Basel (Switzerland)**
- Equipment: **PYREG PX1500**
- Commissioning: **early 2021**
- Feedstock: **Municipal green waste**
- Energy utilization: **Feeding up to 750 kW_{th} into the local district heating network**
- Biochar production: **700 t/a of Biochar corresponding to 1.500 t CO₂**

EAD Darmstadt

Reference Project (“Large”)



- Customer: **EAD Darmstadt (Germany)**
- Equipment: **CTS 20**, two carbonization units
- Commissioning: **in process**
- Feedstock: **Municipal green waste**
- Energy utilization: **Feeding** up to **400.000 kWh_{eI}** into the electrical grid
- Biochar production: up to **800 t/a**

Circular Carbon

Reference Project (“Very large”)



CIRCULAR **CARBON**



E T I A
ECOTECHNOLOGIES



- Customer: **Circular Carbon GmbH (GER)** (general contractor)
- Equipment: **ETIA/VOW** (carbonisation unit)
- Commissioning: end **2021**
- Feedstock: **Cocoa shells**
- Energy utilization: up to **2.500 kW_{th}** steam for an industrial company
- Biochar production: up to **3.000 t/a**

Bioenergie Frauenfeld

Reference Project (“Very large”)



- Customer: **Bioenergie Frauenfeld (CH)**
- Equipment: **4 x SynCraft CW1800x2-1000**
- Commissioning: **in process**
- Feedstock: **Forest residues, wood chips**
- Energy utilization:
 - up to **45 GWh/a renewable heat** for the **local district heating network** and a **sugar factory**
 - **30 GWh/a electricity** (8.000 households)
- Biochar production: **4.000 t/a Biochar**
up to **12.000 t CO_{2e}**

Carbonex

Reference Project (“Industrial”)

CARBONEX



- Customer: **CARBONEX, SAS**
Gyé-sur-Saine (France)
- Equipment: **Carbonex**, 2 carbonization units
- Commissioning: **2012/2019**,
since **2020 EBC**
- Feedstock: **Forest energy wood**
- Energy utilization: **5 MW_{el} renew. electricity**
- Production: **30.000 t/a total charcoal**,
a small fraction is **Biochar**

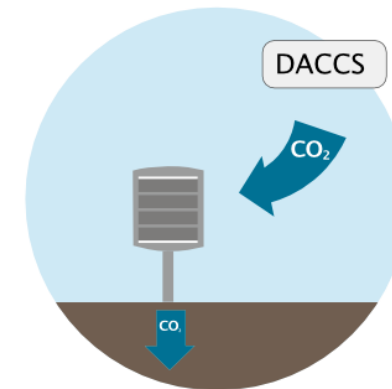
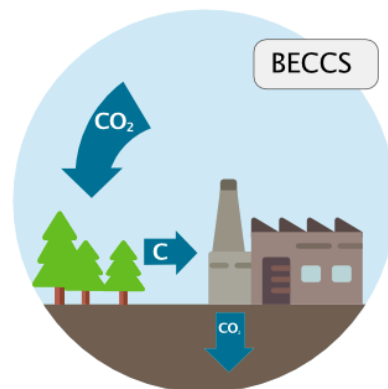
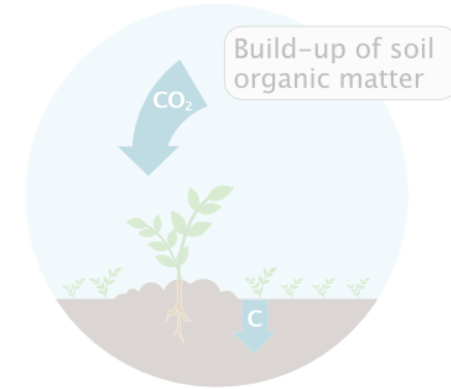
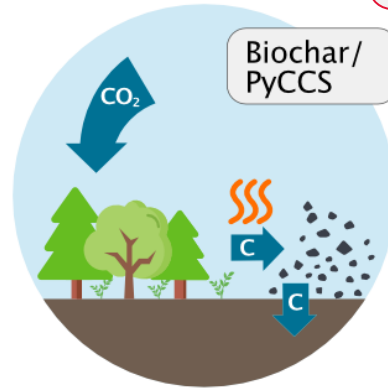


Biochar/PyCCS – Scaling to climate relevance

Options for negative emissions (NET6)

Six options currently considered promising, four of them being mainly technical/industrial

Permanent
C-Sinks

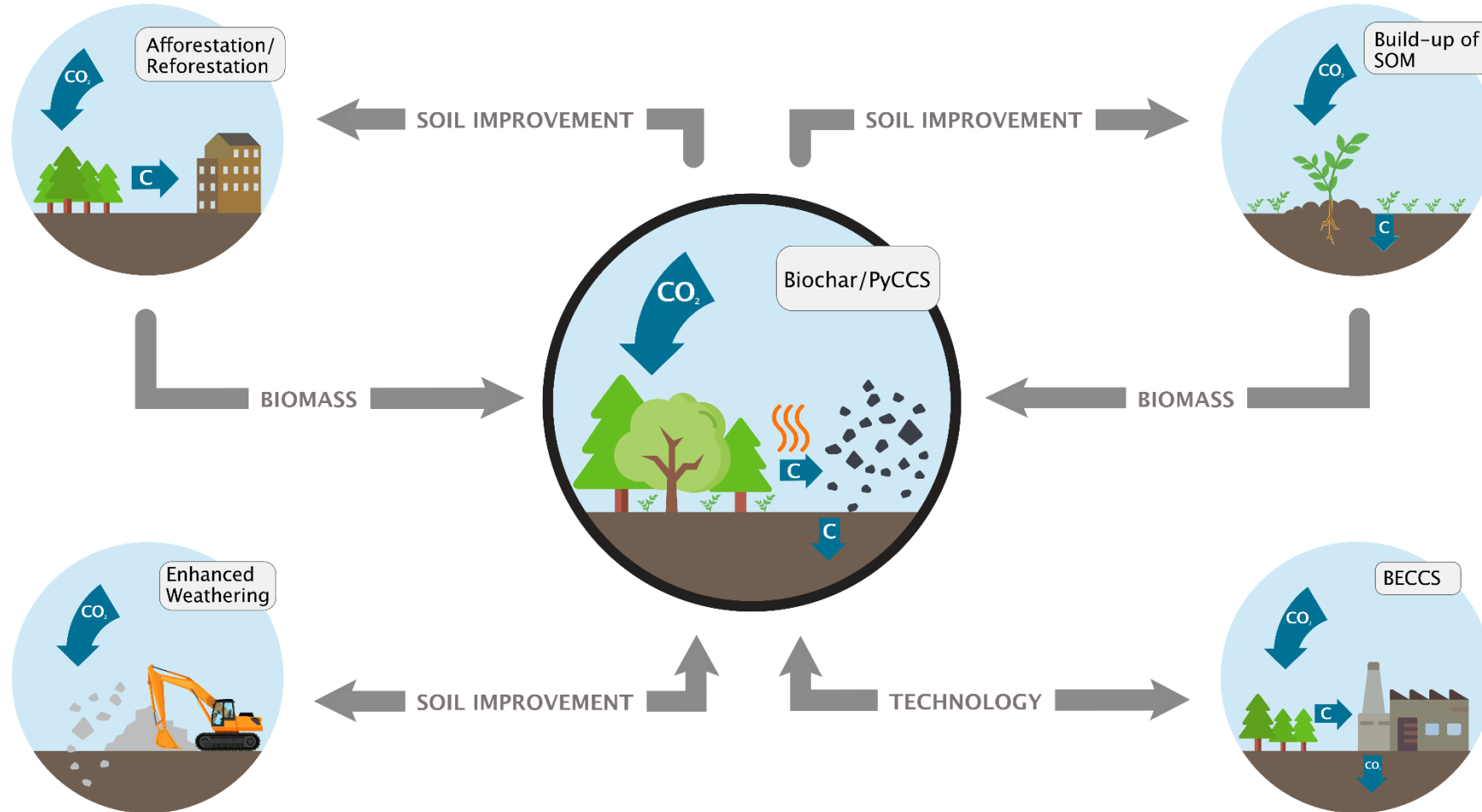


Biochar/PyCCS plays a vital role in the **portfolio of NETs**

*Hansjörg Lerchenmüller
in a discussion with DG-CLIMA, February 2022*

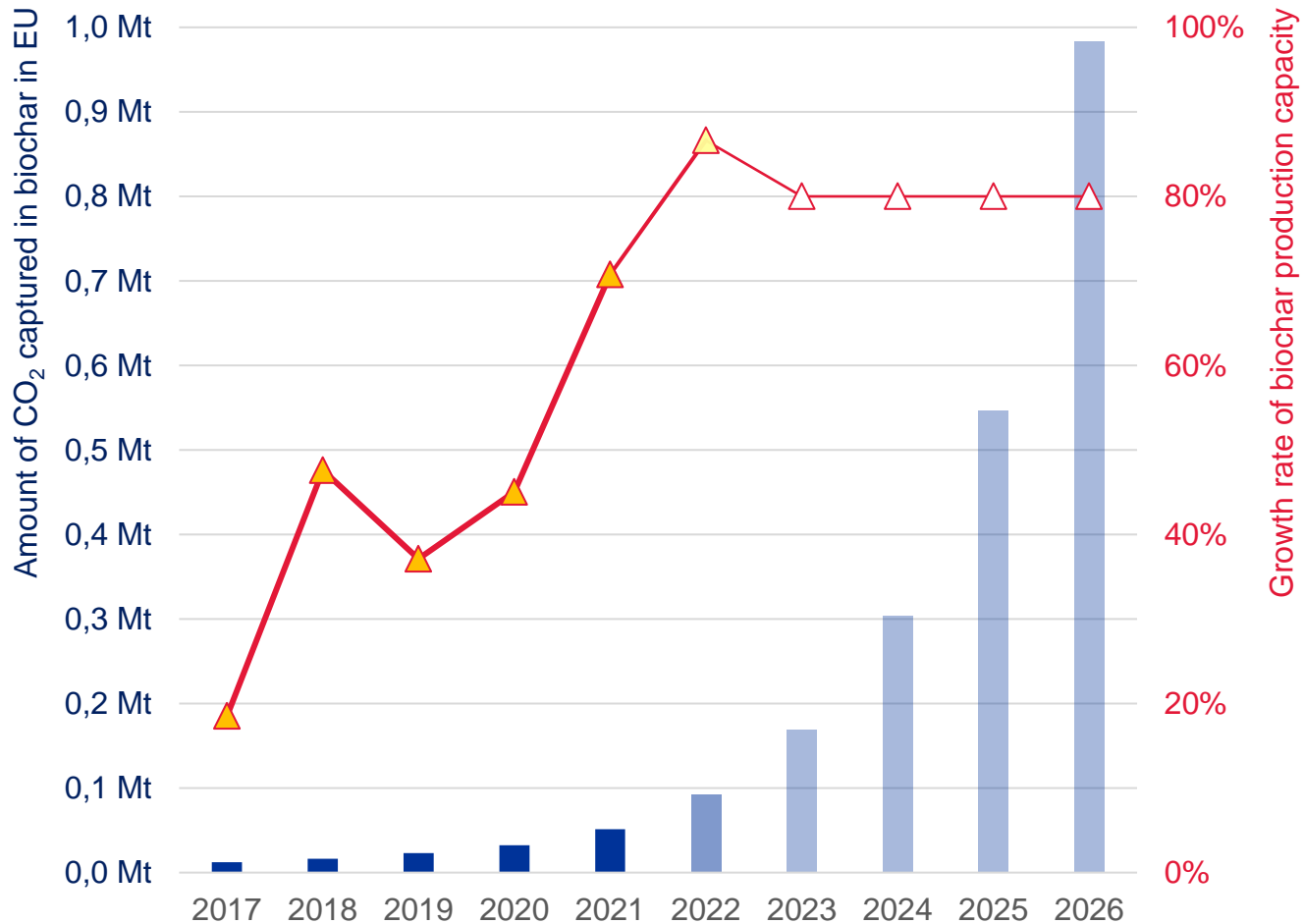
Synergies between different NETs

It is about synergies, not about competition



1 megaton of carbon removal is within reach

Extrapolation of the current growth rates

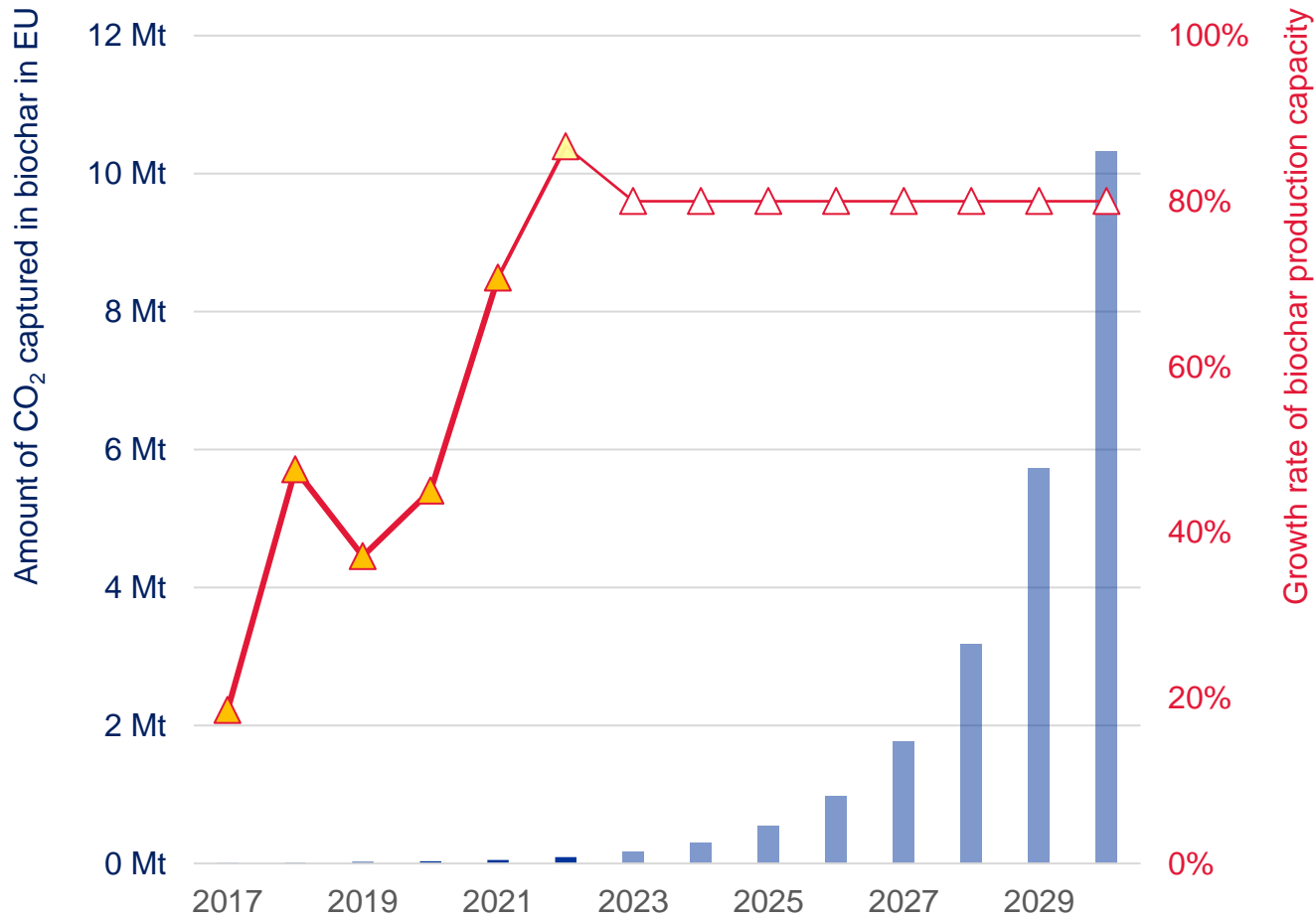


- **2022 growth rate > 85%** is logged-in with projects under construction or under contract
- Continuing for 4 more years with **80%** growth will bring PyCCS to **1 megaton by 2026** in Europe alone

www.biochar-industry.com/market-overview/ © EBI 2022

10 megaton of carbon removal by 2030

Extrapolation of the current growth rates

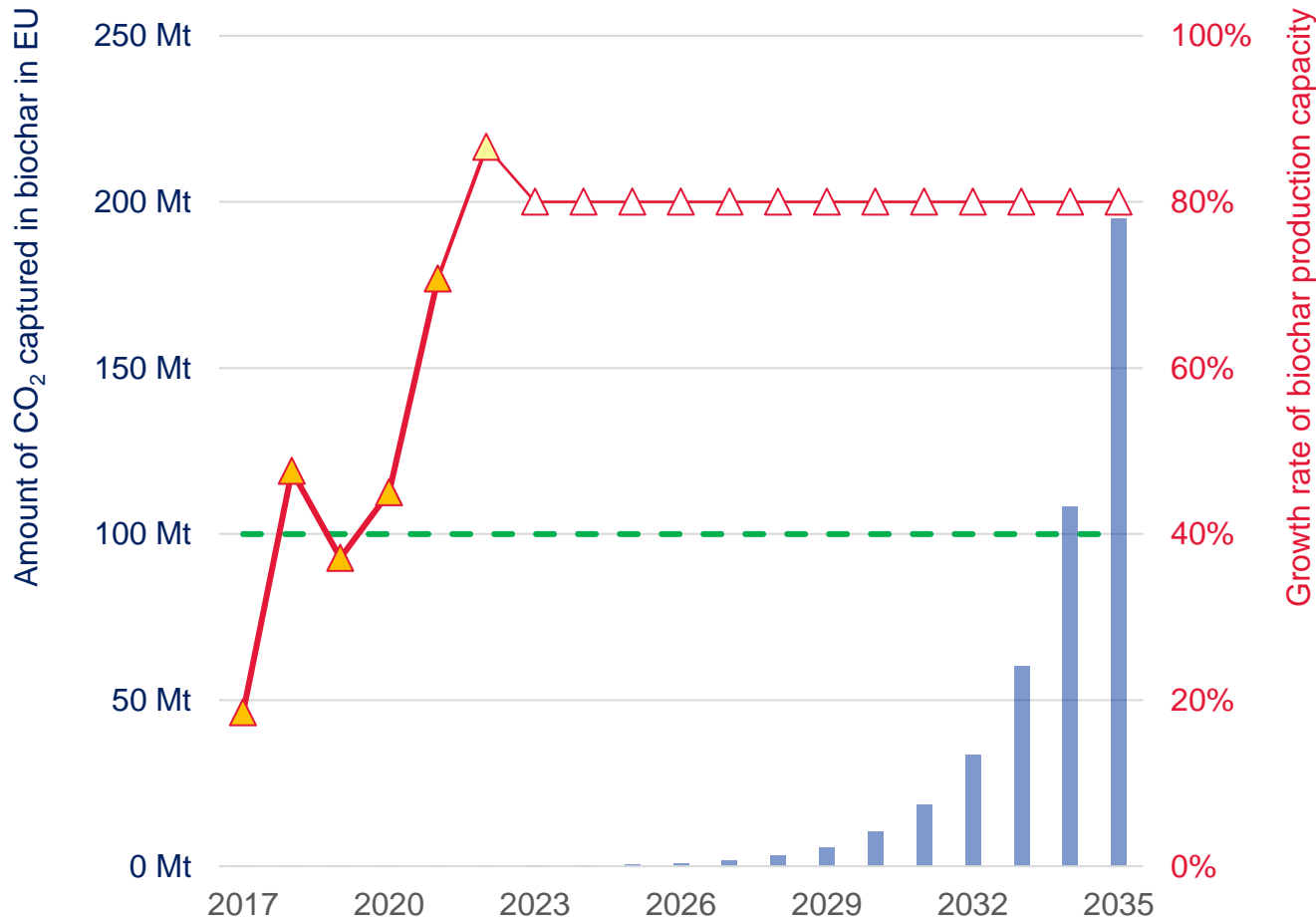


- ... and there is also **no reasons why growth rates of 80% could not be maintained** until 2030
- With that, PyCCS will sequester just over **10 megatons by 2030** in Europe (2x of the Commission's current target for all industrial sinks)

www.biochar-industry.com/market-overview/ © EBI 2022

100 megaton of carbon removal by 2034

Extrapolation of the current growth rates



- ... and there is even **no reasons why growth rates of 80% could not be maintained even beyond 2030**
- With that PyCCS will sequester just over **100 megatons by 2034** in Europe
- Under this growth scenario, we will exceed the **EBI target of 255 Mt in 2036**; from then on, growth will have to slow down, as the limited availability of biomass will not allow for further exponential growth

www.biochar-industry.com/market-overview/ © EBI 2022

Biochar/PyCCS
will likely
continue to dominate NETs
in terms of volume
for at least a decade

*Hansjörg Lerchenmüller
in a discussion with DG-CLIMA, February 2022*

