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CO_2 removal solutions: A buyer's perspective

As climate change impact becomes increasingly apparent, the adoption of decarbonization commitments is accelerating. Companies are acting rapidly and decisively to reduce greenhouse-gas emissions and neutralize residual emissions.

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It's becoming clear that keeping the rise in global temperatures below 1.5°C will need an increased focus on CO_2 removal (CDR)—taking CO_2 out of the atmosphere through nature-based and technological solutions. CDR methods include natural climate solutions, such as reforestation and restoration of mangroves and peatlands; bioenergy with carbon capture and storage (BECCS); and direct air capture and storage (DACS).

In a blog post, McKinsey experts said CDR solutions would be a crucial part of the effort to achieve net-zero emissions.[1] The Intergovernmental Panel on Climate Change (IPCC) has said ramping up CDR volumes—up to six metric gigatons of CO_2 per year—is "unavoidable if net zero emissions are to be achieved."[2] In addition, companies have set science-based climate targets to reach net-zero emissions, with the number taking action on such corporate targets quadrupling since 2020—to more than 4,000 in January 2023, from approximately 1,000 in 2020.[3]

If companies are to achieve such targets, they need to treat decarbonization as a top priority. However, even after aggressive decarbonization efforts, many will be left with residual emissions that can't be reduced, because of economic, operational, or procedural limitations.[4] Such companies will need CDR solutions to neutralize the residual emissions and achieve their net-zero targets. In addition to helping achieve net zero, CDR could help with other climate goals (for example, Microsoft's stated aim to become carbon negative[5]).

Because of those trends, the demand for CDR solutions has been growing rapidly. It's likely to grow further as voluntary commitments strengthen and proliferate and as more organizations realize the contributions that CDR solutions can make toward meeting their targets. As a result, more companies are now looking to enter the CDR market as buyers. As they do, they face potential uncertainties in a very nascent market, as well as increasingly short supply—the current pipeline of CDR capacity (155 megatons of CO_2 per year) falls 80 percent short of the requirement suggested by IPCC (500–1,200 megatons of CO_2 per year).[6]

As companies begin to scale purchase of CDR solutions, they face four key questions:

— How do we make a credible climate claim?

— How do we identify high-quality CDR solutions?

— How do we design a CDR portfolio?

— How do we source CDR solutions?

How do we make a credible climate claim?

Setting a target for a credible climate claim is the first step to confirm an organization's contribution to limiting the rise in global temperatures above 1.5°C. For most companies, a credible climate claim will result in a need for some quantum of CDR solutions. We see a couple of important considerations for companies as they decide what target to set and chart their strategy to deliver it.

[1] *Sustainability Blog*, "Carbon removals at the forefront of McKinsey's inaugural Green Business Building Summit in Stockholm," blog entry by Emma Gibbs, Mark Patel, Giulia Siccardo, and Shreya Vora, McKinsey, September 21, 2022.
[2] "Summary for policymakers," in *Climate Change 2022: Mitigation of climate change,* Intergovernmental Panel on Climate Change, April 4, 2022.
[3] *Science-based net zero: Scaling urgent corporate climate action worldwide*, version 1.2, Science Based Targets, June 2022; Target Dashboard, Science Based Targets, January 18, 2023.
[4] It's paramount for the development of a sustainable and inclusive economy that companies back any sustainability-related claims they make with genuine actions.
[5] *Official Microsoft Blog*, "Microsoft will be carbon negative by 2030," blog entry by Brad Smith, January 16, 2020.
[6] The estimated current pipeline of CO2 removal (CDR) solutions reflects the long lead times with technologies for bioenergy with carbon capture and storage (BECCS) and projects with direct air capture and storage (DACS) and the historic run rates for projects with natural climate solutions. The BECCS pipeline estimate is based on projects recorded by Global CCS Institute. The DACS estimate is based on the publicly stated pipelines of Carbon Engineering, Climeworks, and Global Thermostat, which are the three largest DACS producers. The estimated pipeline for natural climate solutions accounts for historical activity rates (approximately three million hectares per year between 2010 and 2030 and average CDR solutions of approximately ten metric tons per hectare) and a conservative assumption of five full years to 2025. Value represents the average of the median values for three 1.5°C pathways published by the Intergovernmental Panel on Climate Change (less than 1.5°C, low overshoot, and high overshoot).

Set a science-based climate claim, if possible, backed by a globally recognized initiative

Companies face a variety of options in their claims, including carbon neutral, climate neutral, climate friendly, and net zero, each with different requirements and degrees of stringency. In the absence of a global governance body, these claims are often applied inconsistently, which can lead to significant variance in companies' climate decarbonization ambitions, the emissions considered to be covered under a claim, and the rules around offsetting emissions through emission avoidance or CDR credits. This inconsistency contributes to stakeholder concerns about greenwashing.[7]

Several initiatives provide guidance to improve the credibility of climate claims and set standards for how carbon credits, and CDR solutions in particular, contribute to such claims. The Science Based Targets initiative (SBTi), the Climate Pledge, and the Race to Zero Campaign offer guidance on what it means to be net zero and what actions organizations can take to reach that goal. The Oxford Principles for Net Zero Aligned Carbon Offsetting and the Voluntary Carbon Markets Integrity Initiative (VCMI) both provide guidance on how to use CDR solutions as part of a credible pathway to reach climate goals. It's worth noting that despite the lack of a clear, single standard, there is an emerging consensus to support the role of CDR in net-zero claims to neutralize residual emissions after achieving significant internal emission reductions.

Reduce emissions before removing carbon

Some critics of offsetting (including the use of CDR solutions) cite potential concerns that it provides emitters with a "licence to pollute"[8] and represents "a dangerous distraction"[9] from internal decarbonization. These critiques have informed the consensus view that companies should first decarbonize as much as they can and then rely on CDR only to neutralize residual emissions, where compelling physical, operational, or economic barriers prevent further emission reductions.

A transparent and ambitious decarbonization claim that prioritizes internal emission reductions before offsetting is key to upholding credibility. For example, SBTi's Net-Zero Standard requires a 90 to 95 percent cut in value chain emissions by 2050 with permanent CDR solutions to neutralize residual emissions at net zero.[10] Offsetting emissions in the interim is recommended as an additional way to contribute to mitigating climate change, beyond an organization's own net-zero trajectory. Whichever the approach, using CDR solutions to deliver a credible climate claim requires organizations to commit to full transparency on the CDR credits used and retired in their sustainability reports.

How do we identify high-quality CDR solutions?

Most credible claims will require organizations to secure CDR solutions to neutralize residual emissions. CDR credits are of varying quality, and low-quality credits can weaken the credibility of a claim. To mitigate that risk, companies would need to invest in ensuring the quality of the credits they buy.

Understand what constitutes high-quality CDR solutions

Sourcing high-quality CDR solutions is critical: first to ensure that a company has the climate impact intended by its purchase of the solution; and second to avoid potential reputational risks resulting from making climate claims that can't be supported by the CDR solutions that it has bought. Carbon credit quality is driven by eight environmental integrity drivers, which are relevant for both CDR credits and emission avoidance credits (see sidebar, "Carbon credit quality drivers").[11]

[7] Greenwashing, which refers to empty or misleading claims about the environmental or social attributes of a product or service, poses reputational risks to businesses, erodes consumers' trust—as well as their ability to make more environmentally and socially responsible choices—and potentially undermines the role of regulators.

[8] Camilla Hodgson and Billy Nauman, "Carbon offsets: A licence to pollute or a path to net zero emissions?," *Financial Times*, August 31, 2021.

[9] Mike Childs and Paul de Zylva, "A dangerous distraction—the offsetting con," Friends of the Earth, October 22, 2021.

[10] *Science-based net zero*, June 2022.

[11] Emission avoidance credits are certified emission reductions from projects that reduce emissions compared with the most likely course of action—the baseline scenario (for example, renewable energy, energy efficiency, and avoided deforestation).

These integrity drivers would need to be considered not only for a CDR type (for example, how permanent is DACS?) but also by project, given the potential for risks to vary depending on the practices of individual project developers.

A primary role of carbon credit standards setters such as Verra and Gold Standard is to ensure that carbon credits are issued only from projects that implement their required range of safeguards to control these risks and that have been validated by a third party. However, these safeguards vary significantly across standards and even individual projects, leading to a wide range of outcomes. For example, standards require long-term monitoring as part of their range of permanence safeguards, but how many years is considered long term? By way of illustration, American Carbon Registry requires 40 years as a minimum duration of carbon sequestration, while Climate Action Reserve stipulates 100 years.

Invest in robust due diligence and quality assurance processes

To select high-quality CDR solutions, companies will need a due-diligence and quality assurance capability that can assess how well a technology and a project performs against the carbon credit quality drivers. Quality assurance processes need to be data led, standardized (including using benchmarks), and clear to enable robust

Carbon credit quality drivers

Carbon credit quality assessment can be based on underlying environmental integrity as evaluated across well-established standards.

Environmental-integrity drivers of carbon credit quality include the following:

- *Permanence.* CO_2 emission reduction and CO_2 removal (CDR) can't be reversed in the future.
- *Additionality.* CO_2 reduction and CDR wouldn't happen without the carbon crediting project.
- *No leakage.* CO_2 emissions shouldn't be displaced outside the project boundary.
- *Monitoring, reporting, and verification.* Carbon credits are issued based on actual and accurately measured CO_2 emission reduction or CDR, following robust, independent, third-party validation and verification.
- *Baselines.* The counterfactual baseline is accurate and credible, and it avoids overestimation to avoid overcrediting.
- *Counted only once.* There's no double counting of CO_2 emission reduction or CDR from double issuance, double sale, or double claiming.
- *No net harm.* There aren't any unintended negative impacts on biodiversity, local communities, or sustainable development more generally.
- *Cobenefits.* Activity creates positive benefits not related to greenhouse-gas emissions, such as enhanced biodiversity, sustainable development, health, and resilience.

decision making, manage risks, and communicate decisions simply.

A company's risk appetite is a key consideration here, with nonpermanence risk a particularly important dimension. Nonpermanence risks differ across nature- and technology-based CDR solutions. Carbon removed and stored into biological sinks (for example, as carbon is stored in soil or trees) has a *higher* risk of being rereleased into the atmosphere over *decades* through events such as wildfires. On the other hand, carbon removed into geological storage (for example, carbon captured and stored in deep saline aquifers through BECCS and DACS technology or in rocks through mineralization) has a *low* risk of being rereleased into the atmosphere over *centuries to millennia*.[12] Certain initiatives recommend a shift from less to more permanent CDR options over time, yet most of the CDR volumes on the market today are nature-based CDR solutions that use biological storage with higher nonpermanence risk. A growing number of project developers are working on bringing more permanent CDR solutions to market; however, this supply is still short of what will be required in a 1.5°C pathway, with an approximately 80 percent shortage expected by 2025.[13]

While the market is still in its infancy, with many standards and protocols still to be defined, CDR quality assessment can be complex and resource intensive. Indeed, as TSVCM noted in its 2021 report, "Buyers struggle to navigate various standards and to find high-quality carbon credits at transparent prices. For a new market participant, it may be difficult to understand what constitutes a high-quality credit."[14] This is echoed by buyers across the market, including participants such as Shell and Microsoft.[15]

Buyers can potentially learn from the selection criteria developed by companies that are active in this space and from advanced market commitment (AMC) buying clubs, such as First Movers Coalition and Frontier.[16] Global initiatives are also creating open-source assessments to draw on, such as the Carbon Credit Quality Initiative scoring tool by the World Wildlife Fund, Öko-Institut, and Environmental Defense Fund or the Integrity Council for the Voluntary Carbon Market's (IC-VCM's) expected Core Carbon Principles that will introduce a global threshold standard for quality. Eventually, emerging rating agencies will perform independent assessments for buyers to monitor and verify their portfolios.

3. How do we design a CDR portfolio?

Once companies have established what CDR solutions qualify as high quality, they will still face a range of project types from which they can choose. At this point, company preferences, risk appetites, and strategic fit will shape the design of a CDR portfolio.

In addition to assessing quality and risk, a company will need to determine how well a CDR technology or project contributes to company-specific preferences. In addition to quality, this may be informed by the following:

— *Preference for cobenefits.* CDR solutions come with cobenefits and companies may have preferences for which they want to prioritize. For example, a nature-based CDR that restores degraded land will help to promote biodiversity and the important cause of nature recovery, whereas a BECCS CDR that is created from a decommissioned coal power station could potentially support job growth in the area.

[12] *The Oxford Principles for net zero aligned carbon offsetting*, University of Oxford, September 2021.
[13] Shortage estimated based on CDR capacity required in 1.5°C warming pathways versus current pipeline, metric tons of CO_2.
[14] *Taskforce on Scaling Voluntary Carbon Markets: Final report*, TSVCM, January 2021.
[15] *Ensuring high quality nature-based carbon credits,* Shell, November 2021; *Microsoft carbon removal: Lessons from an early corporate purchase,* Microsoft, 2021.
[16] For more, see *New at McKinsey Blog*, "McKinsey partners with Stripe, Alphabet, Shopify, and Meta on $925 million carbon removal commitment," April 13, 2022.

— *Permanence increase.* Companies might follow the recommendation from the Oxford Principles for Net Zero Aligned Carbon Offsetting to gradually shift toward more permanent CDR. To do this, companies would need to increase the share of CDR credits that they buy from projects that have low permanence risk—for example, BECCS and DACS—over time.

— *Ability to pay.* Technology-based CDR solutions are significantly costlier than nature-based solutions.[17] Typically, they are bought by buyers with high ratios of business profits to carbon emissions (such as technology, financial-services, and professional-services companies) that are inclined to pay more per unit of CDR, permitting more flexibility in the types of CDR credits to include in their portfolio. Another approach is companies designing a portfolio of CDR solutions aligned with their own carbon price and then sourcing CDR credits only at their carbon price or above.

— *Strategic fit.* Companies may prefer CDR types that have synergies with their existing business. For example, the aviation industry is investing in DACS, a technology that can also contribute to sustainable aviation fuels. Similarly, given their position in the biomass value chain as timber users, pulp and paper companies may have a natural affinity for BECCS to decarbonize their own operations and create new value streams in a net-zero world. Nicolas Chrétien, head of sustainability and environment at Airbus, underscores these considerations in the design of the company's CDR portfolio. "When we looked at procuring CDR offsets, we focused on high-quality offsets with high permanence, technology-driven to fit with the company's engineering culture but also uplifting the overall decarbonization path for the aviation industry," Chrétien told us. "Our first commitment to source DACS offsets is a concrete step toward the use of this promising technology for both Airbus's own decarbonization plan and the aviation sector's ambition to achieve net-zero carbon emissions by 2050."

— *Timing.* Because of the role CDR solutions play alongside carbon emission reduction, the timing of a company's purchase of CDR solution credits will depend on the buyer's target climate claim and strategy to deliver it. However, given the shortage of supply of high-quality CDR credits, companies should consider early investment in CDR solutions before they need them to support a specific net-zero claim. The CDR solutions industry is still in its infancy, with supply falling short of what will be required. Moreover, the nature of the projects means there will be a time lag between the demand signal and the industry's ability to supply large volumes. Engineered CDR solutions rely on the build-out of multiyear infrastructure projects that each cost hundreds of millions of dollars in capital expenditures. Similarly, reforestation projects often need years to grow before they can sequester meaningful volumes of carbon.

— *Exposure to risk.* The CDR industry is in its infancy and many projects are first of their kind, with varying levels of potential technical, commercial, and operational risks. As companies build their CDR credit portfolio, they may need to consider how to manage their exposures across different projects, different technologies, and different suppliers to mitigate delivery risk and risks arising from rapidly evolving standards and definitions of quality. Similarly, companies should consider a range of contractual schemes that match their appetite for exposure to risks linked to project development and to nascent markets. These contractual schemes include long-term offtake agreements that can create some certainty on price and volume for buyers and revenue certainty for project developers, which, in turn, can make a project investable and more likely to happen. By contrast, spot market purchases expose buyers to greater market volatility but may involve less exposure to individual developers' risks.

[17] "Summary for policymakers," April 4, 2022.

Buying clubs have attracted strong media attention, which has helped build awareness and momentum for CO_2 removal solutions among a broader group of stakeholders.

4. How do we source CDR solutions?

Once a company has set its target climate claim, created a strategy to meet it that includes CDR solutions, and designed a CDR portfolio that fits its preferences and willingness to accommodate risk, the practical question of how to buy CDR credits arises.

Decide whether to generate or buy

Sourcing strategies range from full reliance on markets to becoming a CDR project developer. Specifically, buyers may do one of the following:

— Generate direct CDR internally[18] through partnerships and investments in project developers, or even through acquisitions of developers and their projects.

— Buy CDR solutions from existing brokers and retailers or emerging marketplaces or directly from project developers through competitive sourcing.

This is a strategic question that rests on the criticality of CDR solutions to a company's ability to create value in the future. To the extent that CDR solutions can be a future source of value and growth, a company may choose to be more invested in the development of CDR credits by developing its own projects or gaining exposure to the upside of other companies' projects.

For buyers, decide how much to delegate CDR sourcing

Low-volume, less-experienced buyers may choose to rely on external sourcing options, such as brokers and retailers that have pre-vetted CDR credits for quality, cobenefits, and risks. Higher-volume buyers may consider running a competitive bidding process for CDR developers to control more closely the characteristics of the products they buy and use buying power to shape the market; this requires much more investment of time and in capabilities.

One trend is the emergence of buyers' clubs, such as First Movers Coalition and Frontier. These clubs pool resources to procure CDR solutions with similar characteristics. This concept has the following potential benefits:

— *Market signal.* Aggregated demand for CDR solutions demonstrates that there is an accessible market for suppliers that meet transparent criteria, which helps to accelerate this essential, nascent industry to generate more supply to meet climatic needs and climate claim demands.

— *Efficiency.* Members can issue a single request for proposal, hire common technical expertise to set criteria, and evaluate against them. Similarly, suppliers can prepare a single proposal for multiple potential buyers and pool their knowledge and experience.

[18] This occurs when a company offsets its emissions through a project in its own value chain. It's primarily suited to companies with a focus on land use, such as food and beverages companies. These entities can leverage their networks of farmers and wider land-use capabilities to fund afforestation, reforestation, or sustainable agriculture activities within their value chain.

— *Awareness.* Buying clubs, so far, have attracted strong media attention, which has helped build awareness and momentum for CDR solutions among a broader group of stakeholders. Buyers' clubs can help send a demand signal to suppliers and investors that there is a market for carbon removal and to begin building quickly.

Note that sourcing avenues for technology-based CDR solutions are significantly more limited than for nature-based solutions. Nature-based CDR solutions are available across all sourcing avenues (for example, from brokers, marketplaces, or competitive sourcing), with several established methodologies for forestry CDR and many emerging for soil and blue carbon CDR. On the other hand, newer technology-based CDR solutions, such as DACS and BECCS, aren't currently accredited by established standards and are available only through alternative avenues via reserving capacity at one of the few emerging facilities in the world or through a small number of emerging exchange platforms that deal in more permanent CDR.[19] Some of this dynamic may change as standard setters publish CDR methodologies for technology-based CDR solutions.

Keeping up with the industry

Building a CDR strategy and the associated capabilities needed will enable buyers to navigate the uncertainties of this emerging market. Early movers will benefit from lessons they learn by being in the market, and their ability to secure scarce supply, helping them to gain a competitive advantage over competitors entering the CDR solutions space later.

Given that, buyers would be wise to develop a CDR strategy but be prepared to change it to adapt to fast-evolving norms. For example, as the criteria for high-quality carbon credits and standards for monitoring, reporting, and verification evolve over time, companies may need to rebalance their CDR portfolios, most likely toward higher-quality, more permanent CDR credits.

That means staying up to date as norms regarding carbon credits continue to evolve to withstand public scrutiny. For example, the World Wildlife Fund's Carbon Credit Quality Initiative and the VCMI's Claims Code of Practice launched in May and June, respectively, and the IC-VCM will begin rolling out their codes later in 2023. SBTi is expected to publish guidance on "beyond value chain mitigation" later in 2023, while the Greenhouse Gas Protocol works on guidance for the accounting of CDR solutions. These outputs will undergo road testing and revisions in the next few years. In addition to incorporating updates in CDR strategies continuously to avoid potential reputational risks, buyers can actively participate in these initiatives to support global consensus building.

CDR is now widely recognized alongside CO_2 emission reduction as a vital element of the global effort to curb damaging climate change. Consequently, companies making net-zero commitments urgently need to understand the role that CDR could play in their climate strategies and how they can engage in the marketplace for CDR solutions in a way that creates value and matches their appetites for risk. The practical steps outlined in this article are a good place to start, and the time to act is now.

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[19] Emerging facilities for DACCS CDR solutions include 1PointFive, Aircela, Carbon Engineering, Climeworks, and Sustera (list isn't exhaustive). Existing platforms proposing CDR solutions include Carbon^X, Compensate, Klimate, Patch.io, Puro.earth, and Removement (list isn't exhaustive).