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24 Orion Court
Dartmouth, Nova Scotia
B2Y 4W6
Canada

Date: June 18, 2023
To: Article 6.4 Supervisory Body
From: Dr. Greg H. Rau, co-founder & CTO, Planetary Technologies; Senior Scientist, UC Santa Cruz, Calif.; email: greg@planetarytech.com, grau@ucsc.edu
About: Comments in response to A6.4-SB005-AA-A09

Dear Article 6.4 Supervisory Body,

I am co-founder and CTO at Canadian company Planetary Technologies that is engaged in CDR RD&D. I am also a Senior Scientist at the University of California, Santa Cruz, and until recently was a Visiting Scientist for many years at Lawrence Livermore National Laboratory in California. I have been engaged in CO_2 management technology R&D for the past 20+ years. Given the growing, critical importance of CDR as a global CO_2 management tool, I applaud the COP/SB for taking on the task of creating definitions, rules and regulations for CDR's practice and crediting. It is in the interest of making your final recommendations as accurate and inclusive as possible that I offer the follow comments pertaining to document A6.4-SB005-AA-A09 that I hope can be considered in crafting future reports and policies.

My concerns primarily center on the definitions of removals and CDR and, thus, the scope of the activities being considered:

2.1. **Definition of removals**

The following definition offered in parag 11 is too limited and seriously flawed:

"As an uncountable noun, removal refers to the process of separating greenhouse gases (GHGs) from the atmosphere. Atmosphere here refers to the free atmosphere where GHGs have already been uniformly mixed with the air. The capture of GHGs at or near emission sources counts as GHG avoidance, not removal."

My concerns are:

1) The term "separating greenhouse gases" implies that gases are physically separated. While this is true of CDR methods such as DAC where CO_2 gas is concentrated from the atmosphere, this does not describe CDR processes that react CO_2 from the atmosphere by chemical, geochemical or biochemical means such as enhanced rock weathering (ERW), ocean alkalinity enhancement (OAE) or photosynthesis (e.g.,

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afforestation). Here, CO_2 gas does not survive the process and hence gases are neither being separated nor concentrated but are being removed and transformed to other compounds. Your current definition seems method-prescriptive rather than inclusive.
2) Furthermore, in the context of atmospheric GHG/CO_2 management, removal alone is not relevant without subsequent sequestration of the material from the atmosphere for a climate-relevant period of time. This needs to be explicitly stated.
3) Most critically, restricting GHG removal to removal from the "free atmosphere" ignores the considerable potential of removing CO_2 from, for example, non-free-atmosphere settings that are in communication with the free atmosphere. Such settings include soils, the surface ocean and certain geologic reservoirs. The consequence of removing CO_2 from such environments results in either 1) a reduction in natural emissions to the atmosphere, or 2) if enough CO_2 is removed, the creation of a CO_2 sink for atmospheric CO_2. For example, the application of alkaline material to soils (soil ERW or soil liming) consumes CO_2 present in the soil environments (not the "free atmosphere"), most of which is derived from soil respiration that generates local CO_2 concentrations that can be orders of magnitude higher than in free air and thus are otherwise a natural source of CO_2 to the "free atmosphere" . Likewise, addition of alkaline materials to or promotion of photosynthesis in large regions of the surface ocean that are naturally supersaturated in CO_2 relative to air (e.g., upwelling areas that are significant, natural source of CO_2 to air (IPCC 2019) can exclusively consume and remove CO_2 that would otherwise degas to the atmosphere. Conceivably, CO_2 could also be removed from gases naturally venting to the atmosphere from natural, hydrothermal or other geologic reservoirs. In all the preceding examples the CO_2 burden in the atmosphere is beneficially reduced, but the CDR performed may not directly "separate" and "remove CO_2 from the free atmosphere". Instead, they often remove CO_2 that would otherwise naturally be emitted to the atmosphere, and this beneficial CO_2 emissions reduction from a natural source can be distinguished from activities that reduce unnatural, anthropogenic CO_2 emissions. I also point out that annual, gross, natural CO_2 emissions to the atmosphere is more than 10 times that of anthropogenic CO_2 emissions, 166 Gt C/yr vs 11 Gt C/yr, respectively (IPCC 2021). If we are truly interested in stabilizing/reducing atmospheric CO_2, we cannot ignore the

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capabilities of CDR to also reduce natural CO_2 emissions. I'll also note that the age of the CO_2 removed in the preceding CDR examples is not relevant since the reduction of natural CO_2 emissions, young or ancient, to air beneficially reduces the atmospheric CO_2 burden, but without removing CO_2 from the free atmosphere or reducing anthropogenic CO_2 emissions.

Therefore, I suggest that both in the interest of accurately describing GHG/CO_2 removal, and not unwisely excluding any such beneficial activities, that the definition be modified accordingly. For example:

As an uncountable noun, removal refers to the process removing greenhouse gases (GHGs) from the atmosphere or from natural GHG emissions to the atmosphere (such as from soils, the ocean or geologic reservoirs), and durably sequestering from the atmosphere the removed GHGs for a climate-relevant period of time.

I ask that the concept that removal = separation and that removal only refer to removal from the free atmosphere, as used throughout document A6.4-SB005-AA-A09, be modified accordingly in subsequent Article 6.4 related documents.

2.2 **Definition of removal activities**

Paragraph 15, points a-c cite three attempts by the AR6, WGIII to define CDR. For the same reasons discussed above, these definitions, in my opinion, needlessly if not dangerously restrict CDR activities just to removal from the atmosphere. My suggested rewording is:

Carbon dioxide removal (CDR) refers to human activities that 1) remove carbon dioxide (CO_2) from the atmosphere or 2) remove CO_2 from natural emissions to the atmosphere (such as from soils, certain regions of the ocean and geologic reservoirs) and 3) durably sequester from the atmosphere the removed CO_2 or products thereof for a climate-relevant period of time. CDR includes enhancement of natural biological, geochemical or physical CO_2 sinks, the creation of artificial removal and sequestration methods, or some combination of the preceding. CDR excludes 1) natural CO_2 uptake not directly caused by human activities, and 2) removal of CO_2 directly from an anthropogenic CO_2 source emitting to the atmosphere.

I ask that this more accurate and inclusive definition or something equivalent be used in future SB documents pertaining to CDR.

Other comments:

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Pg. 11, “Removal of CO_2 from oceans”, parag. 21 and 22
Please include abiotic CO_2 removal from the ocean, for example, via the addition of CO_2-reactive alkalinity - OAE (Renforth and Henderson 2017) or via the physical/chemical extraction of CO_2 from seawater (de Lannoy et al. 2018).

Pg. 15 3.1. “Taxonomy of removal activities”, parag. 36 b)
Please include ocean-chemistry-based CDR such as OAE. I can assure you that the massive retention of CO_2 by abiotic ocean chemistry (38,000 Gt C) is both proven and highly effective, and natural ERW and OAE currently removes about 1 Gt CO_2/yr from the atmosphere (IPCC 2021). By stating that such methods will not be available until 2030 and beyond, the SB is making an unfounded judgement that seemingly will make sure that is the outcome. Rather, the SB needs to provide a non-pre-judgmental, tech-neutral framework with which to encourage innovation and evaluation of CDR approaches as quickly as possible so as to determine which if any methods can provide the timely, safe, cost-effective, high-capacity CDR required. Predicting and prescribing the future of technology has a notoriously poor track record. Please do not engage in such prescriptive speculation on matters where the best technologies have yet to be determined, and especially when the future of the entire planet rest on such decisions.

Pg. 16 parag. 37 “The following are broad categories of storage methods:”
Storage of dissolve inorganic carbon in the ocean, by far the largest carbon reservoir on the Earth’s surface, needs to be included here! Both ERW and OAE are well-describe methods of CDR (Campbell et al.2022, Renforth and Henderson 2017 that can lead to transfer of CO_2 from the atmosphere (or reduction of CO_2 transfer from soils or ocean to air) and storage in ocean seawater as dissolve alkaline bicarbonate and carbonate ions. Do not ignore this CDR and C sink – Mother Nature doesn’t (IPCC 2021, Archer et al 2009).

Pg. 17, Table 2 Please add ocean-chemistry-based storage, by far the largest C reservoir on the Earth’s surface – 38,000 Gt C (IPCC 2021).

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Pg 18, Table 3 The pigeonholing of CDR activities into two, narrow categories, engineering- and land-based, completely ignores ocean-based approaches and eliminates the possibilities of hybrid approaches and the blending of pro and con attributes. The pro and con attributes listed seem highly arbitrary, subjective and biased, clearly aimed at downplaying engineered approaches in favor of land methods. This should not be an exercise in painting all engineered methods with the same broad brush, and playing favorites and selecting winners. It should be about creating a level playing field and set of rules with which to objectively evaluate all methods, rather than predetermining winners based on personal preferences, ideology and/or unproven assumptions and fear.

Pg. 19. Table 4. Ocean CDR is completely absent in this evaluation. Please see NASEM (2022) and rectify accordingly.

For the remainder of the document ocean CDR goes unmentioned as does the concept of reducing natural CO_2 emissions as a valid and creditable CDR activity. Natural, annual, gross global CO_2 emissions dwarf anthropogenic emissions, yet the possibility of reducing the former emissions as a removal activity is absent in your document. With regard to the ocean, it occupies 70% of the Earth's surface, already naturally removes about ¼ of annual anthropogenic emissions from the atmosphere and has a carbon reservoir that is at least 10X that of any other in direct contact with the atmosphere. If the SB/COP/UNFCCC is truly interested in finding and crediting activities that safely and effectively manage atmospheric CO_2 or GHGs in general, they would do well not to continue to ignore/downplay certain activities and to refrain from making grand predictions about ultimate feasibility and desirability of methods without well-demonstrated justification. Please include in your recommendations CDR's potential to reduce natural CO_2 emissions and to include 70% of the planet (the ocean) in helping solve a global, existential CO_2 threat.

Thanks and regards,

Greg H. Rau, Ph.D.