UNFCCC ARTICLE 6.4 CALL FOR INPUT 2023 - ISSUES INCLUDED IN THE ANNOTATED AGENDA AND RELATED ANNEXES OF THE FIFTH MEETING OF THE ARTICLE 6.4 SUPERVISORY BODY: CARBON ENGINEERING RESPONSE

June 28, 2023

EXECUTIVE SUMMARY

The inclusion of direct air capture (DAC) in Article 6.4 of the guidance would be a significant step towards advancing climate action and achieving the objectives of the Paris Agreement. By recognizing the role of DAC and other carbon removal activities, we can enhance our ability to balance emissions with removals, paving the way for a more sustainable and resilient future. The proven effectiveness of permanent geological sequestration, supported by evidence from regulated systems, underscores the scientific confidence in quantification of DAC projects. Coupled with robust regulation and third-party or government verification, the inclusion of DAC in Article 6.4 would foster public trust and confidence in the comprehensiveness of the process, ensuring the responsible deployment of DAC technologies.

INCLUSION OF STAKEHOLDER INPUT

As a leading direct air capture company, we commend the efforts of the Supervisory Body in recognizing the importance of removals activities in addressing climate change. Carbon Engineering is committed to deploying DAC technologies responsibly, ensuring they contribute to sustainable development objectives while effectively removing carbon dioxide from the atmosphere.

Our submission builds upon information we've previously provided:

- May 25, 2023: Response to Information Note
- April 11, 2023: Methodology Requirements
- October 12, 2022: Activities involving removals
- October 11, 2022: Development of Mechanism

THE ROLE OF REMOVAL ACTIVITIES

To effectively meet the goals of the Paris Agreement and achieve a balance between emissions and removals, it is imperative to include both carbon removals and reductions as integral components of our climate mitigation strategies. While emissions reductions play a critical role in reducing greenhouse gas emissions at their source, carbon removals, such as those achieved through DAC projects, offer a complementary solution by actively removing carbon dioxide from the atmosphere. By combining these approaches, we can enhance the likelihood of achieving net-zero emissions and preventing further climate change. Given their complementary roles, removals and reductions should be differentiated with separate accounting to ensure visibility over their roles in achieving net zero outcomes. Temporal storage timelines must also be considered with permanent storage as the benchmark for comparing different removal approaches. We encourage removals to be differentiated from reductions and land and geological sinks to be considered separately.

AVOIDANCE OF LEAKAGE

Acknowledging the significance of addressing leakage concerns in DAC projects, we place utmost importance on implementing robust measures to mitigate and minimize the release of potent greenhouse gases during the DAC process. Our projects adhere to stringent facility emissions monitoring, which enables us to closely track, manage, and account for any potential emissions resulting in net removal. By strictly adhering to existing regulations and reference standards, we ensure that best practices are followed to prevent leakage. Methodological design also plays a crucial role in this regard, as it requires comprehensive accounting of all project emissions, including upstream energy and process emissions, such as those associated with sorbents and chemicals. By incorporating such comprehensive methodologies for DAC removals, we can effectively address leakage concerns and ensure the integrity of our carbon removal activities.

PERMANENCE

When considering the permanence of carbon removals, geological sequestration is a proven approach. Geological sequestration involves the long-term storage of captured carbon dioxide in carefully selected and regulated geological formations deep underground. Extensive evidence from regulated systems, such as those governing large-scale CO_2 storage projects in regions such as Norway and the United States, demonstrates that permanent geological sequestration has minimal leakage and poses low risks of carbon dioxide release. Rigorous monitoring and verification protocols ensure the integrity of the sequestration process, enabling confidence in the permanence of the stored carbon dioxide.

The following resources can be supportive evidence for the statements above:

Alcalde, J., Flude, S., Wilkinson, M. *et al.* Estimating geological CO_2 storage security to deliver on climate mitigation. *Nat Commun* **9**, 2201 (2018). https://doi.org/10.1038/s41467-018-04423-1

IPCC Special Report - Carbon Dioxide Capture and Storage (2005)

IPCC Special Report – Summary for Policy Makers- Carbon Dioxide Capture and Storage (2005)

THE ROLE OF GOVERMENT REGULATION

To ensure public trust and confidence in the geological sequestration of carbon dioxide, robust regulation with third-party and/or government verification is essential. Implementing a comprehensive regulatory framework that includes rigorous monitoring, reporting, and verification processes is crucial to guarantee the effectiveness, transparency, and accountability of geological sequestration activities. Third-party or government verification serves as an independent and objective mechanism to assess the compliance and adherence to regulatory standards, providing assurance that carbon dioxide is securely stored and permanently removed from the atmosphere. By establishing a regulatory framework with robust verification mechanisms, we can instill public confidence in the integrity of geological sequestration and create a strong foundation for the widespread deployment of DAC projects as a key climate solution.

MONITORING PERIODS, CREDITING PERIODS AND REVERSALS

Carbon Engineering offers the following comments on the interrelationship's functions, timeframes, and implementation of monitoring periods, crediting periods and reversals:

(a) **Monitoring period:** The monitoring period refers to the timeframe during which the measurement and verification of carbon dioxide removals take place in a DAC project. It is essential to establish a well-defined monitoring period to accurately assess the effectiveness of the removal activities and ensure the credibility of reported removals. The monitoring period typically aligns with the project's operational phase, encompassing the regular monitoring and reporting of removals data.

In the context of DAC projects, the monitoring period involves the continuous measurement of carbon dioxide capture rates, energy consumption, and other relevant parameters. This data is collected using monitoring equipment installed in the DAC facility. The monitoring period may vary depending on the project's scale and operational characteristics but is typically aligned with the project's lifespan to provide a comprehensive understanding of removals performance over time.

The interrelationship between the monitoring period and other elements, such as the crediting period, is crucial. The monitoring period provides the data necessary to calculate and assess the amount of carbon dioxide removed during a specific timeframe. It serves as the basis for generating verified removal credits, which are then used during the crediting period.

(b) **Crediting period:** For DAC projects, the crediting period should align with the long-term nature of engineered carbon dioxide removal solutions. Since DAC technologies will be deployed as large infrastructure projects spanning multi-decade lifespans and have the potential for permanent removal of carbon dioxide, longer crediting periods may be appropriate to reflect the sustained environmental benefits. The interrelationship between the monitoring period and the crediting period ensures that the monitoring data collected during the project's operation is used to accurately quantify the removals and assign corresponding credits.

Under the Article 6.4 RMP (CMA 3 para 31. (f)), activities involving removals under the Article 6.4 mechanism shall apply for a crediting period of a maximum of 15 years renewable twice that is appropriate to the activity and subject to approval by the Supervisory Body. Carbon Engineering supports the approach agreed upon in the RMP and does not foresee the need to deliberate further.

(c) **Reversals:** The timeframe for addressing reversals refers to the period within which any potential reversal of removals must be identified, reported, and accounted for in a DAC project. Reversals can occur when previously removed carbon dioxide is released back into the atmosphere, compromising the permanent removal aspect of DAC activities.

To address reversals effectively, a robust MRV system must be in place. It allows for the timely detection and assessment of any factors that could lead to reversals, such as equipment malfunctions, maintenance issues, or unexpected events. The timeframe for addressing reversals should be designed to enable prompt action and mitigation measures to prevent or compensate for any loss of removals.

In the context of DAC projects, the timeframe for addressing reversals should be integrated into the monitoring and reporting procedures. It involves regular monitoring of the DAC facility's performance, prompt reporting of any observed events that could potentially lead to reversals, and the implementation of corrective actions within a specified timeframe to ensure the integrity and permanence of the removals.

CASE STUDY: THE PROJECT LIFE CYCLE OF A DAC FACILITY

Direct air capture is a technology that uses engineered equipment to absorb carbon dioxide from atmospheric air, and typically, to then purify it for use or sequestration. DAC with geological carbon dioxide sequestration may be a key means to deliver the permanent carbon dioxide removal described by the IPCC, IEA, and others as required to reach 1.5 °C climate targets.

As an illustrative example of how Article 6 and carbon credits may play a role in enabling direct air capture, let's examine the project life cycle of a direct air capture facility that delivers carbon dioxide for sequestration in a saline aquifer. Here we use Carbon Engineering's own liquid-based DAC technology as the case study, but virtually all aspects of this case study will apply to the other forms of DAC being studied and developed by others.

A reference-scale DAC facility based on Carbon Engineering's technology will capture roughly 1,000,000 tonnes of carbon dioxide from atmospheric air each year. It will occupy roughly 60-80 acres of land area, typically in areas that have availability of energy and suitable geology for CO_2 sequestration, and it will be located on industrial or marginal land outside of settled areas. The facility will be comprised of air contactors, which scrub CO_2 from the air that passes through them, and purification equipment to deliver pure compressed CO_2 at pipeline specification.

The facility will deliver this CO_2 to a sequestration site, either proximate to the DAC facility or via a CO_2 pipeline, which will consist of one (or more) CO_2 injection wells and a selection of monitoring wells. When CO_2 is sequestered into properly selected geology within a properly regulated operation, it is expected to be stored for millenia with anticipated time-integrated leakage well under 1%[1]. Such regulation could be accomplished through existing Governmental systems such as the EU's CCS Directive, the US-EPA's Underground Injection Control Program, or California's CCS Protocol. Alternatively, it could be governed by voluntary market protocols such as American Carbon Registry's CCS Protocol, or the ISO 27914 standard for CO_2 transport and sequestration.[2] All MRV systems mentioned here are based on actual flow-meter data and rely on standard geophysical data gathering from injection and monitoring wells. For further detail, please refer to the EU CCS Directive or US EPA's UIC Program.

Such a DAC facility would require on the order of $1B USD of upfront capital expenditure for engineering, construction, and commissioning. Once operating, it would incur operating expenditures in the $10's to $100's of M USD per year to operate. In order to secure these up-front expenditures and to cover operating expenditures with sufficient margin to warrant investment within competitive capital markets, the facility will need to quantify the net carbon dioxide removal accomplished each year, and then to unitize this into credits to sell them as revenue. Such a facility (as well as all other CDR efforts) should be required to use a full life-cycle assessment[3] method to calculate such credits, starting with gross atmospheric tonnes captured, and then subtracting all project emissions including planned and unplanned CO_2 venting from equipment and upstream emissions from energy and consumables. The goal should be to quantify total net tonnes of carbon dioxide permanently removed, in order to generate credits for sale.

As the sole product of a DAC to sequestration facility is carbon dioxide removal, the generation and sale of CDR credits is expected to be the **only** long-run revenue source for the project[4]. It is thus imperative that the facility be able to generate credits for sale for its entire project lifespan, which is typically 25-30 years though extensions may be possible with refurbishment. During this life-span, and especially during initial engineering and construction, the DAC facility will contribute jobs and demand for materials and services to the local economy, will provide on-going employment to operators and suppliers, and will not generate pollution to local air, soil, or water[5].

[1] https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_summaryforpolicymakers-1.pdf

[2] For any carbon removal pathways that involve geological sequestration of CO2, Article 6 policymakers could simply reference these existing regulations and require that they be used, or in jurisdictions without such regulations in force, proponents be required to prove to third-party evaluators that they're conducting operations in an equivalent manner.

[3] U.S. DOE. (2022). Best Practices for Life Cycle Assessment (LCA) of Direct Air Capture with Storage (DACS). U.S. Department of Energy, Office of Fossil Energy and Carbon Management. https://www.energy.gov/fecm/best-practices-LCA-DACS

[4] Government grants or incentives may be available in the early years of the project, but are not expected to cover the life-time of the project, nor are they expected to be available after early demonstration projects are completed and the industry is ready to scale-up.

[5] In fact, liquid air scrubbers are expected to *remove* particulates and pollution from atmospheric air as they capture CO2, but the impact to overall regional air quality is expected to be small.

In summary, direct air capture with geological sequestration offers a clear case study of a CDR project which could be financed and executed with carbon trading under Article 6.4. The DAC facility itself, and the geologic sequestration of CO_2 are both governable and "regulate-able" under many pre-existing systems in a variety of jurisdictions, which can be drawn upon or referenced in the design of Article 6. Direct air capture, and all other forms of carbon dioxide removal, should be held to high standards of lifecycle accounting to determine net removals, and should be held to high standards of permanence and CO_2 monitoring. Only under these conditions will carbon dioxide removal deliver the true, accurate, and reliable environmental benefit needed to complement the at-source mitigation and behavioral change needed to reach climate targets.

ABOUT CARBON ENGINEERING

Carbon Engineering is a global leader in the development of Direct Air Capture (DAC) technology capable of removing CO_2 from atmospheric air and, through a series of chemical reactions, delivering it in a pure compressed stream suitable for storage or use.

Carbon Engineering was founded more than a decade ago with the mission to develop and commercialize affordable and highly scalable carbon removal technology. Carbon Engineering is a developer and licensor of direct air capture (DAC) technology. A standard commercial-scale CE DAC facility will annually capture over 1.0 $MtCO_2$ directly from the atmosphere. Carbon Engineering's DAC technology is a liquid-based DAC technology (L-DAC) that deploys an aqueous basic solution to pull CO2 directly from the atmosphere and, after a series of clever chemical looping processes, conditions the atmospheric CO2 into a dense phase that is optimized for transport and final end-use.

Carbon Engineering's DAC technology can provide highly durable CDR when combined with secure geologic storage. This rock-solid combination of DAC + secure geologic storage (DACCS) provides a highly scalable and verifiable CDR mechanism for safely storing CO_2 for 1,000+ years, all with relatively low land and water use. Today, leading commercial markets are ready and we're working with global partners to deploy large-scale commercial facilities in multiple locations around the world.

The first large-scale commercial facility to utilize our DAC technology is in active development with our partner, 1PointFive, and is expected to have an annual atmospheric capture capacity of 1.0 $MtCO_2$ when complete.[6] It's our goal to have this first plant ignite an industry by demonstrating that megaton-scale DAC technology is feasible, affordable, and available. We envision fleets of DAC facilities working alongside emissions-free electricity, energy efficiency, and clean innovations in all commercial and industrial sectors to fully tackle the climate challenge. Engineering has already commenced at a second site capable of supporting a capacity of 30 $MtCO_2$ per year. Additional information on Carbon Engineering's technology and commercial developments is provided at www.carbonengineering.com.

[6] Occidental, 1PointFive to Begin Construction of World's Largest Direct Air Capture Plant in the Texas Permian Basin