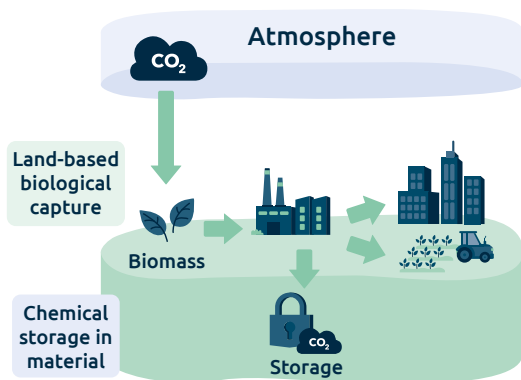


# Biochar

*A material that stores carbon and can reduce CO<sub>2</sub> emissions*



Expected permanence	decades to millennia
Reversal risk	medium
Uncertainty in amount of initially captured carbon	low
Uncertainty in amount of carbon stored over time	high
Ease of MRV	medium
Key co-benefits	increased crop yields, reduced soil N <sub>2</sub> O emissions, soil pH, reduce use of synthetic fertiliser

## What is biochar and how does it store carbon?

Biochar is produced through the thermal decomposition of biomass in the absence of oxygen, in a process called pyrolysis, at a feasible temperature range between 450°-600°C. Heating levels above this range can create liquid form 'bio-oil' and 'pyrogas'.

Biomass can be obtained from a variety of sources, such as urban and municipal waste or agricultural, plant and forestry residues as well as dedicated biomass crops, and its quality determined by its feedstock source and the temperature at which it was produced. For example, a woody feedstock that was heated beyond 450°C has greater stability and a lower decay rate than manure-derived feedstock, heated at a lower temperature.

Permanence and reversibility are dependent on labile and recalcitrant carbon fractions, storage, and storage medium. Biochar can be added to construction material, such as cements and tar, or can be added to soils as it enriches the natural soil carbon sink. Research has shown that the recalcitrant portion of biochar is highly stable, however, due to a lack of long-term field studies, the potential release of stored carbon in biochar over time periods relevant for CDR is unclear.

According to the latest European Biochar Industry report, by the end of 2023, biochar production reached around 49 000 t (equivalent to over 130 000 t CO<sub>2</sub>e).

Relevant regulatory frameworks: Regulation on an EU certification for carbon removals; Renewable Energy Directive; Land Use, Land-Use Change and Forestry Regulation; Regulation for the purpose of adding pyrolysis and gasification materials as a component material category in EU fertilising products as a fertiliser.

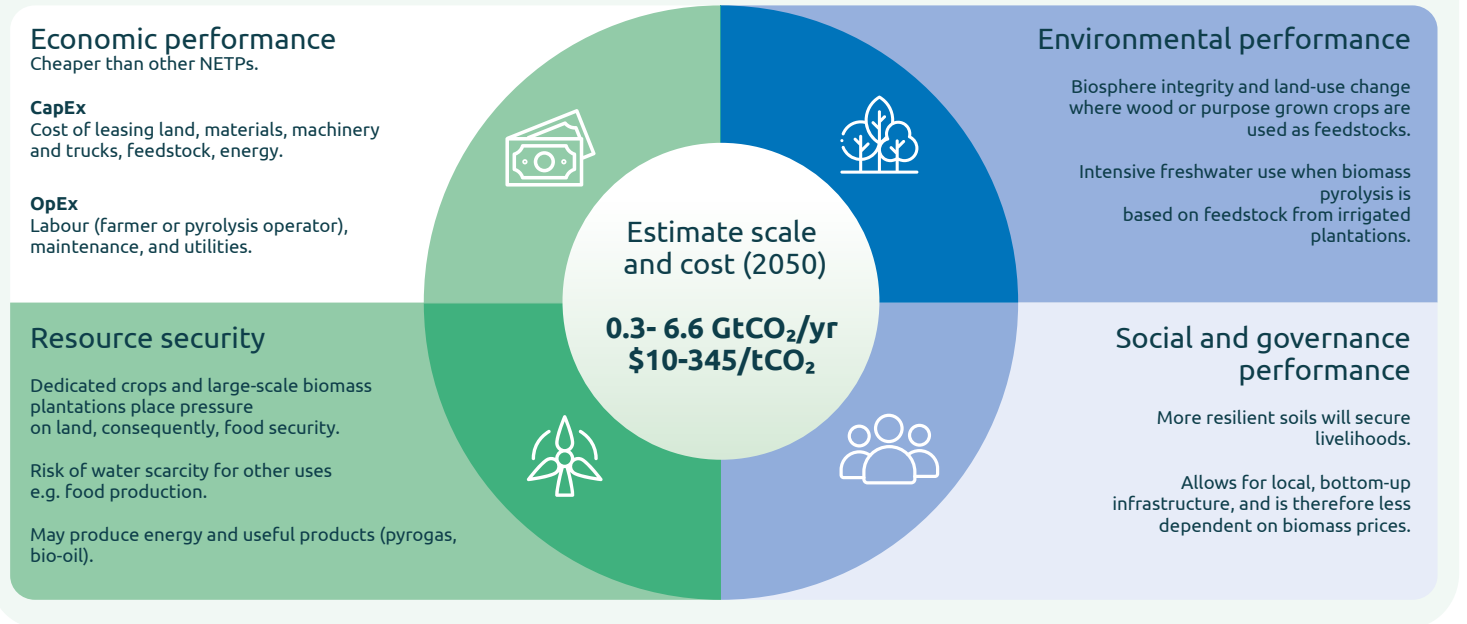
### ADVANTAGES

- MULTIPLE CO-BENEFITS**  
Biochar properties (e.g. high porosity) provide a range of co-benefits for agriculture, such as increased soil nutrient and moisture retention.
- MIXED FEEDSTOCK**  
No separation of feedstock types is required throughout the pyrolysis process.
- SMALL-SCALE DEPLOYMENT**  
Can be widely and rapidly deployed through multiple small-scale plants, utilising locally sourced and sustainable biomass side-streams.
- COST-EFFICIENT**  
Economic viability is high; co-produced syngas and bio-oil can be sold for profit, generating revenue to the plant operators.

### CHALLENGES

- STANDARDISED CERTIFICATION CHALLENGING**  
The numerous storage options for biochar makes a standardised approach to certification of permanently stored carbon with certainty challenging.
- LESS CDR EFFICIENT**  
Lower CDR efficiency than other negative emission technologies and practices due to carbon lost during pyrolysis process and decay.
- SUSTAINABLE FEEDSTOCK COMPETITION**  
Overall biomass demand will increase, leading to competition with other biomass-based NETS such as BioCCS.
- HARD TO MONITOR**  
Permanence of carbon storage biochar and reactivity in open field applications is still unproven. Applied over a large area it is difficult to monitor the dispersed storage of extracted CO<sub>2</sub> and adhere to MRV requirements with certainty.
- ECOSYSTEM DEPENDENT CO-BENEFITS**  
Agricultural benefits are dependent on the soil and properties of the biochar, climate conditions and the interaction between these.
- POTENTIAL CLIMATE FEEDBACKS**  
Albedo changes may result, depending on the application method and the land on which biochar is applied.

# What is the sustainable potential of biochar to sequester carbon?



## Current unknowns and future research perspectives

Reactivity of biochar in different storage mediums (e.g. soils, buildings materials, concrete, asphalt, tar) and the proportion of labile (chemically unstable) and recalcitrant (stable) biochar carbon retained in storage medium e.g. soils over long time periods.

Interaction between biochar and soil properties at the application site and the influence on total carbon loss (i.e. from soil organic carbon stocks and biochar degradation).

Interaction between biochar and soil properties at the application site and the influence on ecosystem co-benefits of biochar application in different soil types e.g. water-holding capacity, crops, yield, climate conditions, non-CO<sub>2</sub> GHG emissions, and binding of heavy-metal pollutants.

## Policy recommendations



Design long-term duration field experiments to provide an increased understanding on biochar properties, functions, and to help develop a comprehensive biochar application policy.



Ensure that the addition of biochar to soil suits the application context by, amongst others, considering climate and soil conditions. Create a regulation with a robust methodology that monitors dispersed storage, potential albedo change, accounts for decay rates and emissions, and assigns liability for reversal.



Ensure that biomass is sourced from side streams such as agricultural and forestry residues, or food waste to avoid accumulating a carbon debt, taking land away from nature, competition with other NETPs, or food insecurity.



Avoid growing dedicated crops. Prioritise growth in abandoned cropland or apply a land- and calorie-neutral pyrolysis system that requires fewer fertilisers, pesticides and irrigation, while providing co-benefits.

## Relevant literature

[CDR Primer](#)

[European Biochar Market Report 2023/2024](#)

[State of CDR](#)

[NEGEM Deliverables](#) NEGEM Deliverables: D1.2, D3.2, D3.8, D3.10, D4.5, D6.3, D7.2