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RE: RECOMMENDATIONS TO THE ARTICLE 6.4 SUPERVISORY BODY ON ACTIVITIES INVOLVING REMOVALS / Mandate: FCCC/PA/CMA/2022/L.14, para. 19

AirCapture's and Denominator's submission to issue:
'Guidance on the mechanism established by Article 6, paragraph 4, of the Paris Agreement'.

The Conference of the Parties (COP) serving as the meeting of the Parties to the Paris Agreement (CMA), by its decision "Guidance on the mechanism established by Article 6, paragraph 4, of the Paris Agreement," invited parties and observers to submit their views on "activities involving removals, including appropriate monitoring, reporting, accounting for removals and crediting periods, addressing reversals, avoidance of leakage, and avoidance of other negative environmental and social impacts, in addition to the activities referred to in chapter V of the rules, modalities and procedures."

This note presents recommendations for consideration by the Article 6.4 Supervisory Body as it continues its work to develop guidance to the CMA on removal activities under the mechanism. It complements a previous submission by Aircapture, joined by Denominator Collective.

1. Definition of removals

The initial recommendations advanced by the Article 6.4 Supervisory Body echoed the Intergovernmental Panel on Climate Change (IPCC) definition of carbon dioxide removals, while expanding it to encompass all greenhouse gasses (GHGs). This definition includes durable storage in geological, terrestrial, or ocean reservoirs, or in products. New technologies aimed at utilizing CO_2 now present us with the possibility to incorporate CO_2 into higher-value products.

2. **Rationale for technology based removals:**
    a. High quality of carbon removal due to scalability, permanence, measurability & immediate, low risk of reversal (if not intended via production of carbon-based-products)
    b. Low Land requirements, immediate removals in comparison to ARR
    c. Transparent, real-time MRV (measurement, reporting and verification) is possible but deployment uncertain - framework and guidelines under A6.4 needed
    d. Regulatory framework concerning engineered carbon removals uncertain under NDC's - therefore it is uncertain in which countries' engineered carbon removals will be considered as ITMO's or require corresponding adjustments
    e. Possible co-benefits – especially economic and educational, possibly other environmental. Example for SDG' crossover when used for water filtration, considerations for SDG 6.
    f. Direct Air Capture enables a diverse set of industrial downstream applications of carbon, particularly at the point-of-use. Opportunities and applications are fast evolving, especially in the context of carbon capture utilization and storage (CCUS) as explained below.

Guidance: Views on activities involving engineered removals, including appropriate monitoring, reporting, accounting for removals and crediting periods, addressing reversals, avoidance of leakage, and avoidance of other negative environmental and social impacts, in addition to the activities referred to in chapter V of the rules, modalities and procedure.

Concerning Direct Air Capture technology based carbon removal guidance, it is imperative to consider both pathways under the Article 6.4 mechanism (as described in Appendix I: Summary descriptions of engineering-based removal activities) - DACCS and DACCU - and extend it to DACCUS - Direct Air Capture Utilization **and** Storage.

While DACCS addresses geological sequestration, DACCU is often affiliated with downstream use cases with short durability such as fuels, beverage carbonization and enhanced oil recovery. Unlike Carbon Capture and Storage (CCS) technologies, which aim to store large quantities of CO2 underground for a long period of time, in the case of CCU technologies, a significant amount of CO2 can be used in industrial processes. CO2 utilization in these applications are a requisite feedstock for critical industrial applications (e.g., food processing, cold-chain refrigeration, modified atmospheric processing, etc.) which are currently derived from carbon-intensive industrial applications (i.e., byproduct of oil and gas) in which an atmospheric-derived CO2 source (vs. fossil-sourced) has significant reduction in carbon-intensity.

DACCUS however, is affiliated with industrial downstream applications with the difference that the carbon is utilized AND stored, such as in cement, long lived plastics and other materials relevant for hard to abate industries such as graphite, graphene, carbon fibers, carbon black etc. It is imperative to distinguish between CCS, CCU and CCUS under Article 6.4 given a large variance in reversal horizons.

Especially for DACCUS, the concept of carbon insetting in hard to abate industries becomes relevant and allows for supply chain and raw material decarbonization. While it is key to increase the capacity of carbon removal technologies globally, under both IPCC and IEA scenarios, it is crucial to scale not just capacity but also to prove technological readiness in commercial scenarios.

Thus, it is important to distinguish between **risk of reversal** and **intended reversal** within the "downstream decision tree" (CCS/CCUS/CCU) to achieve the CDR scale outlined by IPCC. The main task here is to measure and document both.

Reversal, permanence and additionality can vary greatly, for instance between fuels (with a rapid re-release) and building materials (with long-term to permanent storage). As such, the carbon is returned to the atmosphere with a delay or else captured once again from emissions after combustion processes. Thus, the ecological advantage of CO2 utilization lies more in the substitution of fossil-based carbon materials than it does in the function of a CO2 sink. In all cases, the required process energy can be optimized by developing more efficient CCU technologies.

The precise environmental footprint of a new production process can be gauged using the Life Cycle Assessment (LCA). Studies suggest that CO2-based products can lead to a saving of several tons of CO2 per ton of CO2 used in comparison with conventional incumbent CO2 supplies. This is due to the substitution of fossil-based raw materials that have a high carbon footprint with atmospheric derived CO2. The extent to which this is the case depends on the efficiency of newly developed technologies. Positive effects on the overall economy in addition to national commitments under UNFCCC are also possible, and need to be evaluated under Article 6.4.

When discussing DACCUS, the role of MRV becomes key to determining permanence, additionality, maturity, cost effectiveness, and reversal.

Several Direct Air Capture pathways currently developed have the potential to divert into all downstream pathways while the technology itself is unaffected. It is important to consider that Direct Air Capture currently has several (5-6) fundamental technology pathways that vary in risk, energy efficiency, potential for downstream application etc. (see Appendix). For most technology pathways, the underlying technology could be applied for pure CCS, CCU and/or CCUS. It is further important to note here that some DAC technologies can be deployed on a modular on-site basis enabling atmospheric CO2 capture at industrially relevant scales where it is needed, while other pathways require more centralized infrastructure and therefore shipping the CO2 to its intended end-use application.

The minimum durability in downstream applications can be flexible, with a minimum of 20 years (similar to NBS) and a maximum of 1000+ years - this can be reflected in the price/value of the carbon unit (ITMO). While technology deployment into pure CCS usually requires a higher CapEx and longer project durations (and longer lead times due to injection well permitting processes and pipeline infrastructure - also leading to a more complex investment model), modular deployment and industrial downstream application is often more agile with lower upfront capital required, especially infrastructure finance. It is important to note here, that enablement of these technology pathways into industrial decarbonization under this framework will hasten the financeability and market adoption of these technologies into longer-term permanence applications. Limiting the technology pathway adoption to sequestration or high-capital cost permanent applications has a high likelihood of significantly limiting the speed and scope of market adoption.

Measurability in engineered CDR technologies is critical for all downstream applications:

1. In **CCS** it is important to consider and accurately estimate reversal rates - even though we have 40+ years of historical data through EOR, models are not yet available to calculate a "net carbon sequestered after 100+ years with a 95% confidence." It is important to consider that even in CCS, we face risk of reversal risk and compromised durability.
2. In **CCUS**, is it important to build **transparent and trustable MRV mechanisms** that will be grounded in complex data analytics, sensor measurement and risk profiling.
3. **CCU** might have a net-negative carbon impact as well - especially when modular CDR solutions are deployed in industrial downstream settings that have a high carbon footprint when supplying carbon (such as beverage carbonation where the carbon footprint of a conventional carbon supply chain is often up to 1:10, depending on geographic locations - this is especially impactful for remote island locations). The MRV here is not focused on the reversal of the carbon removed but on the net negative effect of supply chain optimization and logistics.

<u>MRV Guidance (Denominator input)</u>

- It is key to create transparency in the market and qualify tangible impacts (net carbon removals) on project levels, national levels and on a global level. Therefore, MRV industry partner working groups, specifically in Direct Air Capture for industrial downstream applications, is recommended.
- The lack of acknowledgement of CCUS under UNFCCC A6 and therefore methodologies available for technology based carbon removal (DACCUS) might continue to fragment the market into arbitrary self certified carbon projects with opaque technology risks and delivery uncertainties - it is imperative to speed up methodology development with industry partners that can accelerate industrial decarbonization through carbon insetting in raw materials.
- Challenges in bringing technology based removals to market at scale:
    - Diverse technologies with very few methodologies available to technology developers and project developers under which they can register projects through an accredited standard/registry - requirement to bridge technology and carbon market through clear guidelines, integration into Climate Warehouse

(currently only possible through accredited Standards/Registries which do not have methodologies in place to register DACCU and DACCUS projects)

- Difficult access to finance: multilateral climate funds, Technology Need Assessments and technology transfer mechanisms need to be updated to include Direct Air Capture projects and applications in both industries and for expanding geological sequestration infrastructure such as injection wells, pipelines etc.
- Clarity under NDC's: Parties to the UNFCCC will need access to technological advisory services to clarify the role of technology based carbon removals under national policies and will potentially need assistance (technical and financial) to update Technology Need Assessments (TNA's) and include both, the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN) in this work
- Uncertainty: many carbon removal technologies are in early technological development and are far from commercialization - forward purchase agreements for technologies that have delivery uncertainty can be risky, especially if self certified and not independently monitored.

Addressing reversals:

Reversals in CCS, CCUS and CCU need to be measured, reported and verified through advanced MRV mechanisms including maturing data on the lifecycle of carbon in key applications. Investing in reliable and independent ways to deliver measuring and reporting of engineered carbon removal pathways across CCS, CCU and CCUS will be imperative. It will be necessary to understand project level reversal, durability, additionality, carbon to value, PPP potential and stocktake across NDC's and regional, national and global GHG emission reporting. Reliable MRV will be required to tie into existing data infrastructure under the Climate Warehouse and Climate Action Data Trust across national and VCM levels.

Aircapture

Aircapture is a direct air capture technology development and commercialization company focusing on integration of DAC technologies into various existing and developing markets including sequestration, agriculture, critical minerals, building materials, energy products and

Denominator Collective

Denominator delivers tangible MRV solutions for Direct Air Capture technologies in CCS, CCU and CCUS. Spanning primary sensor data generation and data analytics, Denominator is able to deliver reliable, independent real time quality control of carbon removal technology performance.

Appendix: Direct Air Capture Technology Pathways

	Chemisorption (Low temperature solid sorbent)	Physisorption	Mineralization	Humidity Swing (Moisture Swing Adsorption)	Electro-Swing
Description	CO_2 is chemically bound to sorbent (i.e. amine or MOF) and released with heat/vacuum	CO_2 is physically bound to surface of sorbent (i.e. molecular sieves, carbon) and released with heat/vacuum	CO_2 is ionically bonded to a mineral (i.e., metal carbonates) and released by removal of water (if used) and high heat	CO_2 is bound to a sorbent via vanderwalls forces and removed by changing humidity	CO_2 is adsorbed on a chemical substrate which is released using electricity