Imperial College London

Natural Environment Research Council

2024_8_ChemEng_JH: Systems analysis of direct carbon dioxide removal from air and long-term storage through algal biochar production

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Countries, corporations, and societies are all embracing the challenges posed by climate change and in seeking solutions to address it. To achieve the ambitious CO2 emission reduction targets framed by the Paris Agreement, a variety of technologies will need to be deployed and the Intergovernmental Panel on Climate Change recognise that this will include Carbon Dioxide Removal (CDR).

While a nascent field there are many dimensions to CDR. These include afforestation projects (with challenges around additionality and longevity of carbon reduction) and direct air capture projects (with challenges around scalability and the cost of carbon reduction). Our industrial partner Co2Co focuses on removing carbon dioxide from the atmosphere by growing and harvesting microalgae and processing this into long-lasting biochar. The deployment of biochar in various use cases, e.g. agriculture, soil remediation or construction, enables carbon to be locked into the biosphere hence breaking the natural carbon cycle and achieving carbon removal.

While we have been working for several years on developing this solution, our understanding of systems elements beyond the technology itself remain underdeveloped. We have high-level process design and techno-economic models leveraging existing and mature technologies but combining them in a novel and unique way. This will enable the cultivation, harvesting and processing of microalgae at scale and at a commercially competitive price point.

The process we have formulated is highly scalable, thereby making a meaningful impact on the climate (up to 1 Gt/yr CO2e remediation). This bypasses the many challenges of existing CDR options including cost, quality of the solution (specifically longevity) and the ability to scale and capture significant quantities of atmospheric carbon dioxide. There are no CDR solutions in operation today using these methods which makes this approach innovative and unique.

This project will bring a higher level of understanding to the wider impacts of Co2Co's proposed algal biochar process and establish the environmental credentials and potential climate impacts of this technology. We will employ a variety of process and systems level approaches to achieve a deep understanding of the potential positive implications of algal biochar production as a CDR approach. We will initially focus on a complete life cycle assessment to establish the carbon footprint and sequestration cycle of the biochar and evaluate various production scenarios at process and systems levels. We will optimize the production for minimal energy use and evaluate the supply chain implications behind biochar deployment in several target applications and geographical locations.

These findings will then be used, in cooperation with the Supergen Bioenergy Hub, to develop a policy framework for advising government agencies and climate NGOs on the potential benefits and drawbacks surrounding algal biochar as a CDR technology at scale.