CARBON DIOXIDE REMOVAL TECHNOLOGIES (CDR-T):

BIOCHAR (BC)

TURNING BIOMASS INTO A CARBON SINK

One of the most promising CO_2 removal technologies from the atmosphere is biochar (IPCC, 2022), a carbon-rich material produced by heating biomass in the absence of oxygen. This process, called pyrolysis, locks carbon into a stable solid form that can remain in soils for centuries or even millennia (Lehmann & Joseph, 2012).

HOW DOES BIOCHAR WORK?

The process begins with biomass-crop residues, forestry waste, manure, or sewage sludge. Instead of decomposing and releasing CO_2 back into the atmosphere, this biomass is heated to temperatures above 400 °C in low-oxygen conditions. The result is a combination of three products: Biochar (solid carbon), Bio-oil (liquid fuel), and Pyrolysis gas (combustible gas) (Lehmann & Joseph, 2012).

The biochar co-product is the key to carbon removal. Because of its chemical structure, much of the carbon in biochar is highly resistant to chemical and microbial breakdown, moving carbon from the short-lived biosphere into the long-lived geosphere (Chiaramonti et al., 2024; Sanei et al., 2024).

Biochar is similar to charcoal, which is made from wood primarily for fuel. However, biochar is defined not solely on its renewable feedstock basis and production process, but also by its end application. It can be used for environmental management purposes, such as soil amendments, filtration application, or as an additive in other products (e.g. cement and/or steel). Thus, for it to be labelled biochar, the material must be used in applications which ensure long-term stability (i.e. no combustion) (Hagemann et al., 2018).

HOW MUCH CARBON CAN BIOCHAR STORE?

Recent studies estimate that biochar could remove up to 245 million tonnes of CO_2 per year in Europe alone, corresponding to an annual biochar production of around 121 million tonnes (Lefebvre et al., 2023). The permanence of biochar depends on its production conditions and feedstock: higher temperatures showed higher stable carbon in produced biochar (Azzi et al., 2024).

To measure permanence, scientists use methods such as chemical oxidation, incubation experiments, and advanced modelling (Adhikari et al., 2024). These approaches help ensure that carbon credits associated with biochar carbon removal are based on solid science.

WHAT IS THE ECONOMIC VALUE?

The cost and therefore the price of biochar, which is sustainably produced, vary widely depending on feedstock and technology (Trapero et al., 2025). When expressed as cost per ton of CO_2 removed, biochar is very competitive with other engineered CDR methods. As a result of the relatively low cost and the technology readiness and availability, biochar projects already dominate the voluntary carbon market, delivering over 90% of issued CDR credits in 2023 (Smith et al., 2023, CDR.fyi, 2025).

For farmers, biochar offers co-benefits: improved soil health and protection, enhanced water retention (Gholamahmadi et al., 2023; Wei et al., 2023), higher yields (Ye et al., 2020), and reduced need for fertilisers due to improved nutrient retention (Buss et al., 2020). All this means that biochar can generate climate, environmental, and economic value.

WHAT ARE OTHER CO-BENEFITS?

Other co-benefits cover the use of biochar in construction materials such as concrete (Lin et al., 2023) and/or steel industry (Ren et al., 2025) which lead to reducing CO_2 emissions.

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WHAT ARE THE RISKS?

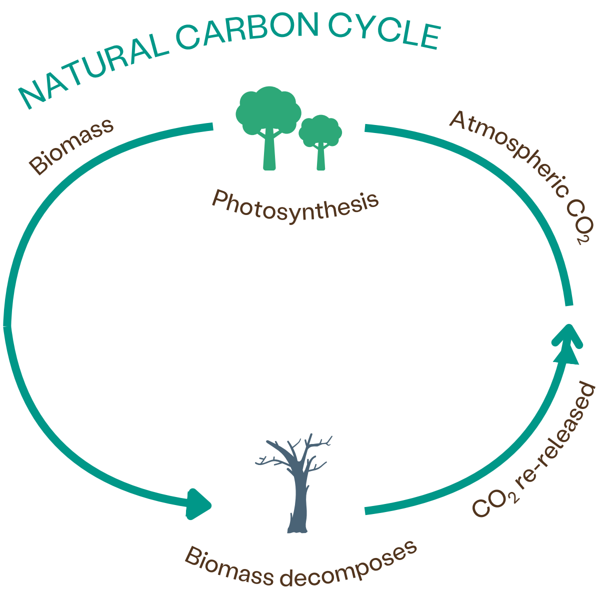
Risks must also be considered, such as unsustainable biomass sourcing, which could harm biodiversity (Smith et al., 2023). Besides, its production may emit particulates or greenhouse gases if not well controlled (Buss et al., 2022). Use of appropriate emissions management technologies is therefore critical.

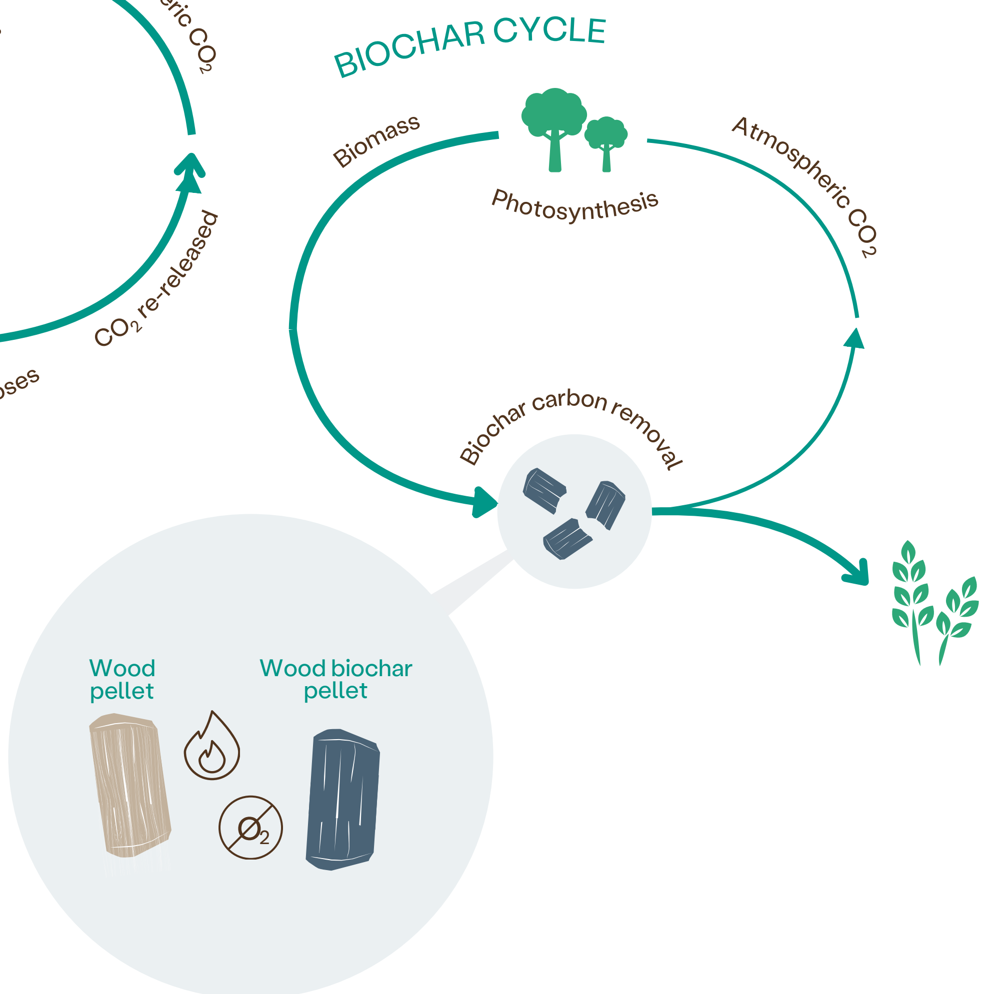
Overall, biochar presents a low reversal risk compared to other CDR methods according to CRCF (2024), since once applied to soils, it is nearly impossible for it to be lost through fire or intentional removal (Chiaramonti et al., 2024).

C-SINK PROJECT

C-SINK is an EU-funded project that aims to establish the foundations for a standardized and transparent European Carbon Dioxide Removal (CDR) market.

For biochar, C-SINK is developing two distinct case studies at operational production and application sites: one in Oliveira de Azeméis, Portugal (Ibero Massa Florestal (IMF) and another linked to an industrial feedstock-to-product demonstration in the UK (Pyrogenesys (PYR)/Birmingham), where MRV is carried out in situ across the full production–application chain. Both case studies test MRV under real, open-system conditions, focusing on transparent, scalable, and long-term sustainable removals by biochar.





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