Input to the Structured Public Consultation

Removal activities under the Article 6.4 mechanism

Dear UNFCCC Supervisory Body and CMA members,

We would like to thank you for the opportunity to provide input on the abovementioned structured consultation. Our input is focused on the evaluation of different removals, the topic of permanence/longevity, and the potential of Biochar Carbon Removal (BCR), which we believe is underrepresented in the current form of the guidance.

Company info:

I am writing in my function as Co-Founder and CEO of ecoLocked GmbH. We are a German climate tech startup focused on turning captured carbon in the form of biochar into a building material additive, thereby enabling long-term carbon storage. I myself, Dr. Mario Schmitt, have long been active in the environmental community, researching and enabling pathways for industrial decarbonization and ecosystem conservation at RWTH Aachen and together with the Boston Consulting Group, WWF, and PIK Potsdam, amongst others.

Our key remark:

We would like to call for biochar carbon removal to be recognized as a key removal technology that is ideally suited for the Article 6.4 mechanism as it combines high permanence with the ability to deliver significant near-term removals, a well-developed system for measurement, reporting, and verification (MRV), and environmental and social co-benefits.

The role of removals:

1. **Role and evaluation criteria:** CDR at scale has become a necessity for the world to return to a 1.5° or 2° climate path. In fact, the latest IPCC report shows that for a 1.5° world, we need to deploy carbon dioxide removal (CDR) technologies starting now and increase volumes to 10-20 Gt of CO2 removed per year until 2100 latest, but probably already until 2050. For that, we require long-term carbon removal technologies that prevent the release of the captured carbon for as long as possible; ideally for centuries to millennia. In addition to permanence, CDR technologies must be evaluated by their potential to already deliver significant removals in the near future. For this purpose, we suggest to consider three distinct criteria: 1) Technological readiness, 2) Economic viability, and 3) Global scalability.
2. **Biochar Carbon Removal (BCR):** Biochar is a carbonaceous solid created by concentrating ('locking up') more than half of the carbon contained in organic waste through a high-temperature, oxygen-deprived thermal conversion process. One ton of biochar can "lock up" up to 3.3 tons of CO2. Since it requires technology to convert waste biomass into this inert carbonaceous material, BCR represents an "engineered removal". BCR is currently the leading CDR method in terms of near-term potential and deliveries thanks to higher maturity (technological readiness), economic viability, and versatility (which provides for scalability) versus many of the more nascent and expensive technologies:
    a. **Technological readiness:** As we approach climate tipping points, the time-to-impact of a CDR technology is key. Over the last decade, BCR technology has been optimized for industrial scale so that nowadays, pyrolysis technology is capable of producing more than 1,000 tons a year, handling diverse waste inputs of varying moisture, and capturing pyrolysis oil and syngas as byproducts. This makes many systems net energy generating as they require only a small amount of starting energy and, once up and running, reuse the syngas for operating heat or electricity. Capacity is increasing by 70-80% a year, and both (pre-)purchases (40%) and deliveries (87%) of carbon credits are dominated by BCR. This is not least because with BCR, a verified impact can be achieved within just a few months to one year after investing in a project.
    b. **Economic viability:** BCR is one of the most beneficial ways of recycling waste biomass as it effectively converts all substances contained into valuable outputs: biochar, pyrolysis gas, and sometimes pyrolysis oil. Biochar itself is a highly versatile material that can, for example, be used

as a fertilizer-enhancer for regenerative crop farming, as activated charcoal to filter wastewater, and to replace virgin and/or fossil resources in the production of materials. Meanwhile, pyrolysis gas could serve as a source of biogenic CO_2 and hydrogen for fuel production or as an energy carrier. Revenue streams from those products can cross-subsidize the carbon removal costs from a pyrolysis plant, which are estimated at [anywhere between € 10 and € 345](). With declining Capex and increasing monetization of material outputs, we expect costs to level out at € 30-120 per ton of CO_2 at industrial scale.

c. **Global scalability:** BCR has the potential to deliver several gigatons of carbon removal per year (see Fuss et al., 2018, Slade et al., 2014, Lee & Day, 2012). The IPCC puts the average removal potential at "2.6 (0.2–6.6) GtCO2-eq yr–1, of which 1.1 (0.3–1.8) GtCO2-eq yr–1 is available up to USD100 tCO2 –1" (see IPCC_AR6_WGIII_Chapter07.pdf). One reason is that BCR can use any organic waste biomass as feedstock. This ensures scalability, as production plants are able to accommodate locally available biowaste. Studies estimate the global availability of dry waste biomass at more than 2 and up to 100 Gt (see ICEF 2020, Slade et al., 2014). In addition, biochar can be used profitably in multiple global markets, which makes its production and storage financially viable.

Monitoring, reporting and accounting:

1. **Permanence:** It will be important for the Article 6.4 mechanism to consider the longevity of removals, which can last anywhere from a few years (like in many afforestation projects) to more than 1.000 years. Further details on permanence can be found in the The State of Carbon Dioxide Removal (stateofcdr.org).
2. **Permanence for Biochar Carbon Removal (BCR):** From a chemical perspective, biochar can best be compared to fusinite and inertinite, which define the endpoint of the evolution of carbon as they possess the highest stability (similar to carbonates in the inorganic carbon cycle). BCR has been found to enable removals with a permanence of several hundred years (see Woolf et al., 2021, Biochar Systems Research Group, 2023). For geological storage and mineralization in building materials, durations of more than 1.000 years are likely (example for storage in concrete: even if buildings get disassembled, the carbon atoms will stay bound to the hydration products). Considering the higher present value of long-term removals, we strongly advise accounting for differences in the longevity of removals when implementing the Article 6.4 mechanism.

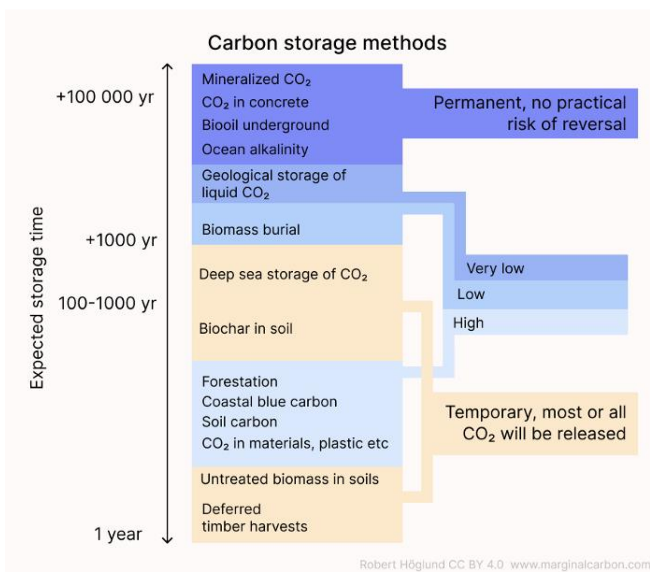

FIGURE TAKEN FROM HOEGLUND, 2022

3. **Accounting for Biochar Carbon Removal (BCR):** The fact that BCR is an engineered removal facilitates robust MRV, especially when compared to nature-based solutions, because the carbon removal is a) linked

to a specific machine whose output can be tracked and b) delivered and validated within a short timeframe. As biochar gets produced via pyrolysis and other technologies, it is assigned a carbon sink potential. This is established by a third-party verifier (e.g., Carbonfuture) who validates the LCA provided by the producer according to already established certification standards such as the European Biochar Certification or Puro.earth. Before that carbon sink potential can be turned into an actual carbon credit, the end use of the biochar must be validated. This is easiest when introducing biochar into materials such as concrete (where it is almost impossible to loosen the bond between the carbon and the cement hydration products) but can also be done for biochar in soils. In general, the risk of reversal is extremely low for biochar in most applications due to its chemical structure and the bonds it forms with other substances.

Environmental and social impacts:

1. **Risks from Biochar Carbon Removal (BCR):** Risks from biochar production are minimal as carbon in solid form does not pose any danger to the environment when leaching. Naturally, all production facilities must be certified to local environmental standards; for example, the REACH Directive in the EU. Furthermore, explosion risk from flammability of the material must be mitigated by managing the material's moisture content. Finally, all biochar producers must have a sustainable sourcing strategy in place to prevent that the extraction of waste biomass from an ecosystem has negative impacts on biodiversity but also dependent communities.
2. **Co-benefits from Biochar Carbon Removal (BCR):** Since BCR transforms waste materials into valuable and monetizable resources, it can provide significant social benefits by unlocking new revenue streams for local communities. This is particularly relevant in rural areas in the Global South where agricultural waste and invasive plant species are abundant. As described above, revenue streams include not only the biochar as a material but also CO2 certificates and pyrolysis gas or oil. The latter can be converted to carbon-neutral energy to replace fossil fuels for powering close-by industries and communities. Meanwhile, thanks to the functional abilities of the biochar, its use as a fertilizing agent in agriculture or as a building material additive can be engineered to deliver further environmental benefits such as pollutant filtration, carbon-neutral insulation, or water retention.