Carbon Business Council

Unlocking Carbon Dioxide Removal with Voluntary Carbon Markets:

Recommendations to Expedite Climate Solutions

September 2022

Acknowledgments

This white paper is developed by the Carbon Business Council's Working Group on Voluntary Carbon Markets. Working group members include Radhika Moolgavkar with Nori, Kelly Erhart with Vesta, Nico Julian with Phykos, Tony Qu with Sequestr, Ryan Anderson with Parallel Carbon, Ben Rubin, and Isabella Corpora with the Carbon Business Council. Lead authors are Radhika Moolgavkar, Kelly Erhart, Ryan Anderson, and Ben Rubin. The viewpoints in this white paper do not necessarily represent the individual perspectives of all Carbon Business Council members. Thank you to Na'im Merchant with Carbon Curve LLC, Robert Höglund with Marginal Carbon, and Jason Hochman with the DAC Coalition for their review. Morgan, Lewis, and Bockius provided pro bono legal review.

Table of Contents

Executive Summary

Introduction

Overview of Existing Voluntary Carbon Markets

Challenges with Existing Frameworks

Opportunities for Growth

Policy & Market Recommendations

Conclusion & Next Steps

Executive Summary

A new generation of companies are creating an array of promising carbon dioxide removal (CDR) solutions to remove legacy climate pollution from the atmosphere and restore the climate. These companies are looking toward carbon marketplaces to expedite the industry's growth and help fulfill carbon reduction targets. Companies are quickly discovering both challenges and opportunities of voluntary carbon markets (VCMs). How can VCMs be shaped to help foster carbon removal while ensuring rigor, accuracy, and accountability in the amount of carbon being removed from the atmosphere? A working group convened by the Carbon Business Council offers pathways forward in the "Unlocking Carbon Removal" white paper, with the intent to expedite the responsible growth of VCMs and address challenges.

Overview of Existing Voluntary Carbon Markets

VCMs are projected to grow to a $50 billion market in the next eight years and provide an important platform to achieve net-zero climate targets. While carbon credits can also be traded under cap-and-trade and compliance marketplaces, VCMs are growing globally as governments and corporations seek multi-access pathways to drive carbon reductions and combat climate change. VCMs provide unique and expansive potential: market regulations are still being defined and new solutions are being put forward. As VCMs continue to scale, they will benefit from multiple CDR companies competing in the marketplace in a responsible and streamlined manner. Despite high growth in VCMs in the past decade, there are important and complex issues to address, such as additionality, leakage, verification, and permanence.

Challenges with Existing Frameworks

CDR is fundamentally different from emissions avoidance; carbon emissions avoidance is about preventing additional emissions, while carbon removal is about removing pre-existing carbon dioxide from the atmosphere. Although this statement may seem obvious, avoidance is often conflated with removal, and credits for the two approaches are largely treated as indistinguishable in some of the current systems. Monetizing and incentivizing carbon removal methods in VCMs can facilitate a gigaton climate impact. Crediting systems and marketplaces must be reimagined to account for the unique approaches, challenges, and opportunities of CDR.

Opportunities for Growth

VCMs have the potential to become a powerful way to help meet climate targets and scale CDR solutions. When properly implemented, VCMs can be a source of reliable financing for high-quality climate action and drive effective climate change prevention and remediation on a global scale.

Policy & Market Recommendations

VCMs have a significant opportunity to evolve in a way that brings durable and promising carbon removal solutions to market. To leverage this benefit, it will be important for governments, regulators, marketplaces, and other stakeholders to develop basic standards and definitions that strengthen the market while allowing sufficient flexibility for VCMs to respond to buyer and seller

needs. Given the challenges and constraints in today's markets, the following recommendations for regulators and existing market providers can help grow VCMs, scale carbon removal, and provide a greater menu of options for purchasers.

- **Distinguish offsets and carbon removal credits.** Traditional offset and removal credits can coexist in VCMs, but these two credit types are different and should be treated as such. Clarity in names and definitions will build greater transparency into net-zero commitments and the markets themselves.
- **Align definitions.** Clearly defined VCM terms will help establish understanding and a common set of principles across markets. These definitions likely need to be developed by a government body or third party and will benefit from broad stakeholder buy-in and community input. An improved definition is particularly needed for *additionality*, which is interpreted, determined, and weighted differently across players and markets.
- **Establish a minimum quality to enter VCM markets.** A wide range of durable carbon removal solutions exists, and as many as possible that meet minimum durability and quality standards should be brought to market. Establishing minimum entry thresholds for durability and quality, along with tools like a quality grading rubric, will help strengthen VCMs and establish broader baselines for CDR. Transparency and context around any quality rubric will be crucial to its success.
- **Streamline VCM verification.** Verifying CDR approaches for removal credits helps build a stronger, more confident market that delivers climate benefits. At the same time, given the short time frame remaining to avert the worst effects of climate change, VCM verification systems will benefit from being agile and efficient to avoid years-long delays in verifying CDR to enter markets.
- **Price to reflect permanence.** Each CDR solution presents unique benefits along with a series of trade-offs, ranging from the permanence of the removal method to the potential removal capacity of the relevant CDR technology. Along with other factors, the durability of a given CDR approach should be factored into VCM pricing, meaning solutions with longer permanence are priced and valued accordingly.
- **Increase transparency in emissions data and net-zero pledges.** There are currently gaps in publicly disclosed data on carbon emissions and offsets in companies' net-zero pledges. Improved transparency in this regard will offer new insight into how many credits CDR buyers will likely require, providing a positive signal for investment and development of CDR projects in VCMs.
- **Ensure CDR Project Developers are Supported to Enter VCMs.** Some VCMs already offer support for CDR companies and identifying and addressing additional needs will help catalyze more high-quality CDR solutions. This may include, for example, credit to support CDR in early-stage research and development or during the verification process.

Introduction

Carbon dioxide removal (CDR) helps restore the climate by removing legacy emissions from the atmosphere. The global scientific consensus is that removing gigatons of carbon emissions is needed to reverse climate change's worst impacts, in tandem with the important work of mitigation. In response, a new generation of companies is creating an array of promising carbon removal solutions. Carbon removal companies are looking toward marketplaces to buy and sell carbon removal credits to expedite the industry's growth and help fulfill net-zero targets. Companies are quickly discovering the challenges of existing voluntary carbon markets (VCMs), many of which are built for offsets and not carbon removals. As VCMs continue to scale, it is vital to address and crystallize the differences between avoidance and removal and overcome barriers to entry for CDR developers.

How can VCMs be shaped to help foster carbon removal while ensuring rigor, accuracy, and accountability in the amount of carbon being removed from the atmosphere? A working group convened by the Carbon Business Council offers a pathway forward in this white paper with the intent to expedite the responsible growth of the VCM and address impediments and challenges.

Overview of Existing Voluntary Carbon Markets

VCMs are projected to grow to a $50 billion market in the next eight years and provide an important pathway to achieving net-zero climate targets. While carbon credits can also be traded under cap-and-trade and compliance marketplaces, VCMs are growing globally and provide an important tool for governments and corporations seeking to combat climate change. A new generation of companies are strengthening VCMs with high-quality accounting and durable carbon management solutions, but not all VCMs are adapting to the rapidly evolving landscape. Despite high growth in the past decade, there are important and complex issues to address, such as additionality, leakage, verification, and permanence.

Historically, VCMs and compliance markets have been used to offset emissions that a company or government produces. One major evolution of the VCM is the introduction of CDR credits alongside offsets. The CDR credit aims to remove atmospheric emissions via nature-based, ocean-based, and technological CDR solutions. CDR approaches vary in cost and duration of carbon storage, offering new opportunities and a greater diversity of options within VCMs.

While offsets have traditionally been thought of as avoiding future emissions, removal credits help sequester historic carbon emissions that are already in the atmosphere and will stay there for decades to millennia. Despite the uniqueness of these credit types and the significant difference in goals, some marketplace still assess removals in the same way as offsets.

There are four main registries to date: Verra, Climate Action Reserve, the American Carbon Registry, and Gold Standard. More registries have recently joined the market, offering expanded CDR options. Further clarification on the verification and durability of specific solutions can

strengthen the VCM market and help align carbon removal credits with the unique benefits of various CDR solutions.

Climate leaders often pledge to reduce future emissions to net-zero; some make 'net-negative' pledges to remove their legacy emissions. CDR in VCMs helps achieve net-zero goals by providing a solution for hard-to-abate emissions, such as from the steel and cement industries. In the context of net-zero and net-negative pledges, CDR in VCMs is an opportunity for companies to reduce or eliminate historic or hard-to-abate emissions alongside continued mitigation efforts.

Corporations and governments fulfilling net-zero pledges are rightfully focused on reducing emissions via solutions that work in tandem with CDR, such as powering operations with renewable energy and transitioning vehicle fleets to run on electric. These efforts to coordinate reduction and removal are enabled by a multitude of methods to generate CDR credits for VCMs. Engineered methods of CDR include direct air capture, enhanced weathering, and bioenergy carbon capture and storage. Nature-based methods include programs like reforestation and coastal blue carbon systems, e.g., mangrove restoration. Some forms intersect engineered and nature-based methods, such as ocean-based removal, which can also reduce ocean acidification. Once carbon is removed, it needs to be stored or utilized. Storage methods can vary in duration, sequestering CO_2 from hundreds to hundreds of thousands of years. Therefore, the storage choice is critically important when a project looks at the overall timespan for carbon removal.

Thanks to a new generation of carbon markets, we will likely see an expansion of private entities striving to account for their emissions and further standardization of credit-issuing documents. Policy development will be needed to support new markets and help regulate VCMs for legitimacy and accountability. Some of this work is already taking place. In 2022, for example, the U.S. Securities and Exchange Commission (SEC) proposed a rule regarding climate-related disclosures. Calls for increased transparency and disclosure of companies' carbon emissions and scrutiny of companies' carbon reduction claims are expected to increase demand for high-quality carbon reduction products, thereby strengthening the VCM market.

A large challenge and opportunity for VCMs has been the measurement, reporting, and verification (MRV) of credits. One concern surrounds credit 'double counting', where multiple parties could purchase or claim the avoided or reduced greenhouse gas emissions (GHGs) from the same project. To avoid double counting, registries or administrators of markets establish certification, reporting, and tracking mechanisms to ensure that multiple entities do not claim credit for the same GHG reductions/offsets.

A third party periodically verifies or confirms the amount of carbon reductions generated by a given project in a VCM, and mechanisms and written protocols govern how to quantify the amount of carbon sequestered by project type. For example, the sequestration potential of 100 juvenile trees will be different than 100 larger matured trees; reforestation projects will also differ in sequestration based on proper maintenance, regrowth, and carbon storage in the underlying sink.

Verification for these projects will entail establishing a baseline from which to measure carbon removals and periodic measurements of the number and size of trees to determine the amount of carbon sequestered. Furthermore, a direct air capture project with transparent and calculated removal coupled with long-term storage methods will require a substantially different verification protocol than that applied to trees. Notably, the process has evolved to exclude valuable CDR solutions, such as ocean-based CDR technologies, from today's VCMs. Improving verification processes can lead to more solutions in the marketplace, adding a greater diversity of options.

The race to net-zero is underway, and VCMs are growing into a multi-billion-dollar marketplace. VCMs provide a unique and expansive opportunity: they can be purchased by anyone, market regulations are still being defined, and new solutions are being put forward. As VCMs continue to scale, multiple CDR project developers must be able to compete in the marketplace responsibly and in a streamlined manner. This is key to realizing net-zero pledges and climate restoration.

Challenges with Existing Frameworks

The CDR industry has seen incredible growth in recent years. The Intergovernmental Panel on Climate Change (IPCC), policymakers, and the private sector increasingly recognize the importance of CDR approaches in alleviating the impacts of climate change and removing legacy emissions from the atmosphere. CDR is fundamentally different from emissions avoidance. While carbon emissions avoidance is about preventing additional emissions from entering the atmosphere, carbon removal is about removing pre-existing atmospheric emissions. Though this statement may be obvious, carbon avoidance is often conflated with removal, and the two approaches are sometimes thought of as a single credit and system.

Early registries were built to address emissions reduction and avoidance, but the purpose of CDR is unique; older systems and processes need rethinking to ensure that the CDR crediting system and marketplaces are designed for the unique methods, challenges, and opportunities of CDR. Revised approaches are needed to create credits, monetize, and incentivize CDR. With these challenges, countries like the United States have a significant opportunity to lead the development of standards in this rapidly growing international industry. Below, we highlight the largest challenges with existing frameworks related to scaling CDR.

Markets Are Not Matching the Urgency of the Climate Crisis

The high levels of carbon in the atmosphere require fast, decisive action. Current voluntary and compliance markets move too slowly considering the scale of the climate crisis. Vetting projects and methodologies for inclusion in a market and project development can take years, and this costly process can impede the entrance of promising CDR solutions into the market. There is growing need to find a balance between scientific rigor and speed to incentivize CDR.

As carbon removal technologies develop, funding and access to capital are vital to ramp up technologies from lab-stage research and development to fully fledged carbon removal businesses. The various CDR approaches associated with MRV protocols need to also be developed. This

process requires efficient methodology development and publication systems. Such systems are critical to ensuring the credibility and economic value of carbon reductions, and credibility is also important to accessing capital that will enable CDR to scale. With CDR development critically needed, rigor must be evaluated as standards are developed, to ensure efficacy while making solutions easier to fund.

Increasing Demand and Incentivizing Supply

A quality carbon removal credit is generally considered durable, verified, additional, and monitorable. There are promising financing mechanisms for CDR companies that help encourage more supply. Companies like Microsoft, Shopify, and Stripe help drive the market by financing early-stage CDR. Several large companies have banded together to fund Advance Market Commitment (AMC) for CDR. These financing mechanisms use pneumococcal vaccine development, including the approach used for COVID-19 vaccines, to fund fast-moving CDR solutions. The most well-known is Frontier, with over $900 million in funding. Frontier aims to accelerate the development of carbon removal technologies by guaranteeing future demand for them. AMCs send a strong signal to researchers, entrepreneurs, and investors that there is a growing demand for these technologies. Importantly, Frontier aims to help create a net new carbon removal supply rather than compete over what exists today. Funding from the philanthropic sector and various legislative efforts to drive government procurement is also fueling demand. However, this demand creates a supply crunch, so more carbon removal credits are needed.

Complex Systems with a High Barrier to Entry

Climate-smart decision-making benefits from being easy and accessible to move the needle on climate change and CDR. Such accessibility requires buy-in from NGOs, corporations, and governments through equal access to positive climate choices. Carbon markets are generally most accessible to sophisticated climate consumers; markets favor companies, consultants, and non-profits steeped in project and credit creation knowledge. Listing a project on a registry generally requires third parties that take broker fees, which can increase a project's costs and complexity. Even for established CDR techniques like regenerative agriculture, the knowledge level required to access registries can make it difficult for all suppliers to participate. Additionally, these registries do not allow all buyer types to participate; project due diligence requires significant staffing and consultants which many companies and individuals lack the resources to engage.

Multiple Definitions of Permanence and Measurement

Accurate verification ensures quality, but the amount of carbon sequestered and removed can be difficult to measure. While preliminary measurements allow companies to iterate and improve, CDR sellers should support good buyer decision-making by being transparent regarding measurement accuracy and any possible risk of reversal, i.e., the accidental re-release of emissions into the atmosphere.

Permanence, meaning the duration or length that removed carbon stays out of the atmosphere, is an important metric for quality in VCMs. Long-term permanence, at times ranging to thousands of

years, is offered by multiple CDR solutions. Credits with less than 100+ years of permanence are still important in mitigating climate change, as less-permanent nature-based carbon removal credits can provide immediate action. Depending on their goals, buyers may purchase shorter- or longer-term carbon credits or both. Crucially, buyers must understand what they are purchasing and be provided with realistic permanence assessments to select credits that meet their sustainability needs. Additionally, a project with 100-year permanence is not guaranteed to last 100 years; the key is ongoing monitoring and methods with a very low risk of reversal or leakage. It's important to be realistic about the type of carbon removal credit offered and provide accurate and easy-to-understand information about the project's permanence and the possibility of reversal.

Additionality

Standardization of definitions will bring confidence to VCMs. Carbon credits have traditionally been considered *additional* if they would *not* have occurred without a market for offset credits. Every time a carbon removal credit is counted across a value chain, an additional carbon unit should be removed from the atmosphere and sequestered. This seems self-evident, as the goal of VCMs is to incentivize decarbonization. However, some carbon credits can currently be traded between organizations and countries multiple times. Multiple trades risk creating various counting inaccuracies. These inaccuracies could be mitigated by disallowing multiple entities to count the credit or developing a policy that stops credit sales from anyone but the originator. There are further accounting challenges with carbon credits when they are used for insetting, i.e., when credits are used to offset Scope 3 emissions within a supply chain but are recounted at multiple tiers within it.[1]

Insurance

There are challenges with current insurance mechanisms within VCMs. To protect against reversals that result in a downward reassessment of carbon reductions for a given project, market stakeholders have established 'buffer pools' comprised of reserved credits to compensate credit holders in the event of a reversal. The number of credits a project must contribute to the buffer reserve is usually based on an assessment of the project's risk for reversals. Theoretically, this approach can cover catastrophic losses affecting individual projects over defined time periods as long as the buffer reserve is sufficiently stocked with credits from projects across an entire program. However, these buffer pools do not always meet their stated goal. As seen with forestry credits, projects can be destroyed beyond the value of the buffer pools, leaving the buyer with worthless credits and no net carbon removed. If a project is successful and there is little to no use of the buffer pool, at the end of the project, the supplier is left with buffer pool credits that have no value. This lowers the economic value of the overall project from the supplier's perspective. Efforts are currently underway to improve insurance for CDR credits.

[1] Scope 1–3 emissions evaluate GHG emissions from various sources, accounted for by companies. Scope 1 emissions represent direct GHGs from point sources, Scope 2 are the indirect emissions produced, and Scope 3 are the emissions produced by companies from sources they do not directly control but that occur within their value chain.

Opportunities for Growth

Although today's VCMs have challenges, they can play a crucial role in achieving net-zero and net-negative emissions. When properly implemented, carbon markets can potentially drive effective climate change prevention and remediation on a global scale. A VCM built on quality can hypothetically bridge voluntary and regulated compliance markets to support climate action. Carbon credit usage and emissions disclosure should mirror the high bar applied to carbon credit certification. Structural changes regarding offset quality and usage can help maximize their potential and are detailed more fully in the next section of the white paper.

Net-negative companies and governments are necessary to achieve global net-zero targets that align with the IPCC's 1.5°C warming scenario. Properly implemented VCMs pave the way for reliable financing of high-quality climate action. With quality established, integration into national credit trading would allow countries to appropriately use offsets for Internationally Transferred Mitigation Outcomes (ITMOs). Such use would allow them to meet their nationally determined contributions (NDCs) as outlined in Article 6 of the Paris Agreement. Below, we outline the opportunities to grow CDR in VCMs.

Structural Changes to Carbon Offset Implementation

A growing number of companies are setting corporate net-zero targets through the Science Based Targets initiative (SBTi). The program disallows carbon reduction offsets and only allows carbon removal credits for 'residual' hard-to-abate emissions (<10%) to meet net-zero emissions. The SBTi encourages corporate efforts to catalyze the carbon removal industry and enhance natural carbon sinks by preserving nature and forcing companies to meet net-zero targets without offsets and with minimal removals. If the SBTi set strengthened targets, it could encourage more companies to remove carbon today.

The SBTi principle matches the offsetting math in the second pathway of Figure 1 below; carbon reduction offsets are not allowed, meaning an emission minus a removal equals net-zero CO_2 emissions (1 - 1 = 0). Importantly, the SBTi principle catalyzes CDR to solve the hard-to-abate residual emissions challenge on the way to net-zero. This is noteworthy as current removals credit supplies are constrained and, unless scaled in the coming decades, will be an insufficient climate solution.

Carbon reduction credits are a tool for rapid decarbonization, assuming the quality of carbon reduction credits is improved. Those without the luxury of preventing Scope 1 and 2 emissions can have stop-gap emissions reduction measures available until they can afford to integrate a permanent decarbonization solution. Those with less control, influence, or decision-making power over their supply chains will need an option to reduce their Scope 3 footprint.

Including carbon reduction offsets in carbon markets structurally changes the net-zero emissions equation. If high-quality carbon reduction offsets are available, they can help drive down emissions. If reduction offsets are an option, every carbon removal credit purchased leaves a

carbon reduction credit unsold. Importantly, net-zero emissions claims would need to follow stricter guidelines if carbon reduction credits were available. There are multiple pathways available (Figure 1):

- 'Buying one of each, i.e., one reduction credit and one removal credit
- 'Only use CDR for residual emissions' or otherwise unabatable GHG sources
- 'Apply CDR to legacy emissions' to make up for previously emitted pollution

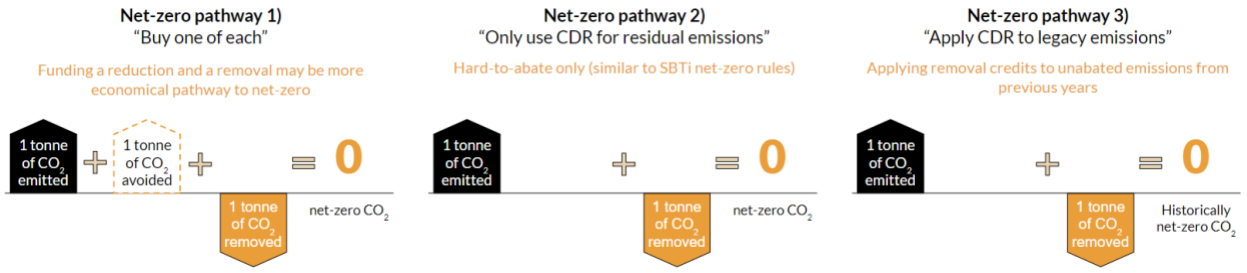

Figure 1. Effective pathways to net-zero emissions using carbon removal credits. Source: Adapted from Swiss Re

Until there are robust, worldwide efforts to prevent all GHG emissions, entities will remain that emit and do not participate in decarbonization, CDR, or offsetting. A company may successfully eliminate all of its annual emissions and achieve its net-zero goals, but another entity might still emit them. Intrinsically, that means the world will not achieve net-zero emissions. Therefore, net-zero entities can only create a net-zero world by removing legacy emissions and going net-negative.

Improving the Efficacy of Carbon Credits

An effective VCM can measure or score offsets by quality and performance, including additionality, durability/permanence, and MRV. Carbon markets originated to spread the cost of reducing emissions. VCMs trade data — digital credit for a physical action — risking a race to the bottom on costs. Without a regulatory backstop, there are already examples of this coming at the expense of carbon offset project quality. Restructuring VCMs with stronger quality metrics around additionality, permanence, leakage, and MRV would create more tangible, effective carbon offsetting.

Numerous metrics to measure carbon offset quality exist. However, not all VCMs and their project certification entities fully align with efforts to improve quality. Establishing a transparent set of quality metrics agreed upon by marketplaces, independent third parties, market participants, and moderators could eliminate low-quality projects and build more confidence in VCMs.

Entering a VCM requires carbon credit producers to clear a high bar before verification and certification. Transparent quality metrics, MRV, and distributed ledger credit tracking could democratize carbon credit generation and accelerate climate action. Projects could achieve faster certification, accelerated by transparent, democratized rules.

Specific quality metrics, such as financial additionality, would likely require credit producers to open their books to approved accountants. Cross-referenced surveys about behavioral and political additionality would ensure high-integrity credits. For example, global agreements and efforts to end deforestation and strengthen other forms of land use, blue carbon, restoration, and conservation efforts will significantly impact the additionality of many nature-based carbon credit types. If governments fall short, the value of biodiversity could separate into its own voluntary market. The pricing effect would necessarily be reflected in carbon credit additionality, or the carbon credit price would be reflected in the biodiversity credit additionality. This would help ensure that artificially low carbon credit prices do not affect direct decarbonization efforts.

Policy & Market Recommendations

VCMs have a significant opportunity to evolve in a way that brings durable and promising carbon removal solutions to market. Based on the challenges and constraints in today's markets, the following recommendations can help grow VCMs, scale carbon removal, and provide a greater menu of options for purchasers. Overall, it will be important for governments, regulators, marketplaces, and other stakeholders to develop basic standards and definitions that strengthen the market while allowing VCMs the flexibility to evolve based on the needs of buyers and sellers. The following recommendations are intended for regulators and existing market providers.

Distinguish Offsets and Carbon Removal Credits

Traditional offsets and removals credits can coexist in VCMs, but these two types of credits are different and should be treated as such. Clarity in names and definitions will build greater transparency into net-zero commitments and the markets themselves.

Align Definitions

A clear definition of VCM terms will help establish understanding and a common set of principles across markets. An improved definition is especially needed for additionality, which is currently determined and weighted in various ways. These definitions likely need to be developed by a government body or third party and will benefit from broad-based buy-in and community input, which speaks to the benefits of oversight to ensure VCMs' integrity.

Establish a Minimum Quality to Enter VCM Markets

A wide range of durable carbon removal solutions exist, and as many as possible that meet minimum durability and quality standards should be brought to market. Establishing minimum entry thresholds for durability and quality, along with tools like a quality grading rubric, will help to strengthen VCMs. Such thresholds would establish broader baselines for CDR. Transparency and context around any quality rubric will be crucial to its success.

Streamline VCM Verification

Verifying CDR approaches for removal credits helps build a stronger, more confident market that delivers climate benefits. At the same time, given the short time frame remaining to avert the worst

effects of climate change, VCM verification systems will benefit from being agile and efficient to avoid years-long delays in verifying CDR to enter.

Price to Reflect Permanence

Each CDR solution presents unique benefits along with a series of trade-offs, ranging from the permanence of the removal method to the potential removal capacity of the relevant CDR approach. Along with other factors, durability of a given CDR approach should be factored into VCM pricing such that solutions with longer permanence, and thus a longer positive climate impact, are priced and valued accordingly. Pricing differentiation will allow buyers to identify a menu of solutions that suits them. Recognizing that the cost of high-quality removal can be high for private sector buyers, governments can help subsidize the cost to make it a net win.

The climate impact of emitting can be offset by accounting for non-permanence. Accounting could include treating each short-term durability carbon credit as an asset that needs replacing at the end of its functional life, i.e., horizontal credit stacking; buying an appropriate number of short-term credits to create the same climate impact as a more-permanent credit, i.e., vertical stacking; blending the two credit purchasing strategies, i.e., the 'bridge approach'. The latter option tends to preserve nature today while catalyzing CDR technology development.

Increase Transparency in Emissions and Net-Zero Pledges

A more transparent market will lead to stronger climate solutions. There are currently gaps in publicly disclosed data; greater transparency on emissions and those being offset will help to measure efficacy. Similarly, greater transparency into net-zero pledges will provide more insights into what CDR buyers require and which forms will help buyers achieve their goals. Transparency on the retirement of carbon removal projects will also be important in accounting.

Ensure CDR Project Developers are Supported to Enter VCMs

Some VCMs already offer support for CDR companies and identifying and addressing additional needs will help catalyze more high-quality CDR solutions. This may include, for example, credit to support CDR in early-stage research and development or during the verification process.

Conclusion and Next Steps

Carbon removal companies are unlocking climate solutions that can help make net-zero and net-negative pledges a reality and reverse the impacts of climate change. VCMs are a powerful way to help scale CDR solutions and meet climate targets in tandem with the important work of reducing emissions. In highlighting the current challenges and emerging opportunities for carbon removal companies, corporates, governments, and regulators, we describe pathways for creating stronger VCMs to help unlock gigaton-scale carbon removal. Implementing these policy recommendations can help to strengthen VCMs and expedite the growth of carbon removal.

Acronyms

AMCs	Advance market commitments
CDR	Carbon dioxide removal
CO_2	Carbon dioxide
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
ITMOs	Internationally transferred mitigation outcomes
MRV	Monitoring, reporting, and verification
NDCs	Nationally determined contributions
REDD+	Reducing emissions from deforestation and forest degradation, a UN program
R&D	Research and development
RD&D	Research, development, and demonstration
SBTi	Science-based targets initiative
SEC	The U.S. Securities and Exchange Commission
VCMs	Voluntary carbon markets

Glossary

Abatement: A reduction or lessening of something, largely referring to a policy style facilitating emissions reduction.

Advance market commitments: Binding contracts or commitments to guarantee a product or the market for it once it has been successfully developed.

Carbon dioxide removal: A process of removing carbon dioxide from the atmosphere, largely targeting legacy or existing emissions. Technologies complete carbon removal processes to sequester carbon dioxide to create negative emissions.

Compliance market: Compliance markets are created and regulated by mandatory national, regional, or international carbon reduction regimes.

Conference of Parties: All States that are Parties to the Convention are represented at the Conference of Parties, also known as COP, where implementation of the Paris Agreement is discussed.

Greenhouse gases: Any gas that has the property of absorbing infrared radiation (net heat energy) emitted from Earth's surface and reradiating it back to Earth's surface, thus contributing to the greenhouse effect.

Horizontal supply chain: Horizontal integration occurs when a business grows by purchasing related businesses.

Intergovernmental Panel on Climate Change: The United Nations body for assessing climate-change-related science.

Mitigation: Making a situation or consequence less severe and reducing a burden.

Nationally Determined Contributions: This is a climate action plan to cut emissions and adapt to climate impacts. Each Party to the Paris Agreement must establish an NDC and update it every five years.

Permanence: The measured longevity of removed carbon.

Value chain: A concept describing the full chain of a business's activities in creating a product or service, from the initial reception of materials to its delivery to market.

Voluntary carbon markets: Voluntary markets function outside compliance markets and enable companies and individuals to purchase carbon offsets voluntarily.

Glossary definitions have been developed from existing literature and resources.