BIOCHAR DEPLOYMENT IN NET ZERO SCENARIOS: IDENTIFICATION OF INDUSTRIAL FEASIBILITY CONSTRAINTS

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Overview

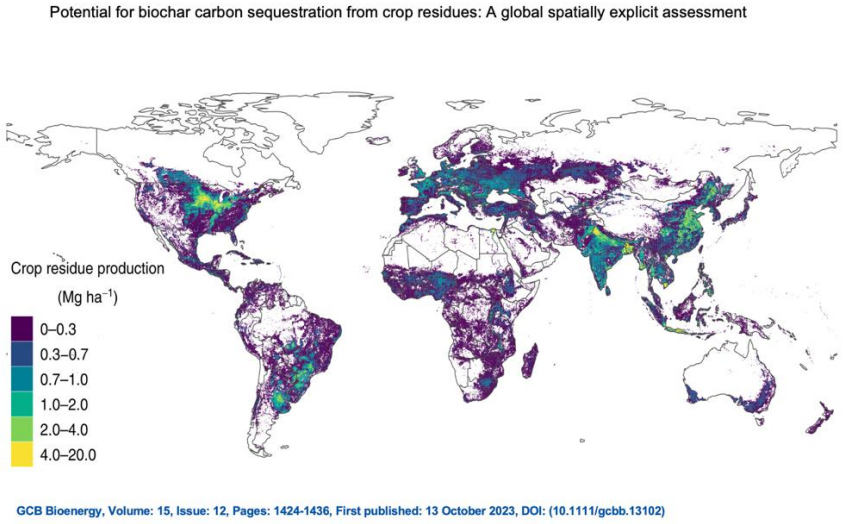
According to the IPCC, carbon dioxide removal is unavoidable to reach the Paris Agreements climate targets C (Shukla et al., 2022). Carbon dioxide removal include all human activities aiming at removing carbon dioxide from the atmosphere and durably storing it (Smith et al., 2024). Biochar is a carbon-dense, biogenic charcoal produced through the pyrolysis of biomass, which transforms the carbon content originating from atmospheric CO2 (fixed through photosynthesis) into a more stable form of carbon for long term storage. This process also co-produces syngas and bio-oil and, once applied to agricultural soil, biochar can increase crop yields.

Biochar is one of the mature CDR methods that private investors invest in the most. In 2023, it represented more carbon removed from the atmosphere than Bioenergy with Carbon Capture and Storage (BECCS) and Direct Air Capture with CCS (DACCS) combined (Pongratz et al., 2024), with a global market worth $600 millions (*Global Biochar Market Soars to $600 Million in 2023, Setting the Stage for Future Growth*, 2024). However, Biochar is much less included in Integrated Assessment Models (IAM) scenarios than the two others less mature CDR technologies, with only two scenarios accounting for biochar in the latest IPCC report compared to 280 for DACCS (Byers et al., 2022). Certain scenarios were shown to rely too heavily on BECCS and CCS to reach our climate targets (Kazlou et al., 2024; Workman et al., 2021), questioning our ability to meet our climate targets and our aim is to identify of it is the case for Biochar.

IPCC scenarios accounting for biochar plan for an acceleration phase until 2040 stabilizing until 2100 with a maximum of 2,4 Gt CO_2 in 2050 (Byers et al., 2022). The objective of this paper is to analyze the industrial feasibility of biochar, beyond the hype in the private sector and the lack of data in the scientific literature. Biochar industrial development challenges existing scenarios and offers new realistic estimates for the potential of carbon dioxide removal with a mature technology. In this paper, we will investigate the potential and industrial limitations of Biochar as a contributor to Net Zero efforts.

Methods

Adapted from (Kazlou et al., 2024) our method aims at using reference cases of technologies already at scale to analyze the potential of biochar to reach the gigaton capacity before 2050.



Technologies usually scale up in different stages: a slow formative, an acceleration and a stabilization phase. Challenges in each stage can be caused by different factors. A first step will be an analysis of the existing project and their failure rate and to produce a review of the literature of the challenges and constraints faced by biochar to scale up, including : policy support (including conflicts of use with other sectors), feedstock availability and logistics, biochar application related challenges, logistic and economic constraints.

The review will allow us to identify reference cases, i.e. already at scale (or failed) technologies and industries that have faced comparable barriers and analyze their scale up rate (or their failure) and challenges during the different phases. The analysis will try to define the industrial potential of biochar and its main characteristics.

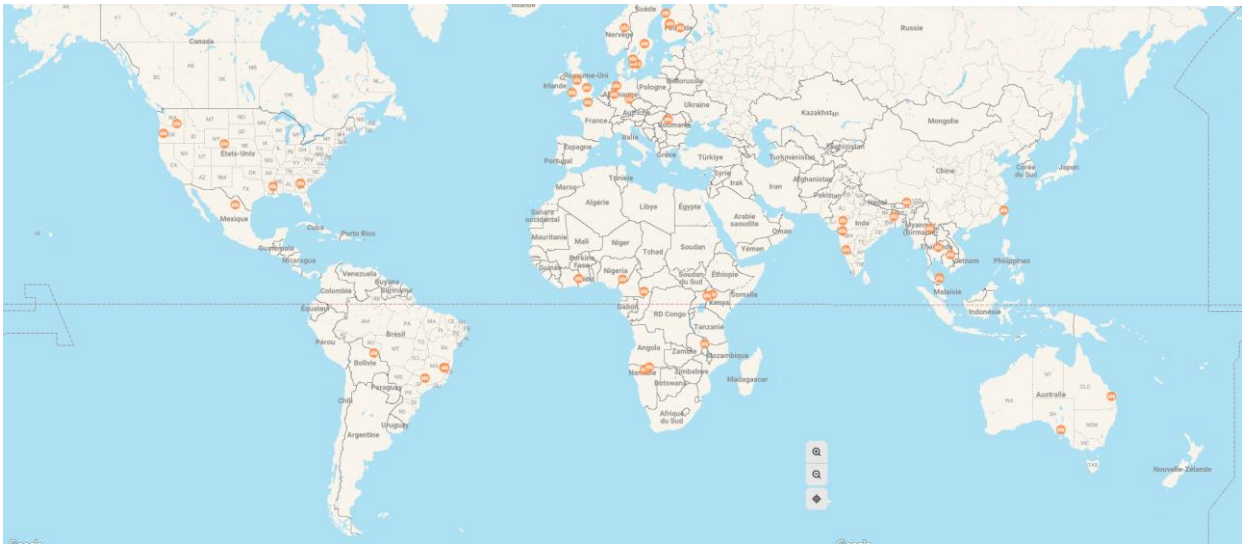


Figure 1 : Map of the 54 current Biochar projects
Source: CDR.fyi, extraction January 2025

Results

This paper will analyze the potential of biochar as a carbon dioxide removal method to participate in climate targets. This includes the positioning of chronological milestones for the formative phase, acceleration and stabilization phases as well as maximum amount of CO_2 removed by biochar at the end of each phase based on the comparison with relevant reference cases. In particular, the relative significance of policy needs versus market demand in upscaling biochar will be analyzed.

These results are crucial to refine the orders of magnitude carbon dioxide removal, in particular biochar, will play in reaching our climate targets. Limited potential for biochar, but also for other CDR activities if further research shows a tendency to rely too heavily on CDR, would have consequences on the decarbonization necessary to reach carbon neutrality. These feasibility estimates could be used to model its contribution to achieving the Paris Agreement targets.

Conclusions

Biochar is one of the CDR methods most attractive to investors and corporations seeking novel CDR for their Net-Zero objective but it is less studied in the literature than BECCS or DACCS. This paper offers an analysis of the industrial potential of biochar in removing carbon from the atmosphere and durably storing it. It can models and scenarios to include biochar in strategies with realistic expectations as well as inform investors of the potential need to complement their strategies with other permanent CDR.

Further research could analyze the public support and policies necessary to allow for the deployment of biochar, i.e. Analyze the lessons to draw from the failure or deployment of the reference case technologies analyzed in this paper. Further research could also apply this methodology to other CDR activities as suggested by (Kazlou et al., 2024).

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