



EBI

European
Biochar
Industry

Scaling Biochar Carbon Removal to Climate Relevance

*State of the European Biochar Industry
BCR's role in Net Zero pathways*

14th of February 2024



EBI, the voice for Biochar Carbon Removal in Europe

Activities 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

Outline

1

The European
Biochar Industry

2

BCR's role in
Net Zero pathways

3

Scaling of BCR to
climate-relevance

4

Biochar
Permanence



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The new Market Report 2023 | 2024 will be released in March 2024



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European Biochar

Market Report 2022 | 2023

March 2023

European Biochar Market Report

2022/2023

Authors and key contributors

- **Hansjörg Lerchenmüller** (EBI) – Lead Author
- **Harald Bier** (EBI)
- **Lea Hettich** (EBI)
- **Mattias Gustafsson** (Ecotopic)
- 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



Broad variety of technology providers

30 technology providers, about 10 of them at TRL8 or even TRL9

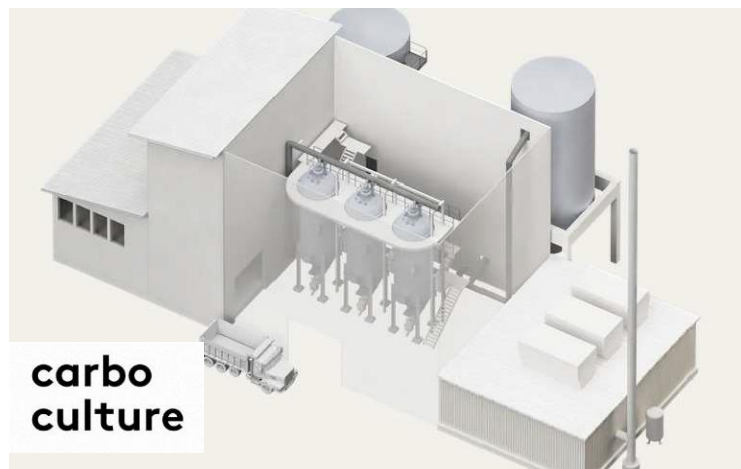


Examples of pyrolysis systems. In Europe there are > 30 technology providers, some with an installed base of several to many systems, up 30+ plants.

For further info see the European Biochar Market Report 2022/2023 

Equipment manufacturers

Examples for industrial equipment producing Biochar



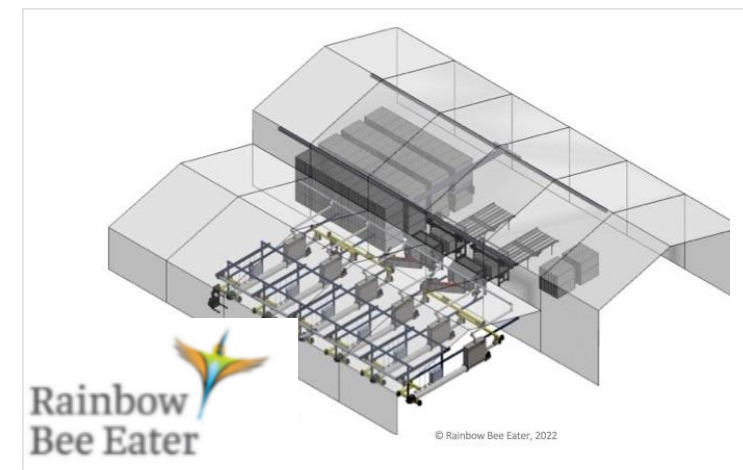
Equipment manufacturers

Examples for industrial equipment producing Biochar



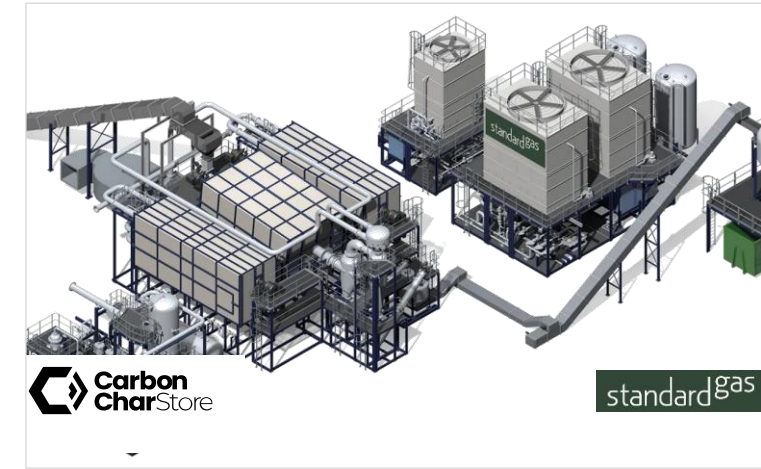
Equipment manufacturers

Examples for industrial equipment producing Biochar



Equipment manufacturers

Examples for industrial equipment producing Biochar

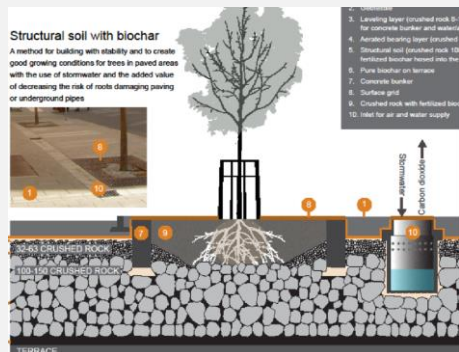


Broad range of biomass suitable for carbonization

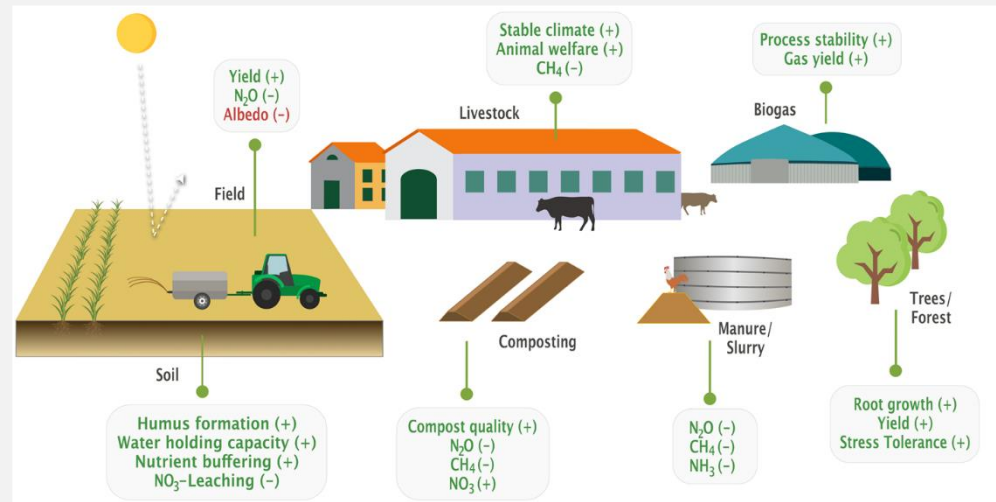


Broad range of applications of Biochar

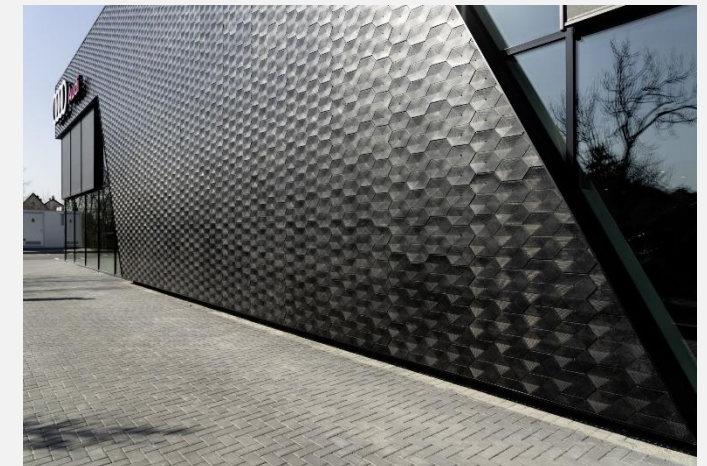
Urban Applications



Agriculture

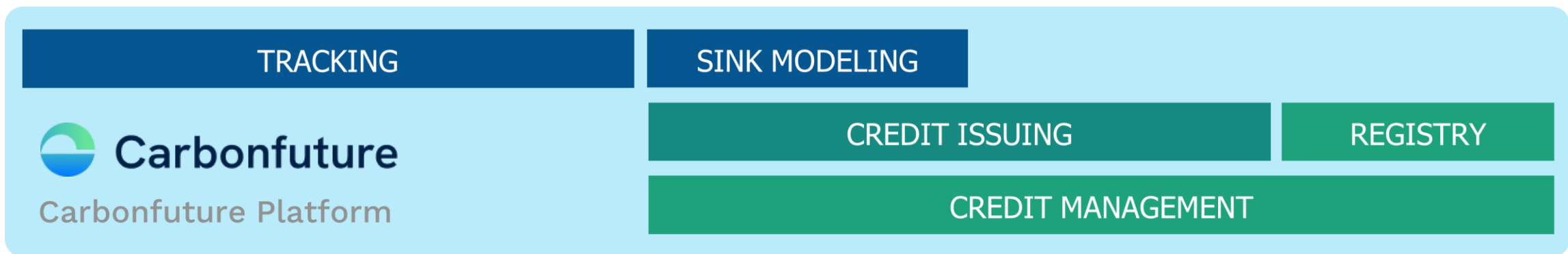


Construction materials



Carbon removal Value Chain

CDR credits: Key driver for further market growth



Thyssenkrupp Lippstadt (Germany)

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: **600 t/yr of Biochar** corresponding to **1,800 t CO_{2e}**

Carbon Removal Park Baltic Sea (Germany)

Reference Project ("Large")



- Customer: **Novocarbo (Germany)**
- Equipment: **PYREG 2x PX1500**
- Commissioning: **2023**
- Feedstock: **Residual forest wood**
- Energy utilization: up to **1,100 kWth** into for the local **district heating network** & **165 kW electrical power**
- Biochar production: **1,400 t/yr of Biochar** corresponding to **4,000 t CO_{2e}**

Auen Pflege Dienst (Switzerland)

Reference Project ("Small")



- Customer: **Auen Pflege Dienst AG (CH)**
- Equipment: **Biomaccon 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**

Sonnenerde (Austria)

Reference Project (“Medium”)



- Customer: **Sonnenerde (Austria)**
- Equipment: **NGE Pyro3**
- Commissioning: **2023**
- Feedstock: **Agricultural residues & municipal green waste**
- Energy utilization: **sewage sludge drying**
- Biochar production: **700 t/yr biochar**
2,000 t CO_{2e}

Circular Carbon Hamburg (Germany)

Reference Project (“large”)



CIRCULARCARBON



- Operator: **Circular Carbon GmbH** (Hamburg)
- Equipment: **ETIA/VOW** (carbonisation unit)
Circular Carbon
- Commissioning: **end of 2021**
- Feedstock: **Cocoa shells**
- Energy utilization: up to **2.500 kW_{th}** steam
for an industrial company
- Biochar production: overall **2,500 t/yr biochar**
up to 6,000 t of CO_{2e}

Südwestdeutsche Salzwerte AG (Germany)

Reference Project ("Large")



- Customer: **Südwestdeutsche Salzwerte AG (Heilbronn)**
- Equipment: **CW1800-x2**
- Commissioning: **Jan 2024**
- Feedstock: **Residual forest wood & woody biomass from roadside landscaping**
- Energy utilization:
 - **11 GWh/yr renewable heat** for the **heat distribution network**
 - **7,5 GWh/yr electricity**
- Biochar production: **1,000 t/yr Biochar**
up to 3,000 t CO_{2e}

Bioenergie Frauenfeld (Switzerland)

Reference Project (“very large”)



- Customer: **Bioenergie Frauenfeld (Switzerland)**
- Equipment: **4 x CW1800-x2**
- Commissioning: **2022**
- Feedstock: **Residual forest wood**
- Energy utilization:
 - **45 GWh/yr renewable heat** for the **local district heating network** and a **sugar factory**
 - **30 GWh/a electricity**
 - Biochar production: **4,000 t/yr Biochar** up to 12,000 t CO_{2e}

Vow Green Metals – Follum plant (Norway)

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 (Denmark)

Reference Project ("Medium")



- Customer: **Odsherred Utility Company (DK)**
- Equipment: **Hecla® Setores 1.000**
- Commissioning: **Q1 2023**
- 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

Summary on state of the industry and market trends

- The **biochar industry is very dynamic** and about to become a **mature industry**
 - around **30 industry equipment manufacturers** active in Europe
 - **~10** of them at **TRL8 or even TRL9**
- **Biomass feedstock**
 - the **dominating feedstock** is still **wood chips** from **forestry residues and landscaping**
 - **agricultural residues** are clearly **on the rise**
- **Certification is key**
 - most of the **biochar** in Europe is **sold under the EBC certificate** for the “physical biochar”
 - **EBC and Puro** are the **dominating certification standards** of **Carbon Removal**
 - there is a **strong market demand for MRV** with **Carbonfuture** dominating the space
- The **market for biochar applications** has **three pillars**
 - **agriculture** is a **stable and growing basis** for sales
 - **urban applications** show **high growth rates**
 - application in **concrete is on the rise** and many companies see the greatest potential here
- **Revenues from sale of Energy** and **Carbon Credits** are **key to economics** of biochar projects

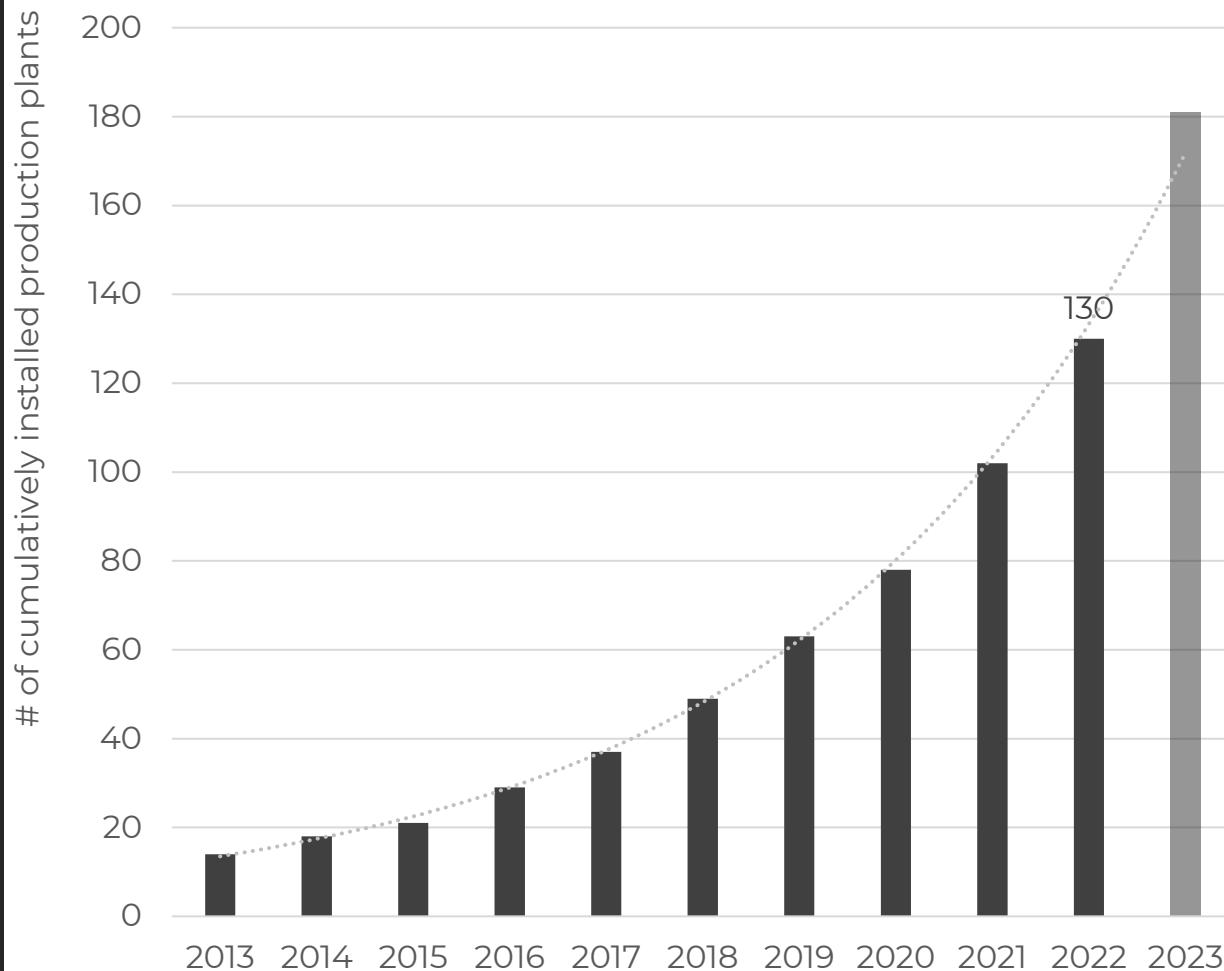
The European Biochar Market

data as of March 2023

Biochar market growth

Cumulative number of Biochar production plants in Europe

Summary slide,
for further details
click here 



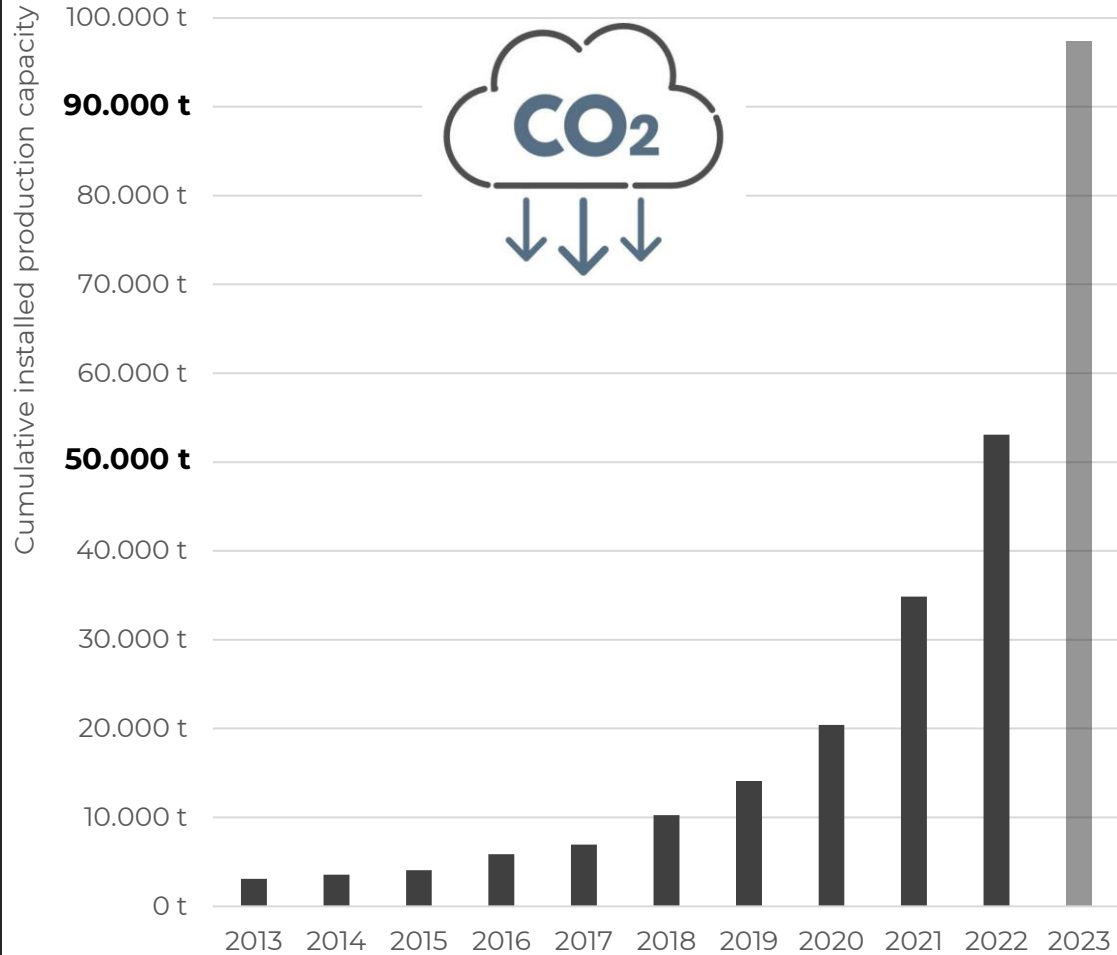
- End of **2022**: a total of **130 production plants** in Europe
- Until the end of **2023**, this number is expected to **grow to 180 installations**

www.biochar-industry.com/market-overview/ © EBI 2023

Biochar market growth

Cumulative Biochar production capacity in Europe

Summary slide,
for further details
click here 



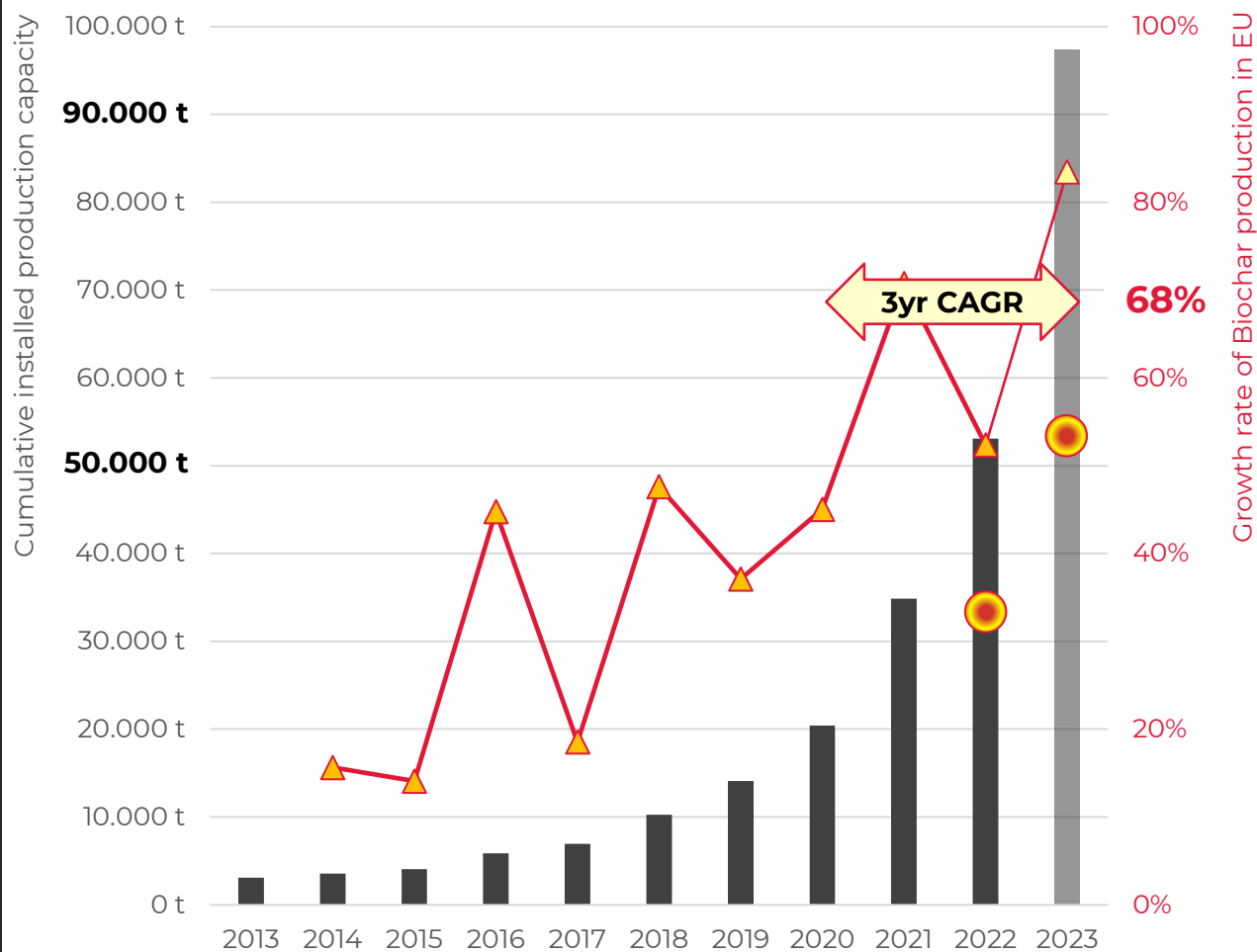
- Biochar **production capacity** is growing at **very high growth rates**

www.biochar-industry.com/market-overview/ © EBI 2023

Biochar market growth and growth rates

Cumulative Biochar production capacity in Europe

Summary slide,
for further details
klik here 



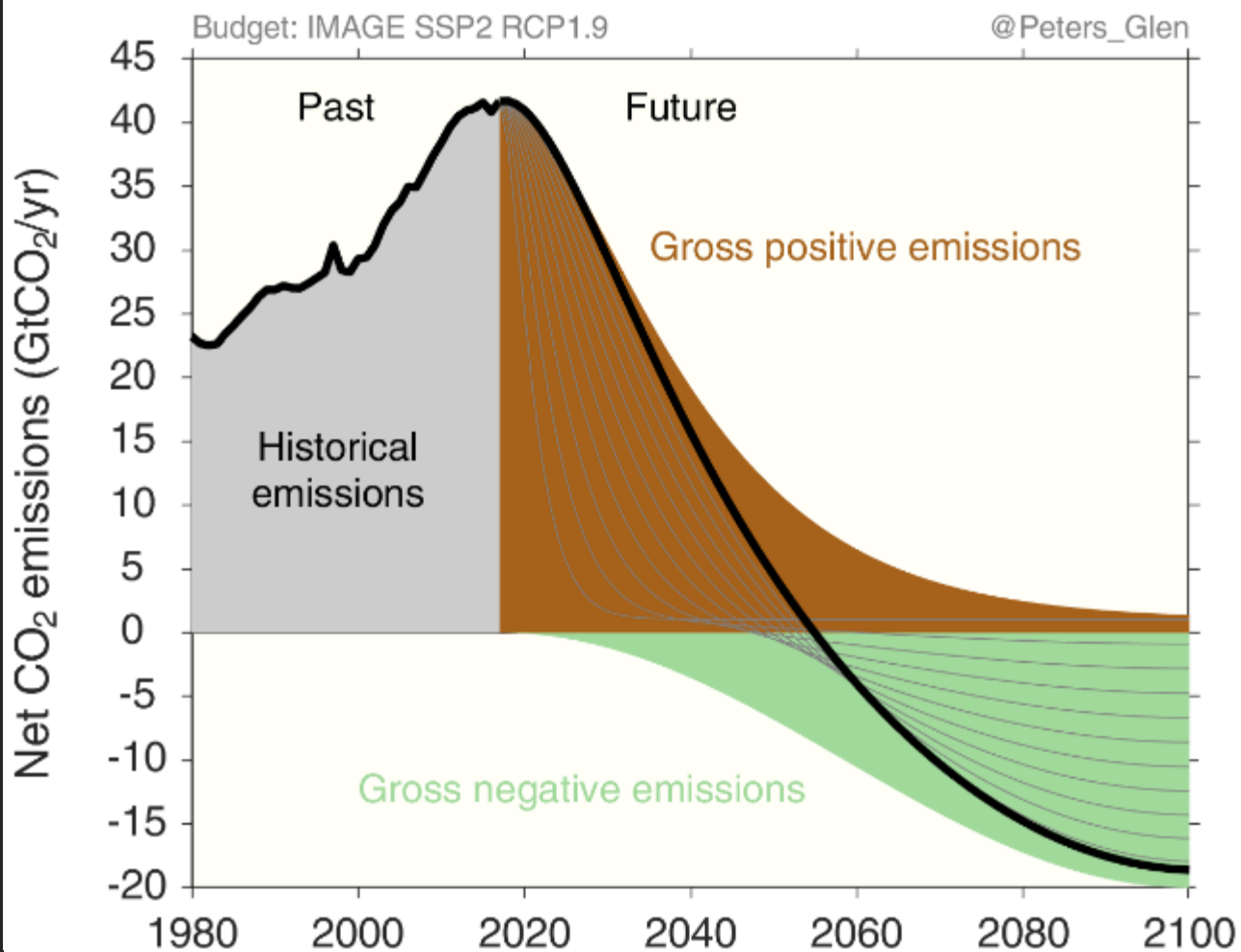
- Biochar **production capacity** is growing at **very high growth rates**
- Total amount of **Biochar produced**
 - **>30.000 t in 2022** → **90.000 t CO_{2e}**
 - **50.000 t in 2023** → **150.000 t CO_{2e}**

www.biochar-industry.com/market-overview/ © EBI 2023

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

at the same time, it is **far away**
from being **climate-relevant** today

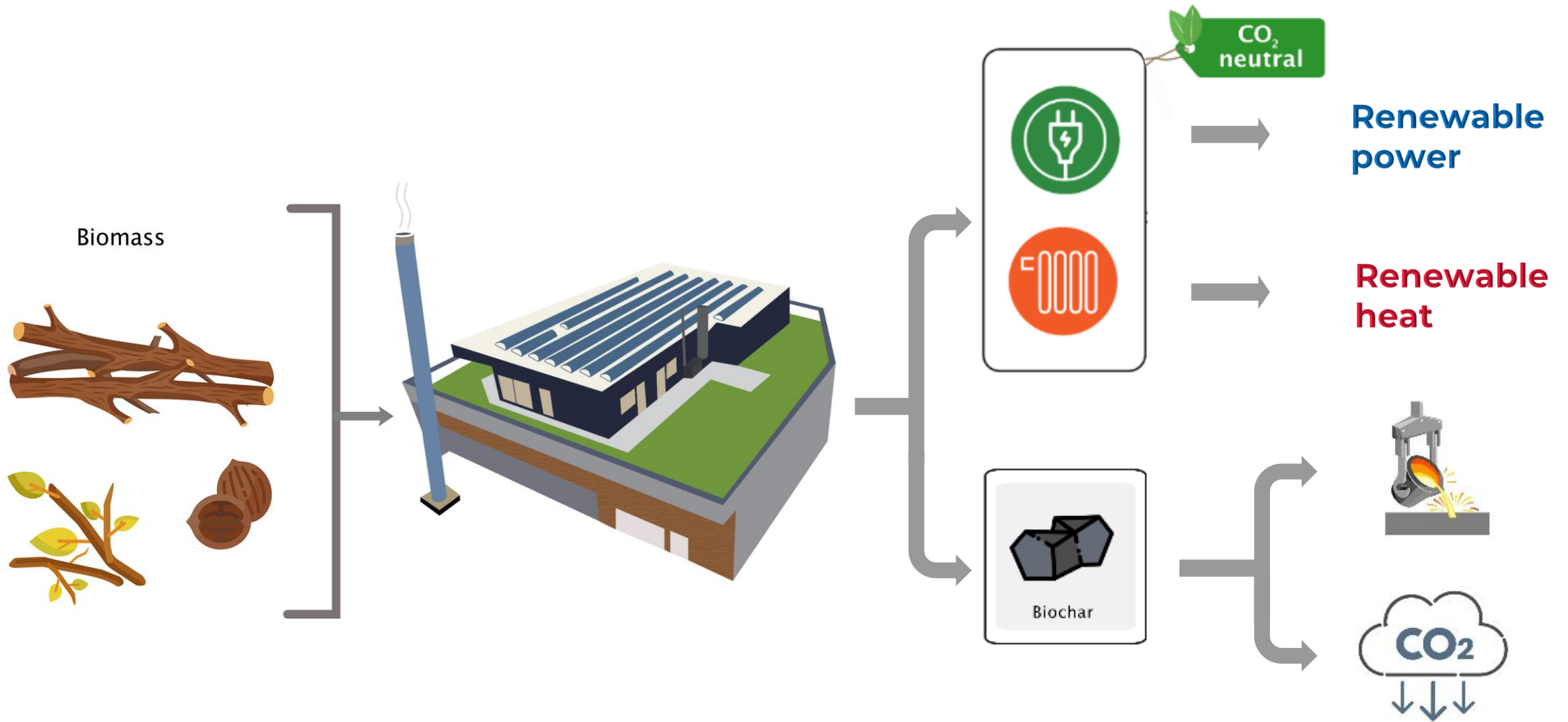
2 BCR's role in Net Zero pathways



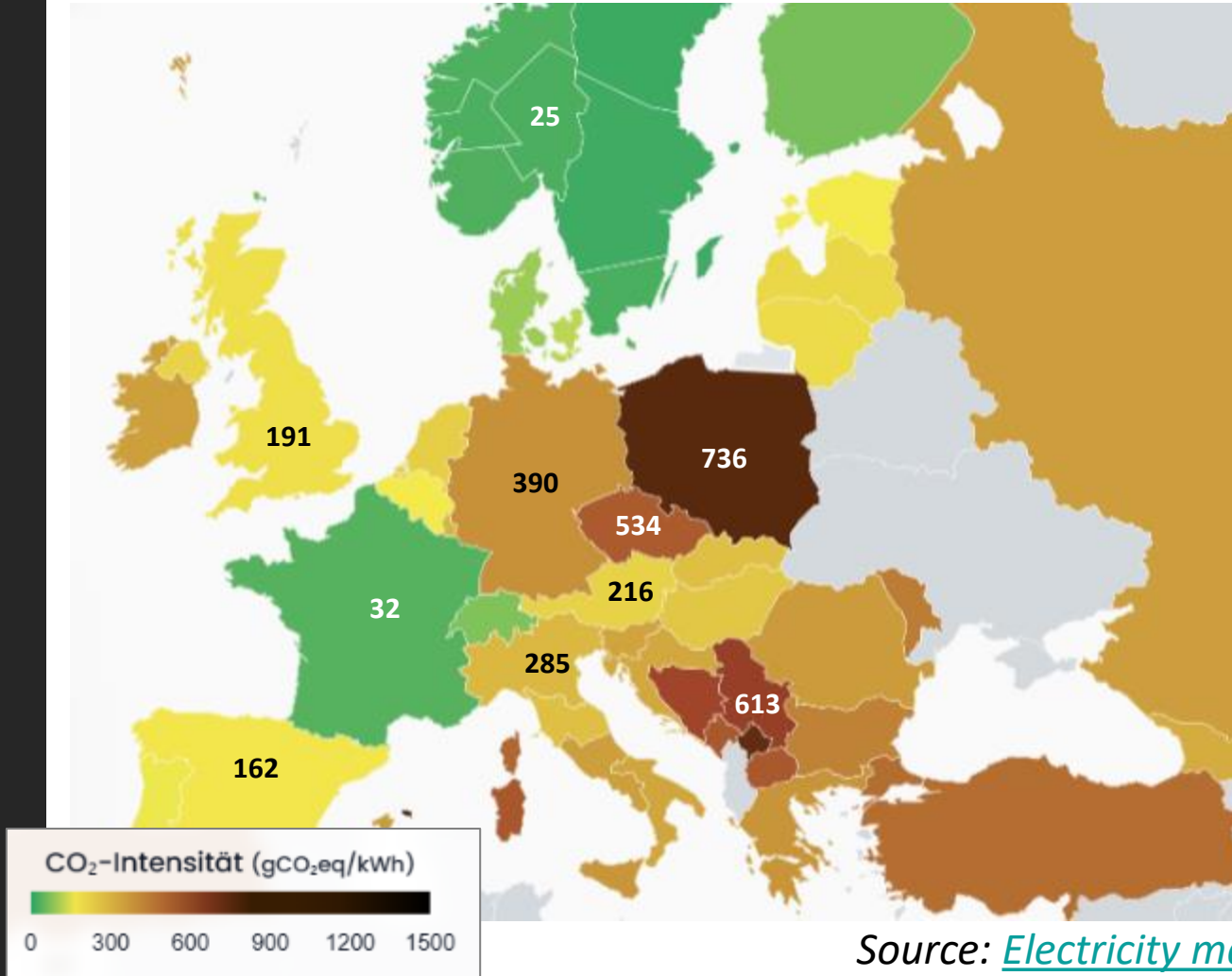
**Emissions
need to be
cut by +90%**

**CDR needs scaling
by a factor of
5.000**

Biomass for energy production and CO₂ removal



CO₂ footprints of energy generation vary widely in Europe



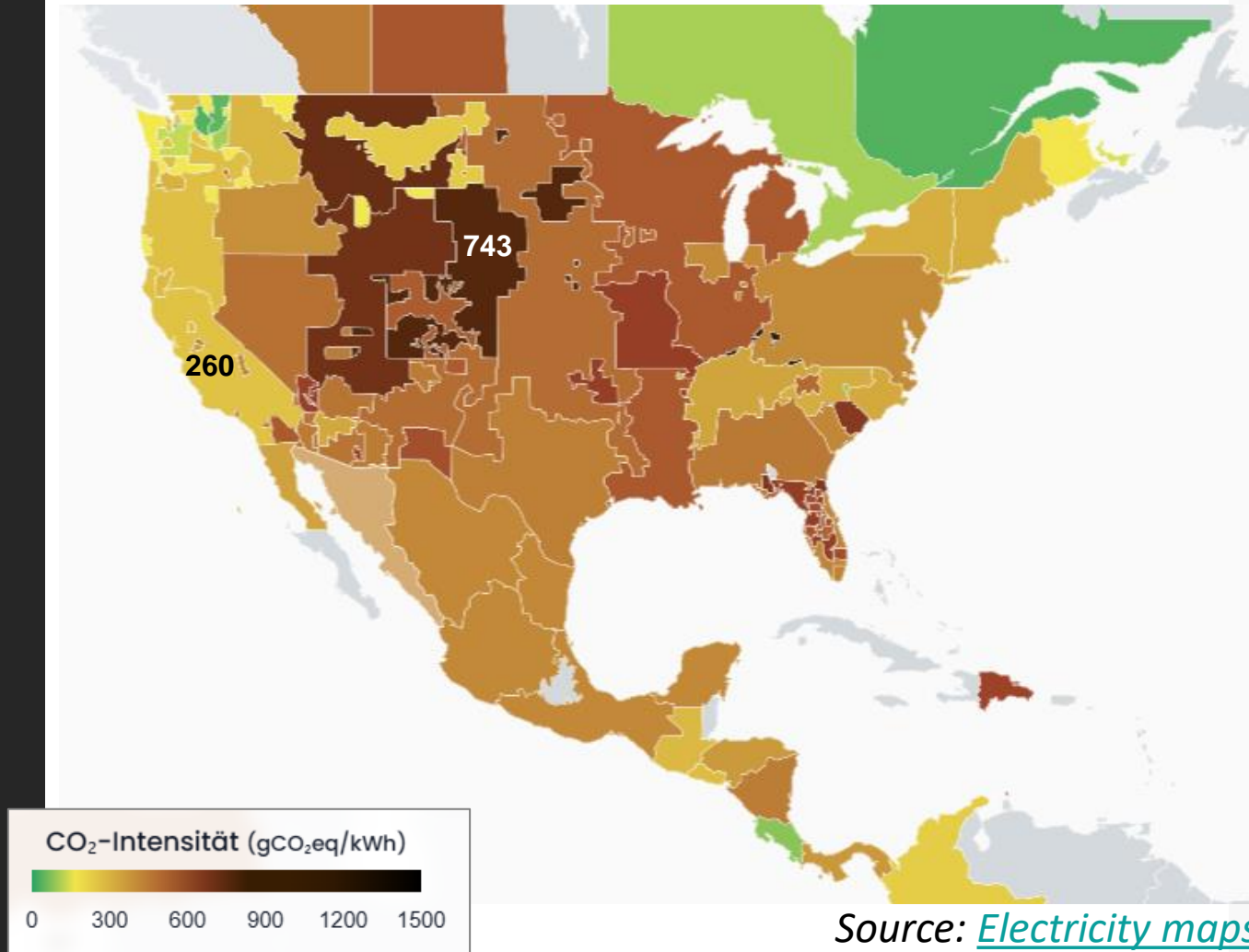
Source: [Electricity maps](#)

* the average footprint in Europe in 2020 was 226 g/kW_{el}

Germany as an example

- At **390 g/kWh**, **Germany** is well **above average** in Europe
- The **problem is coal and lignite** and a **crazy bet on fossil gas**
- The **most/only realistic way** to cut emissions to **zero within 15 - 20 yrs** is to massively **expand wind** and **solar energy** and smart usage of **bioenergy**

CO₂ footprints of energy generation in North America are at very high levels and vary quite substantially



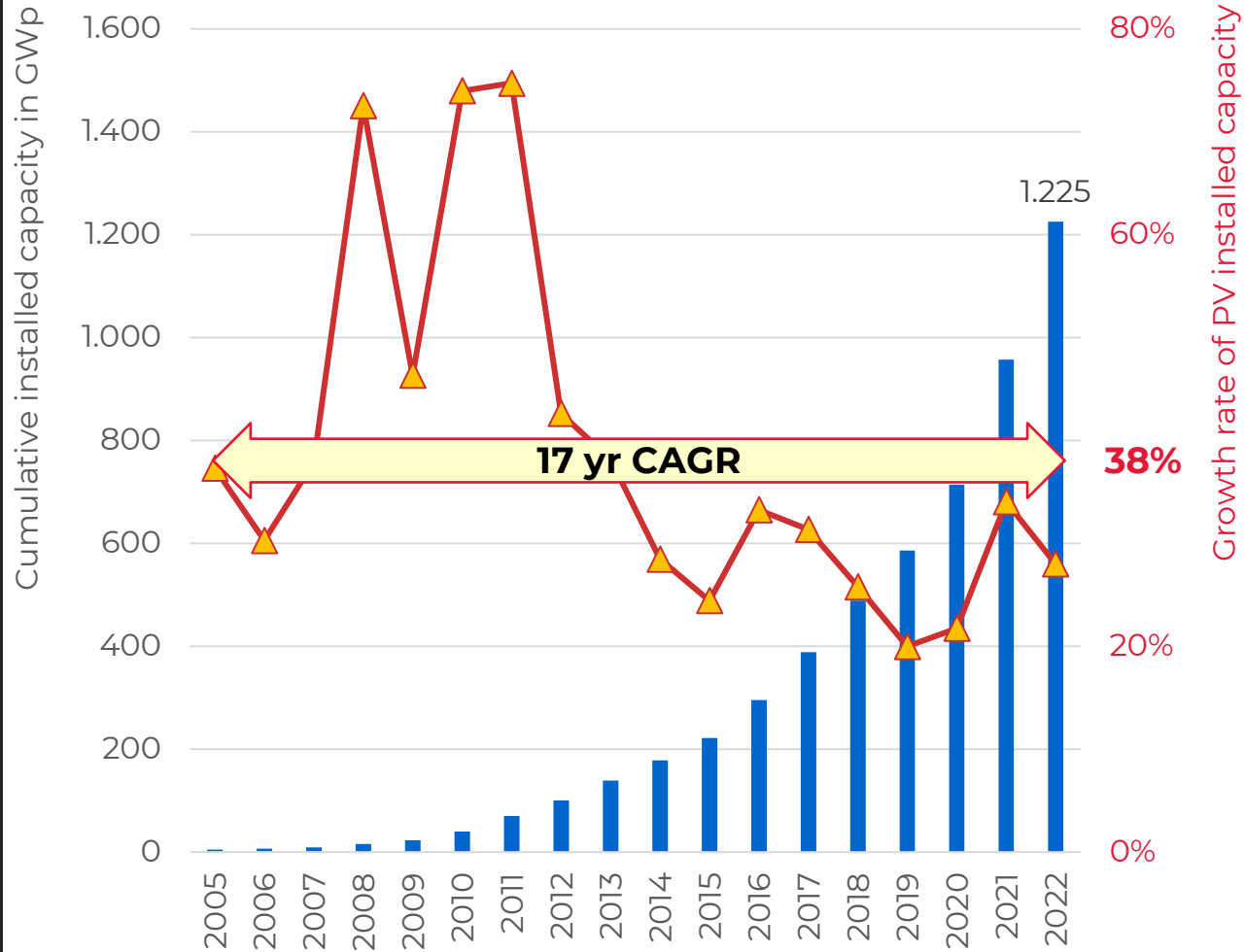
Source: [Electricity maps](#)

- **Without a pathway to de-fossilize the energy sector we don't have to worry too much about carbon removal**
- **Average footprint in US** in 2021 was **370 g/kW_{eI}** (just below Germany)

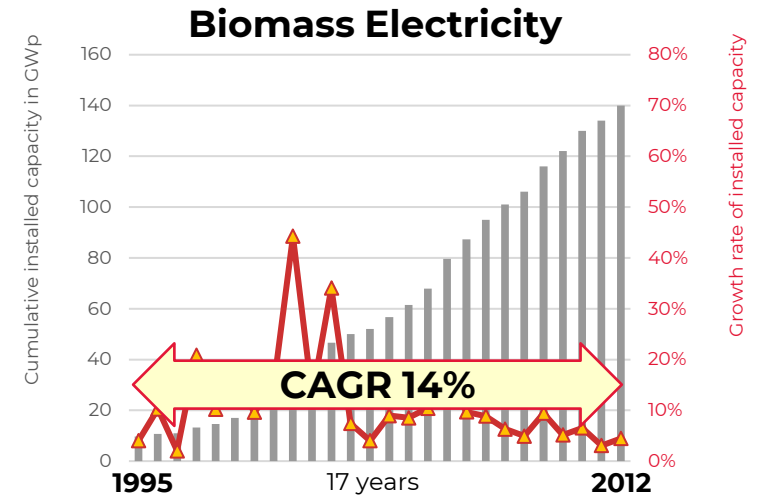
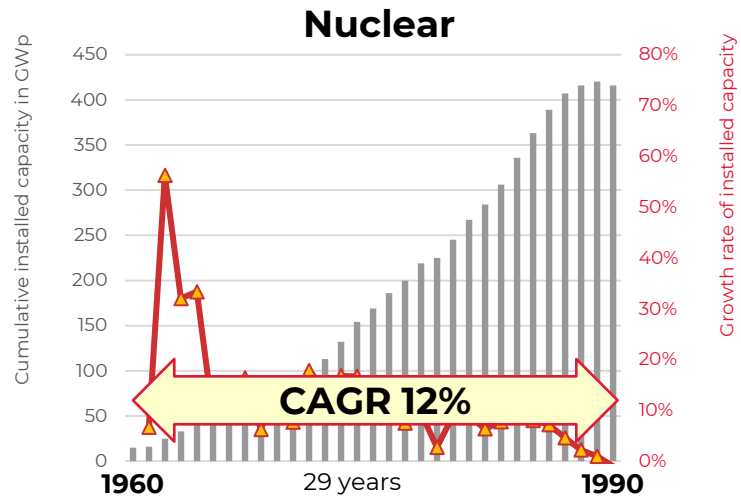
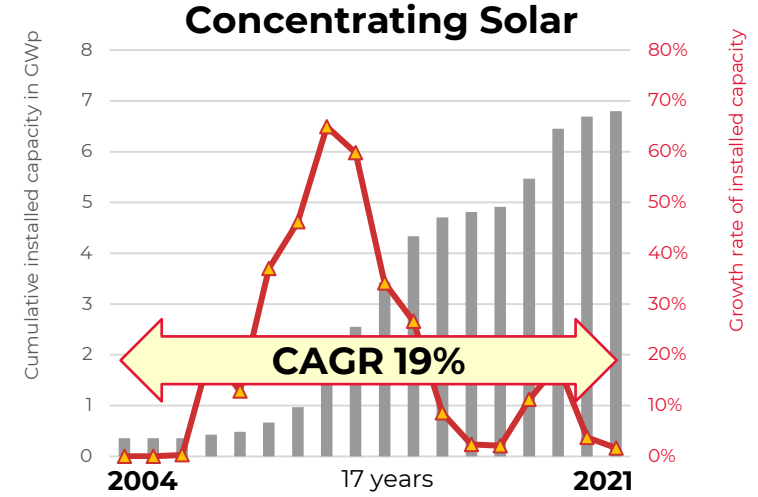
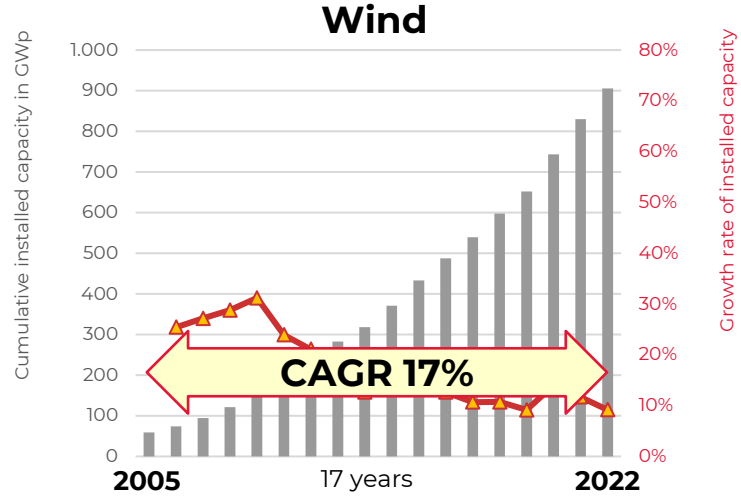
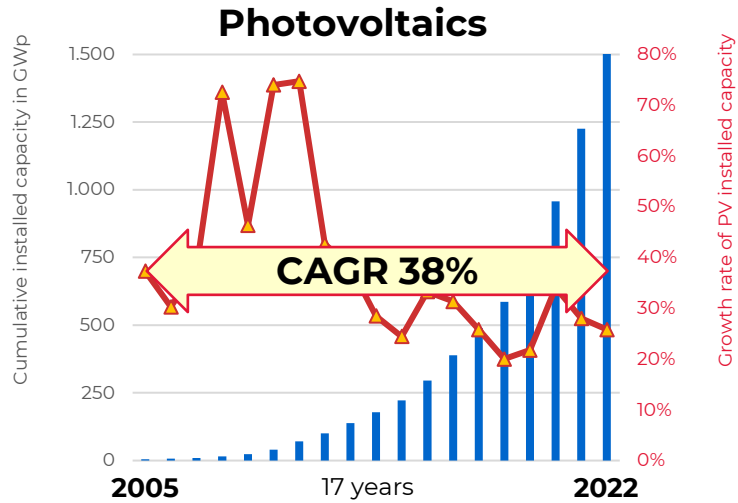
3

Scaling BCR to climate-relevance

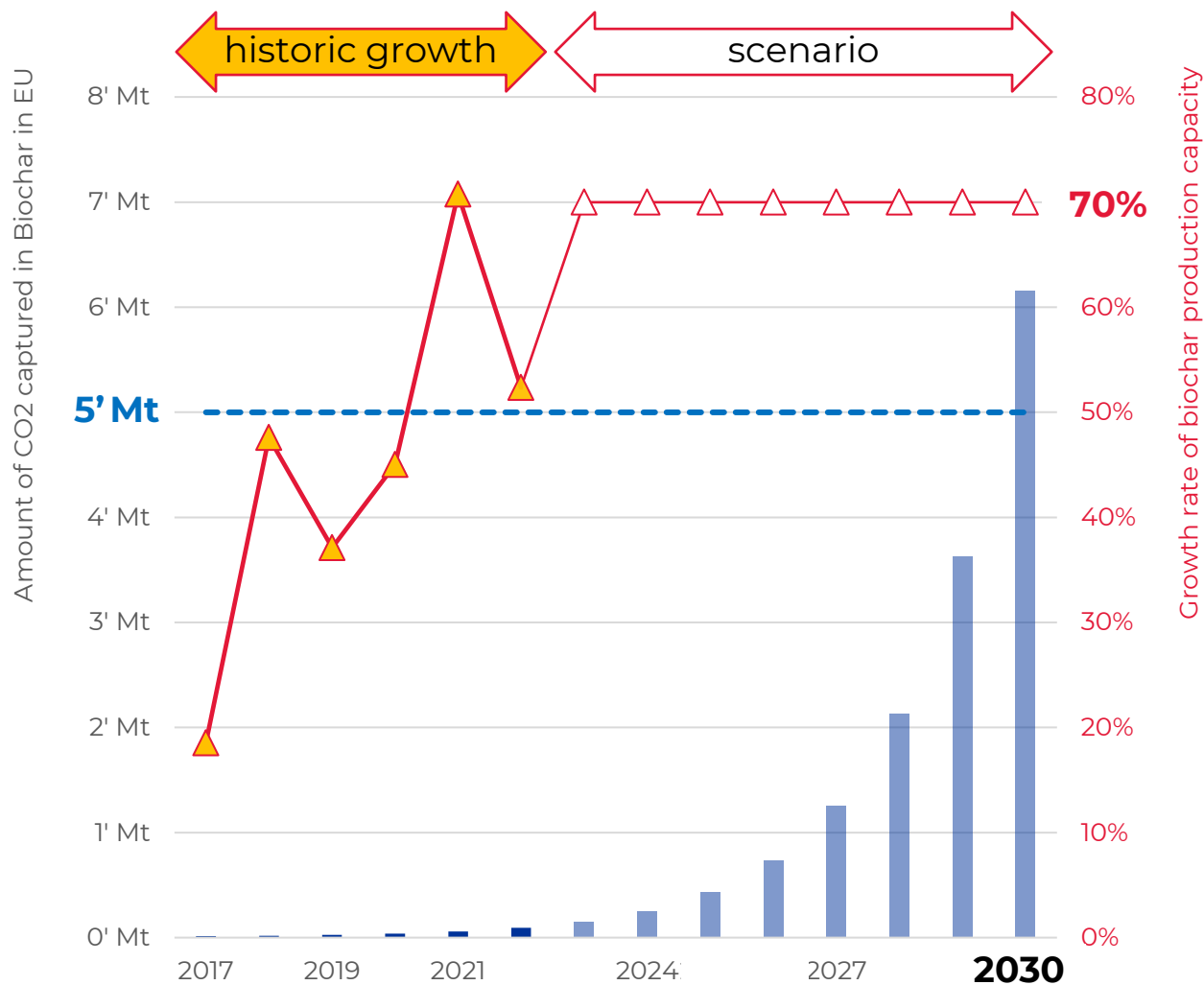
Looking at the PV industry as a benchmark



Growing CAGRs 46% over 17 years is a challenge

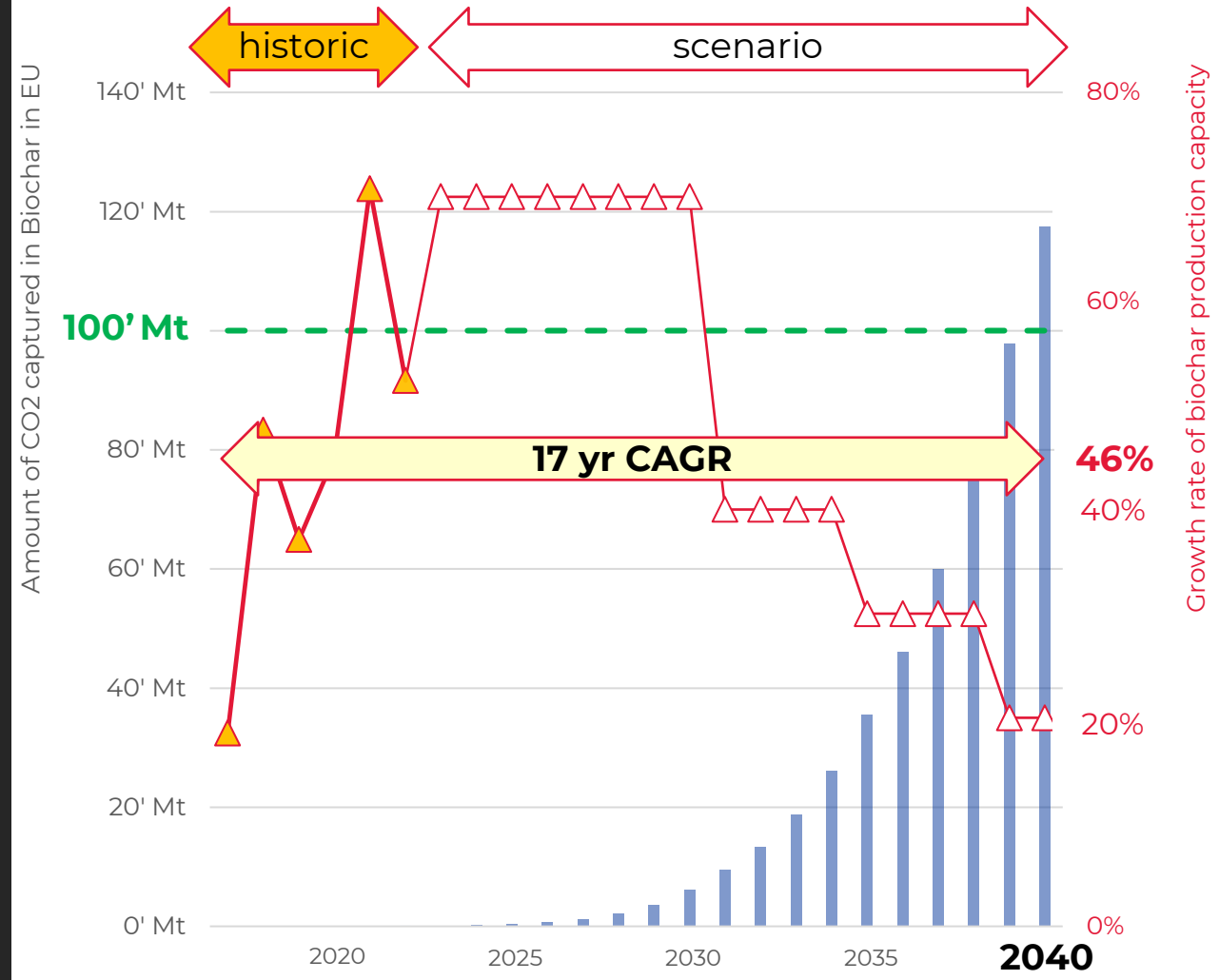


Growing by 70% will bring BCR to 6 megatons by 2030



- The **EU Commission's current target** for industrial CDR in **2030** is **5 Mt**
- At 70% growth, **BCR** will sequester **120%** of that target
- **Denmark** alone has committed to **2 Mt of CO₂e** removal per year in 2030 with pyrolysis (*for which 15 – 20% of estimated available biomass (2030) will be required*)


100 megatons of carbon removal by 2040 in Europe




- **Short term challenge**
 - **commercially attractive setups for producing Biochar**
 - **applications that can scale fast**
- **Long term challenge**
 - **availability of biomass**

Success Criteria for fast growth

Criteria	Biochar
Modularity	100 t to several 10.000 t
Fast project implementation	Preparation: 6 – 24 months Construction: 12 – 24 months
Competitiveness	Competitiveness in niches creates volume which will trigger competitiveness in volume markets
Ease of Financing	Moderate financing volumes High TRL-Levels and revenues from energy are crucial for bankability



BCR is definitely capable of
delivering **carbon removal** at
climate-relevant volumes
by **2040**



4


Biochar Permanence

*Analysis and conclusions from
two groundbreaking papers*

Two groundbreaking papers on permanence of biochar (Jan '24)

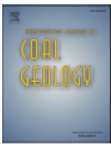
International Journal of Coal Geology 281 (2024) 104409

Contents lists available at [ScienceDirect](#)



International Journal of Coal Geology

journal homepage: www.elsevier.com/locate/coal



Assessing biochar's permanence: An inertinite benchmark

Hamed Sanei^{a,*}, Arka Rudra^a, Zia Møller Moltesen Przewitt^a, Sofie Kousted^a, Marco Benkhettab Sindlev^b, Xiaowei Zheng^a, Søren Bom Nielsen^a, Henrik Ingermann Petersen^{c,*}

^a Lithospheric Organic Carbon (LOC), Department of Geoscience, Aarhus University, Høegh-Guldberg Gade 2, 8000C Aarhus, Denmark
^b Department of Biology, University of Southern Denmark, 5230, Odense, Denmark
^c Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, 1350 Copenhagen, Denmark


Check for updates

Highlights

- Earth's CO₂ storage: inorganic & organic pathways-mineralization and maceralization.
- Biochar: mimics organic pathway, transforms biomass to the permanently stable inertinite.
- Inertinite benchmark: measures biochar's carbonization degree for permanence assessment.
- Study shows 76% commercial biochar as pure inertinite, exceeding benchmark.
- R₀ analysis: reveals carbon pools, calculates carbonization temperature for biochar stability.


Geoderma 441 (2024) 116761

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Geoderma

journal homepage: www.elsevier.com/locate/geoderma



Modelling biochar long-term carbon storage in soil with harmonized analysis of decomposition data

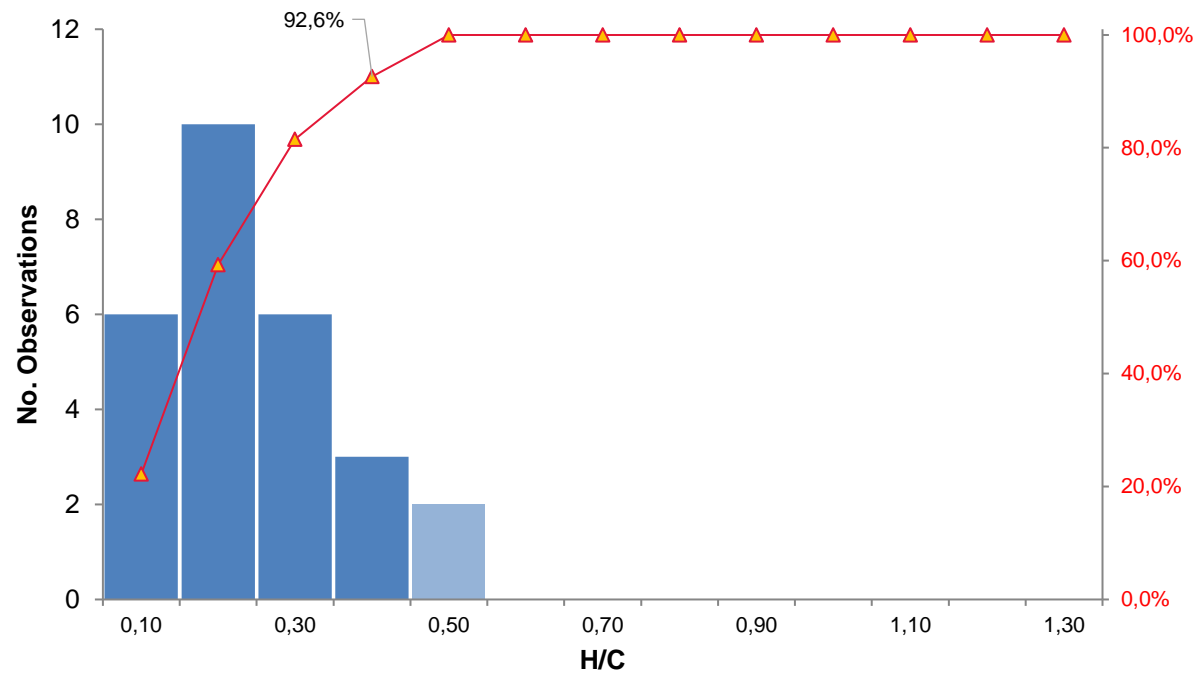
Elias S. Azzi^{a,*}, Haichao Li^b, Harald Cederlund^c, Erik Karlton^b, Cecilia Sundberg^a

^a Department of Energy and Technology, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden
^b Department of Soil and Environment, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden
^c Department of Molecular Sciences, Swedish University of Agricultural Sciences (SLU), Uppsala, Sweden

Highlights

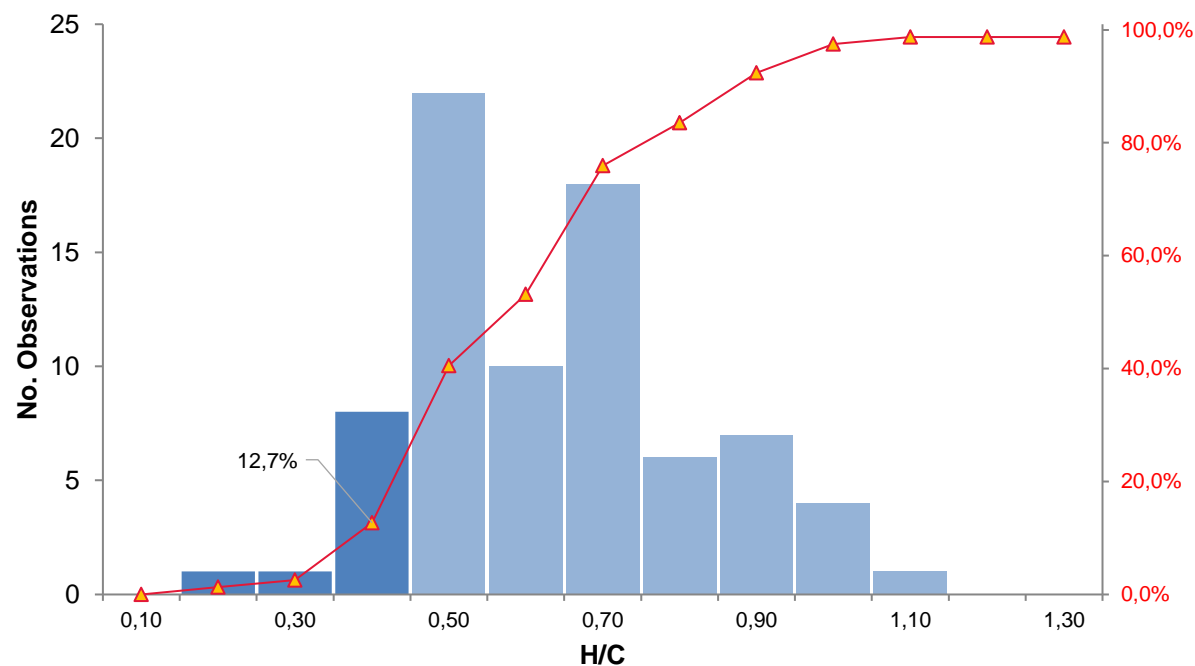
- A dataset of biochar incubations is made available along with code to analyse it.
- Curve fitting and data selection are key steps in biochar persistence modelling.
- The H/C ratio remains the main indicator of biochar persistence.
- Non-linear models improved correlations between BC₁₀₀ estimates and properties.

H/C distribution of 27 commercial/industrial biochars (Sanei 2024)



- From the 64 biochar samples analyzed for **Sanei 2024** EBI selected those biochars that are **volume produced commercial & industrial biochars**
- This leaves us with **27 biochars**
- **25 of these biochar samples (92,3%)** show an **H/C ratio < 0,40** and only 2 samples were slightly above this threshold often used as a proxy for permanence

H/C distribution of 79 data sets of historic publications (Azzi 2024)



- From 134 data sets made available by **Azzi 2024** EBI first followed the selection of Elias Azzi which led to **81 data sets** for “biochar”
- For two data sets no H/C ratio was available so the histogram on the right is on **79 biochars**
 - **10** of these **biochar samples** (12,7%) **show an H/C ratio < 0,40**
 - 69 samples (92,3%) of the samples were above this threshold
 - 50 biochars >0,4 and <0.7
 - 19 biochars even >0.7

“
Biochar fractions
that have been **exposed to high**
temperatures & long enough time are
equivalent to **inertinite**”



Inertinite is the
most stable form of carbon
in the **earth's crust** and stands
as a **benchmark for**
permanence



Inertinite biochar fractions
will **not relevantly degrade**
in soils within
climate-relevant periods
(far beyond 1,000 years)



Hamed Sanei's analysis
of **commercially produced
biochars** shows that
they **consist to 95% - 99%**
of **inertinite biochar** fractions

