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PERSPECTIVE

Aligning incentives for carbon dioxide removal

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Abstract

Carbon dioxide removal (CDR) at the scale needed to meet key climate goals will require the development of a massive industry. The development of regulatory architecture and effective incentive structures must proceed in parallel if this industry is to function in a way that is technically rigorous, environmentally conscious, and socially responsible. Most of the current capital flow, overall technological development in CDR, and third-party monitoring and verification are occurring in the private sector. We argue here that this will need to change in order for robust, responsible carbon removal to be brought to scale. In the short term, a focus on removing flawed incentive structures will be a critical ingredient in the transition to a stable, large-scale marketplace for durable carbon removal.

Carbon dioxide removal (CDR) from Earth's atmosphere will be a key component of efforts to keep global temperature increases below those predicted to cause significant degradation of livelihoods, food security, and water supplies in the coming century. Although CDR will be ineffectual without aggressive decarbonization [1], active CDR is projected with high confidence to be required even in scenarios with rapid and deep cuts to anthropogenic greenhouse gas emissions [2, 3]. For instance, integrated assessment models suggest that achieving below 2 °C of total warming since the preindustrial period will require the removal of ∼1–10 gigatonnes (Gt; 10^9 tons) of CO_2 per year by 2100 [4]. Given a nominal cost of carbon of $100/ton, this implies a trillion-dollar industry in CDR.

Current market demand for CDR is many orders of magnitude below this [5, 6]. However, a significant amount of private equity is currently being directed at CDR, in the form of advanced market commitments, venture investment in startup companies, and offtake purchases by companies attempting to incorporate CDR into their sustainability portfolios. There is also increasing government support of for-profit CDR efforts. This market, and the industry it is meant to support, are extremely nascent. Many initial CDR efforts—mostly focused on storage of organic carbon within the terrestrial biosphere or soils—have yielded mixed results, drawing into question the validity of carbon credits [7–11]. Not surprisingly, there is currently a push to reevaluate the structure and governance of carbon removal marketplaces. There is at present limited regulatory architecture and no generally accepted system for managing quality across CDR techniques. Nevertheless, the most important current actors can be separated into four primary types: (1) investors; (2) suppliers; (3) purchasers; and (4) verifiers. We argue that in current carbon marketplaces none of these actors are properly incentivized to produce durable (long-duration) and robust (high attribution confidence) carbon credits. Without significant and rapid changes this is likely to lead to further erosion of trust in carbon trading—just as attempts to scale durable CDR need to be gaining broad momentum in order to have any tangible impact.

Given that the overall volume of CDR in the near term will have a negligible impact on global temperatures and climate [1], investors stand to benefit the most from rapidly scaling deployment of carbon removal technology. In the current market, investors can and do simultaneously support

suppliers of carbon removal services, registries that set the standards for quantification and crediting for removals, and verifiers that use those standards to evaluate supplier practice. All of these actors directly benefit financially from the sale of credits, and investors benefit at multiple points in the process. Investors can thus maximize returns by leveraging their influence over suppliers, registries, and verifiers. This is not a question of 'good' or 'bad' actors, it is simply a question of incentives and interests and how they will shape public perception of commodified carbon removal—it is difficult to imagine that we will be able to build public trust via a system in which entities or individuals stand to gain financially from both the production of offsets and their verification.

Suppliers of CDR—overwhelmingly dominated at this point by venture-backed carbon removal startups—are also not incentivized toward CDR quality. Instead, startup-stage companies are incentivized to grow, and are focused on acquiring market share, developing secure intellectual property, and minimizing unit costs. While this incentive structure is defensible on its own terms—indeed, it will be a critical driver of bringing carbon removal technology to scale—it is important to clearly recognize it will often not harmonize with the overall goal of creating a robust, transparent, and equitable CDR ecosystem. Again, this is not a question of motivations, it is simply a question of incentives—earnest entrepreneurs acting in good faith can still undermine the credibility of CDR if there are not regulatory or incentive architectures in place to prevent a 'race to the bottom' in terms of quality. Further, although the science behind many forms of CDR is arguably more advanced than the carbon marketplaces they are meant to support, a full cradle-to-grave perspective—that considers the effects of a process on all greenhouse gases—is still under development for essentially all forms of CDR [12]. In this context, CDR suppliers are not incentivized to employ science teams that might reduce the market value of their CDR process (e.g. by highlighting uncertainties or possible carbon leakage in current or future deployments).

Purchasers are perhaps the most diverse of the groups, ranging from large corporations seeking offsets to include in sustainability portfolios to advance market commitments with the aim of creating demand pull to advance and scale CDR technology. In principle, there is a reputational risk associated with purchasing low-quality carbon credits. However, in practice the majority of purchasers have and will continue to have a certain CO_2 tonnage that needs to be met as cheaply as possible and will partner with third-party certifiers of CO_2 removal rather than independently ground-truthing the quality of the tonnage they purchase. In addition, voluntary marketplaces are designed to give buyers more power to modulate the price of carbon downward than a federal or state-administrated carbon pricing scheme developed by government employees and academics that do not stand to benefit financially from carbon removal programs. As a result, purchasers are not inherently incentivized toward—nor are they usually equipped to evaluate—CDR quality.

In principle, this incentive misalignment could be mitigated by third-party actors that independently (and transparently) verify the quantity of carbon captured and set standards that serve as guardrails that ensure claims of CDR are well-founded. However, existing third-party actors that serve as platforms for verifying carbon removal often encounter or have constructed problematic incentives. For instance, many verifiers certify CDR based on privately developed standards of quality, allowing units of carbon removal to be purchased on a voluntary market. These standards are developed by registries and marketplaces that compete for a limited supply of removals, resulting in a clear incentive to adopt standards for certification that have widespread acceptance from suppliers. This can undermine the scientific rigor of carbon removal (and likely has in the past). Once again, this is not a question of 'good' or 'bad' actors, it is a question of incentives. A credit-volume-based model is currently central to the unit economics of private-sector CDR registries and verifiers—but it is challenging to align this incentive structure with the development of robust, transparent, equitable standards in CDR, regardless of the stated intentions of the specific actors involved.

There is a fifth possible category of actor in the carbon removal market: standards developing organizations (SDO) [13]. A carbon removal SDO would set the rules for quantifying net CO_2 removal and storage and associated uncertainties. Though there are numerous efforts—both for-profit and public, across compliance and voluntary carbon markets—to normalize and regulate the certification process for carbon removal credits and generate a fungible commodity for sale, no entity focuses solely on setting recognized and enforceable standards for robust, scientifically rigorous measurement, monitoring, and modeling of long-duration carbon removal that is decoupled from the financial incentive to sell credits. The carbon removal industry faces a pressing need for SDOs in order to bring rigor and transparency to the market and build public trust.

Investors, suppliers, purchasers, and verifiers will all have to play an important role in supporting the transition from privately developed, privately profitable metrics to consensus-based, technically rigorous, publicly visible industry standards. Investors acting in good faith to deploy climate solutions can (and should) excuse themselves from the standards and verification framework development process. Suppliers, individually and through trade organizations, can adopt and use standards developed by a financially independent SDO. Suppliers can

also transparently report data collected using the measurement standard, improving scientific understanding of carbon removal approaches and iteratively improving the standard itself. Purchasers play a uniquely important role in the near-term market: they can require the use of rigorous, science-based standards for pre-purchases and long-term offtake agreements, driving the industry towards greater quality. Purchaser coalitions and advanced market commitments multiply this impact. Verifiers, with growing technical expertise and on-the-ground experience assessing carbon projects, can help identify and close gaps and loopholes in standards. The standard development process also requires the coordinated participation of a sixth group of actors: scientific researchers. Scientists—in particular researchers and technical experts with no financial ties to CDR companies—can lend their expertise to the development of robust measurement standards.

No effort will be a magic bullet, and a healthy CDR ecosystem operating at scale will require the right mix of deployment, oversight, method development, tracking and verification, and standard setting. Carbon marketplaces will need to be able to effectively navigate the tension between overly restrictive incentive structures that could stifle innovation and systems that are overly permissive of offset crediting in order to avoid causing catastrophic damage [14]. This will require an iterative approach, and substantive buy in from all of the actors discussed above and very likely some that either are not currently being fully engaged or do not yet exist. This is likely only possible if government agencies are willing to play a key role in shaping carbon marketplaces at scale, and a key challenge will be navigating the political and practical hurdles of government intervention into durable carbon removal markets. However, in the near-term funding at multiple levels is needed to help the CDR community work to align on incentive structures that allow for rapid growth without compromising CDR quality and open verification. There is an urgent need to revisit incentives in the CDR ecosystem across sectors if we want to continue building—rather than further eroding—public and private trust in CDR and carbon offsetting.

Data availability statement

No new data were created or analysed in this study.

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