



First movers: the commercial case for investing in early-stage carbon dioxide removal

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About BeZero Carbon

BeZero Carbon is a global ratings agency for the Voluntary Carbon Market. Its carbon credit ratings allow all market participants to price and manage risk. BeZero's carbon ratings and research tools support buyers, intermediaries, investors, and carbon project developers.

Founded in April 2020, its team combines climatic and earth sciences, sell-side financial research, earth observation, machine learning, data and technology, engineering, and public policy expertise. Its head office is in London, with people working from five continents.

Abbreviations

ACR - American Carbon Registry

ACX - AirCarbon Exchange

BECCS - Bioenergy with Carbon Capture and Storage

BEIS - Department for Business Energy and Industrial Strategy

BNEF - BloombergNEF

CAR - Climate Action Reserve

CCUS - Carbon Capture Use and Storage

CDR - Carbon Dioxide Removal

CfD - Contract for Difference

DAC - Direct Air Capture

ETS - Emission Trading Scheme

GGR - Greenhouse Gas Removal

IPCC - Intergovernmental Panel on Climate Change

LCFS - Low Carbon Fuel Standard

MRV - Monitoring, Reporting & Verification

NBS - Nature-based Solutions

NPV - Net Present Value

p.a. - per annum

SBTi - Science Based Targets Initiative

TSVCM - Taskforce for Scaling Voluntary Carbon Markets

VCM - Voluntary Carbon Market

Executive Summary

The climate case for carbon dioxide removal (CDR) is clear. By 2050, a cumulative total of 165 billion tonnes of removal is going to be needed, amounting to as much as 10 billion tonnes per year, to limit climate change to 1.5°C ([Energy Transitions Commission, 2022](#)). According to the Intergovernmental Panel on Climate Change (IPCC), billion tonne scale CDR is now “unavoidable” if we are to hit climate targets.

There is also a strong commercial case for investing in early-stage CDR, but as of yet it has not been made. In summary, there are six key reasons for investing:

- Future financial savings
- New business opportunities
- To comply with regulatory requirements
- To comply with voluntary standards
- To be seen as a climate leader
- To improve commercial knowledge and networks

There are three avenues for investing in this new industry. First, companies or individuals can buy CDR credits either through intermediaries or directly from suppliers. Second, investors can buy equity to help CDR companies get off the ground. Third, companies can integrate CDR into their supply-chains via an insetting strategy.

The task to scale CDR to a billion tonne industry in just three decades is monumental. Both the private and public sector will need to be firing on all cylinders if we are to have any hope of hitting these targets. For private investors, the climate side of this has been well told. It is time to unpick the business-reasons for investing in CDR.

The Challenge

1. We need enormous amounts of CDR to limit warming to 1.5°C.

Multilateral climate agreements dictate that every country will need to achieve net zero emissions by mid-century. The vast majority of this decarbonisation - roughly 90% - will come from emissions reductions ([Climate Change Committee, 2020](#)). But, there will be a wedge of emissions which will persist beyond 2050 due to hard-to-abate sectors such as aviation, shipping and heavy industry.

Large scale carbon removal is going to be necessary to cater to these residual emissions. By 2050, a cumulative total of 165 billion tonnes of removal will be needed, amounting to as much as 10 billion tonnes per year ([Energy Transition Commission, 2022](#)). This capacity will be split between nature-based and engineered removal.

Nature-based removal	Engineered removal
<ul style="list-style-type: none">- Enhances the natural carbon cycle by developing or restoring carbon sinks.- Technologically mature, in technology readiness levels (TRL) 8-9 (Royal Society, 2018).- Projects are developing and deploying.- Relatively low intervention and easy to scale.- Environmental and social co-benefits: increased green space, cleaner air (health), job opportunities.- Examples:<ul style="list-style-type: none">- Afforestation- Reforestation- Restoration	<ul style="list-style-type: none">- Replicates the carbon cycle by deploying engineered technologies to create new or enhanced existing carbon sinks.- Nascent but developing, in TRL 2-7 (Royal Society, 2018)- Benefits and challenges are method specific. <p>Examples:</p> <ul style="list-style-type: none">- Biochar - a biological method that sees biomass undergo pyrolysis to achieve a state whereby when stored atop soils locks carbon in place and provides a host of benefits to the soil itself: reduced need for fertiliser, and increased crop yield.- Direct Air Capture (DAC) - a geochemical method that removes carbon from ambient air then permanently stores it underground geologically or through mineralisation.¹- Bio-Energy with Carbon Capture & Storage (BECCS)- Bio-oil- Carbon in Concrete- Enhanced Weathering- Ocean Alkalinity Enhancements

Both nature-based and engineered removal are needed for climate targets to be achieved. Presently nature-based removal credits are increasingly accessible in the voluntary carbon market (VCM), contributing 7% to total credit purchases and experiencing annual increases in credit availability and project deployment ([VCM Climate Dashboard, 2022](#)). But nature-based methods alone cannot reach removal targets. There is both a physical land limit to scaling projects and a higher risk of reversal, which can impact the permanence of these methods. Engineered CDR needs to grow in capacity to realise a billion tonne scale industry.

¹ For more information on carbon removal methods read BeZero CDR Explainers - [here](#).

2. Engineered removal supply is currently small and expensive.

There are not enough projects removing carbon at present. Two of the largest CDR developers issuing credits in 2022 are Climeworks (DAC) and Charm Industrial (Bio-oil). Over the last two years, these projects have sequestered a combined total of roughly 15,000 tonnes of carbon, according to available data.² In total, over 30,000 engineered removal tonnes have been retired overall - all since 2019, when engineered removal credits were first sold. This is only 0.000018% of the 165 GtCO₂ target (this excludes the contributions of nature-based removal). In total, over 636,000 engineered credits have been purchased from only 69 CDR suppliers, for both ex-post and future credits ([CDR.fyi, 2022](#)).³ But even with large purchases of future credits, engineered purchases so far correlate to only 0.00039% of the 165 GtCO₂ target. Capacity needs to drastically scale up to have any hope of realising climate targets.

The price of carbon per tonne via these current projects is prohibitively expensive for the majority of buyers. For example, DAC at the high end of the price spectrum, has seen credits range from \$320 - \$2,050 a tonne. Biochar ranges from \$100 - \$590 a tonne.⁴ Comparatively, nature-based removal ranges from \$3 - \$50 a tonne ([Allied Offsets, 2022](#); [Patch, 2022](#)). As a result of these high prices for engineered CDR, there are only a select group of buyers in the market who are willing to purchase carbon at current costs.

To improve demand and help CDR scale, the cost of engineered CDR needs to be brought down. However, this will not happen until CDR suppliers and projects mature and become commercially operational. This highlights the “chicken and egg” problem currently facing engineered CDR, which is typical of a deflationary investment cycle. The costs of the technologies will not be brought down unless they demonstrate success, but they cannot demonstrate success without funding. In short, funding is urgently needed today to bring down costs in the future.

² Based on Charm's published retirement data (5,506 tCO₂) and an estimation of Climeworks delivered capacity from Orca (4,000 tCO₂ per annum (p.a.)) that has been operational since 2021, Capricorn (900 tCO₂ p.a.) and Arctic Fox (50 tCO₂ p.a.), both operational since 2017.

³ Ex-post credits refer to the purchase of a retired tonne of carbon and future credits refer to the purchase of one tonne of carbon that has not yet been delivered, via for example an offtake agreement or pre-purchase agreement.

⁴ Pricing based on purchases which have been tracked [here](#).

3. The CDR industry is in the early stage of its development - funding can be catalytic.

To scale a nascent industry, significant investment is needed today to bring it through the development S-curve.⁵ This was seen in the case of Solar, whereby high initial investment - mostly from Governments - helped move the technology through the innovation curve. Solar is often used as a successful model for the development of low carbon technologies (Nemet, 2020). In recent years its capacity has started to exponentially increase, in line with its development S-curve, as is presented in Figure 1.

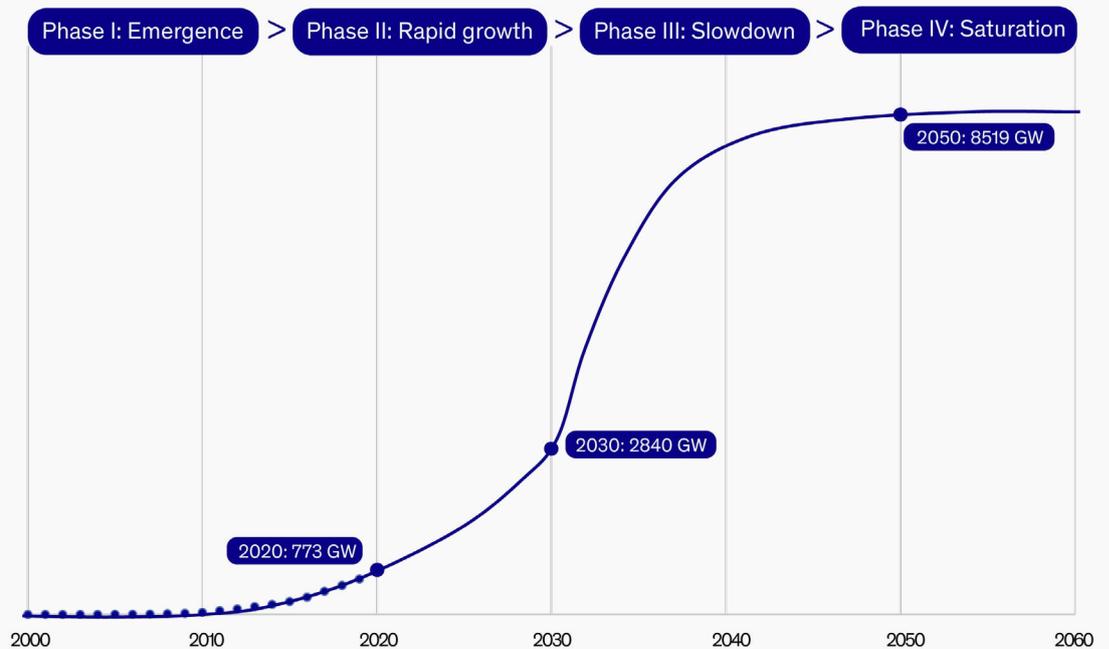


Figure 1. The Innovation Curve for Solar PV. Data from REN21, 2020, IRENA, 2021 and IRENA, 2019.

Solar capacity is now comfortably in a stage of rapid deployment following several decades of development and advancement. In 2020, Solar Photovoltaics (PV) had a global capacity of 773 GW which is projected to quadruple to 2840 GW by 2030 (IRENA, 2021; IRENA, 2019). In 2021, 4% of the UK's electricity production came from Solar (Our World in Data, 2022). CDR technologies offer a comparable decarbonisation solution to Solar PV. Applying the same development timeline of Solar to CDR, a timeline for its progression can be estimated.

⁵ The S-curve is a graph that helps to visualise a technology's growth, recognising that development is not linear with time but occurs in stages.

Engineered CDR currently contributes less than 1% to 2050 capacity projections, equating to Phase One of the development S-curve - Emergence. Thus, CDR is trailing Solar but can potentially follow a similar development curve. In Figures 2 and 3, the cost curve reductions achieved for a Solar PV module over 50 years, from 1970 - 2020, have been projected onto the current costs of engineered CDR for a similar 50 year timeframe, from 2015 - 2065. While solar cost trajectory will not be an exact replica for the CDR industry for a number of reasons, including longer development timeline or existence of ancillary supply chains in the electricity grid, it provides an estimation for how costs could decline by creating a market for CDR.

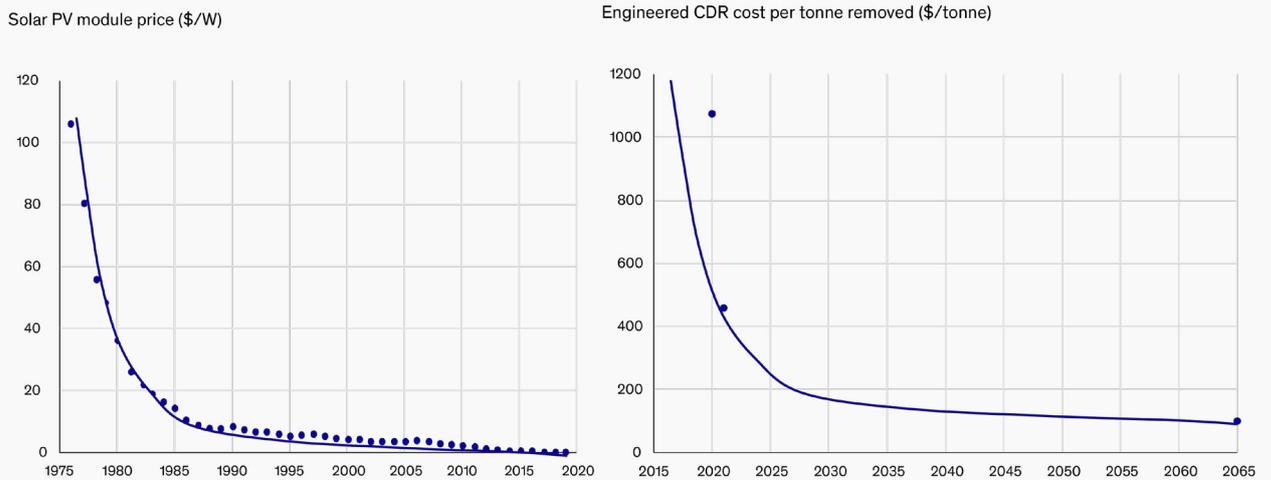


Figure 2. The cost-curve for Solar PV modules. Data from [International Energy Agency, 2020](#).

Figure 3. This solar curve projected onto the average price per tonne of CO₂ removed by engineered CDR to project potential price reductions for the CDR industry.

CDR has been projected to decrease to an average base cost of about \$100 per tonne, the projected point of commercialisation for CDR identified by academics and industry experts, including Habib Azarabadi & Klaus Lackner ([Azarabadi & Lackner, 2021](#)). This \$100 per tonne was used as the low target cost on which to project Solar's price reductions. Projecting CDR on Solar's cost curve sees rapid cost reductions over the course of this decade to a cost of less than \$200 a tonne, before slower cost reductions towards the mid century. This pathway is in line with cost projections from Climeworks and other suppliers.

CDR could see large cost reductions in the near term. But, these technologies have high infrastructure needs, so to enable this cost curve to come down, large capital expenditure is needed.

To fund this, the public sector will certainly have a role to play, just as it did in Solar. This is already being seen in the US with the Bipartisan Infrastructure Bill putting over \$12 billion towards CDR and carbon management. In the UK, the DAC and Greenhouse Gas Removal (GGR) Innovation fund has invested £76 million to CDR (with now £56 million for the 15 'Phase 2' companies) ([BEIS, 2022](#)). This is being backed up by regulation, with changes to the Low Carbon Fuel Standard (LCFS), European Union Emission Trading Scheme (EU ETS) and UK ETS all being explored to help scale the CDR market.

4. The private sector will be crucial to help this emergent industry scale.

Currently, the market is immature. The main route for private sector support for engineered CDR is through bilateral credit purchases at a high price. This is likely to shift in the coming years (read [Removal Reconsidered](#)). But, for now, this system of bilateral credit purchase is most common in the CDR market. Early-stage investment refers to exactly that - private sector investment in the early stage of CDR's development.

Early-stage investment can take many forms but loosely refers to the movement of financing into the industry. It encompasses: purchase of available supply, pre-purchase of future supply, financing to developers, financing to ancillary services, partnerships with developers, or a hybrid of any of the above.

This type of investment embodies the shift in mindset for carbon investments from return on investment in tonne of removal per credit purchased to extend to other benefits and returns. But credit purchasing alone is unlikely to be catalytic for the CDR industry, as these purchases are often small in scale. To overcome the “chicken and egg” problem, a broader and deeper level of demand is necessary.⁶

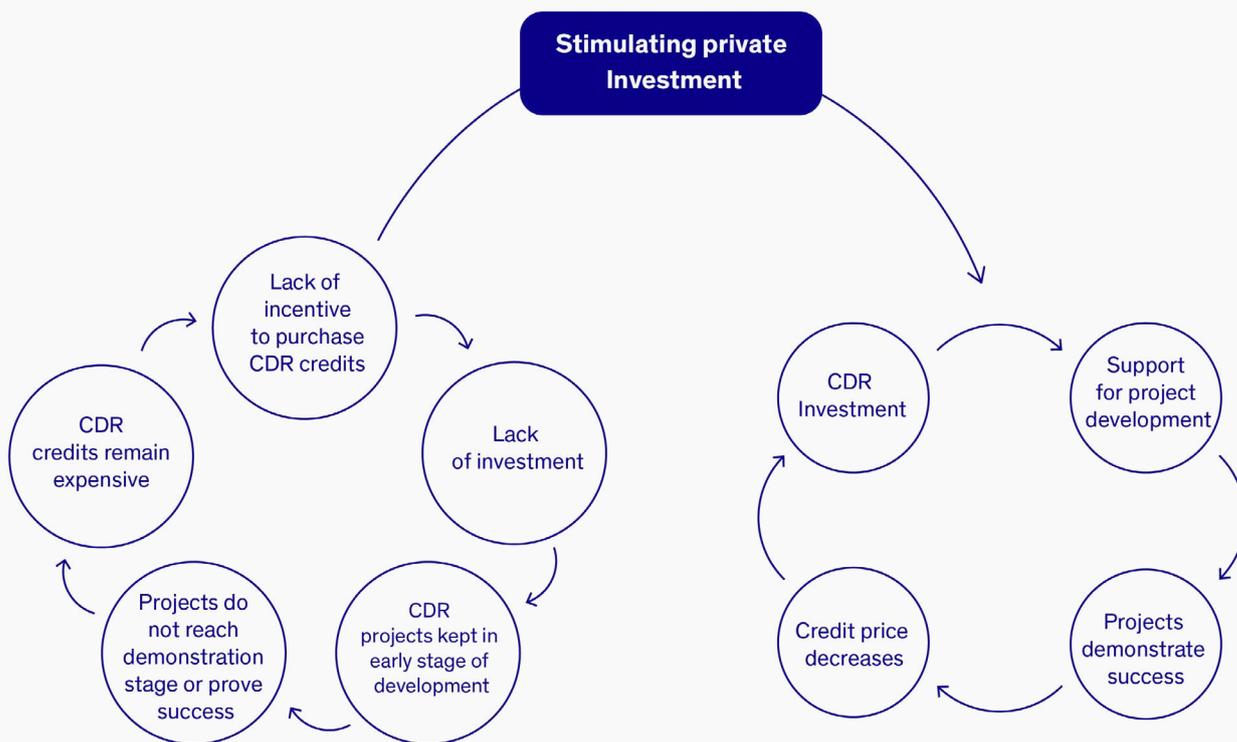


Figure 4. The impact of early-stage investment.

⁶ The CDR industry has a self-identified “chicken and egg” problem. Projects cannot reach a demonstration phase without significant funding, but in the current market structure funding is unlikely to be given until projects demonstrate success.

Early-stage investment is happening already, but the scale needs to dramatically increase. A number of climate-leading companies have become key early-stage investors in CDR, including the likes of Microsoft, Stripe, Shopify and Airbus to name a few.⁷ They are not only purchasing ex-post credits - credits that represent retirable carbon credits - but also future credits, which commit the buyer to a tonne of carbon removed in the future when the CDR supplier is operational. These future credits are catalysing investments for CDR suppliers, and have been mapped in Figure 5.

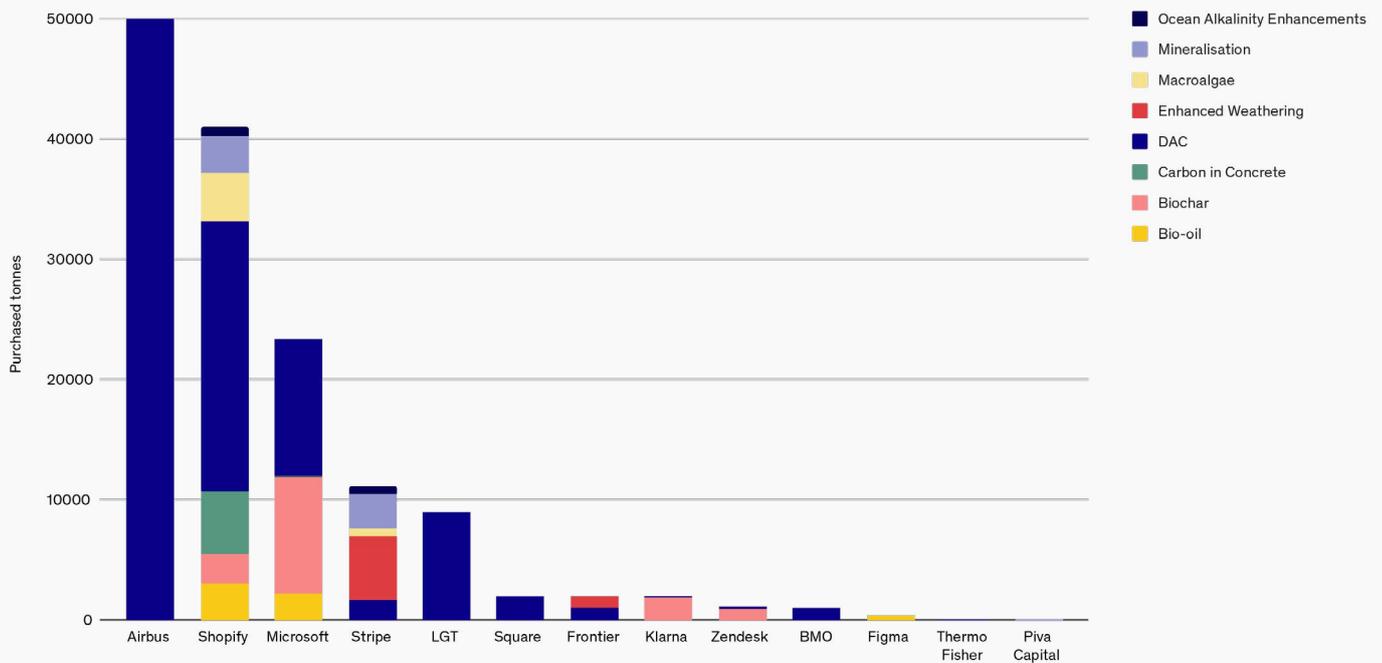


Figure 5. Distribution of ex-ante credit buyers by purchaser. Airbus purchased 400,000 credits from Carbon Engineering / 1PointFive. Data from [CDR.fyi, 2022](https://www.cdri.fyi/).

Early-stage investments are catalysing for the nascent CDR sector and can help to advance the sector through its development curve to a stage of rapid growth. Benefits of such investment will not just be for the climate and the CDR sector - investors can gain as well. Here we look to provide the commercial case for CDR investment to reveal the near-term returns investors can receive whilst supporting CDR to a state of maturity.

⁷ A comprehensive list can be found [here](#).

Commercial Opportunities

Commercial Opportunities

Here we have identified six key commercial opportunities for early-stage investment in CDR.

1. Future financial savings



Investing today can support development and decrease future costs, or secure pre-purchase of future credits at lower costs.

2. New business opportunity



Opening new business focus, to directly or indirectly develop CDR supply, will benefit the industry and return profit.

3. Regulatory compliance



Can help investors meet regional regulatory targets and proactively position themselves as further external requirements emerge.

4. Voluntary standard compliance



Voluntary standards support decarbonisation, but often exclude CDR. Investing can position actors to go beyond minimum requirements.

5. Climate leadership



Acting early, can make investors trailblazers in this nascent industry developing social license and becoming one to learn from.

6. Commercial knowledge and networks



Engaging early places investors in a pioneering community that they can learn from and network with.

1. Future financial savings

Investing in CDR today at the current high prices can generate financial savings in two key ways.

First, it will help support projects to commercial demonstration, bring down future costs and help the industry scale. This is pertinent for companies which will have a heavy reliance on CDR by 2050, such as aviation, shipping and heavy industry. For these industries, there is an urgent need to bring down the costs of CDR. The high capital costs today therefore make long-term economic sense.

Case Study: Aviation

The aviation sector is considered hard-to-abate, but it contributes significantly to annual emissions - about 2.5% ([Ritchie, 2020](#)). In 2050, with the utilisation of Sustainable Aviation Fuel (SAF) (a low carbon fuel alternative), efficiency improvements to global aircraft fleets and air traffic control management, annual emissions are projected to be 88 MtCO₂ ([EuroControl, 2022](#)). They could be as high as 279 MtCO₂ without these three decarbonisation strategies.

If this was met by available DAC credits at \$600 a tonne, neutralising the aviation sector's emissions for net zero will cost \$52.8 billion. But, if the CDR industry advances and credits fall to \$100 a tonne the aviation sector will only endure a cost of \$8.8 billion. This of course overlooks the costs of getting the price down to \$100 by assuming this economic burden is felt outside the aviation sector, but reflects the need and the opportunity to develop the sector to reduce these future costs. The civil aviation sector annually spends about \$113 billion on operating costs ([European Commission, 2022](#)). The cost of high credit pricing on this sector could be up to 46% additional to these costs or as low as 8%.

Second, at the investor level future-discounts on credits could be brokered with developers to achieve even higher savings. As mentioned, the price per tonne is currently high and is set to come down significantly. This makes it difficult for buyers because they are being asked to invest in a deflationary investment cycle. To navigate around this, buyers and developers could broker agreements which commit buyers to a certain amount of tonnes now, in exchange for a percentage discount after an agreed upon future date, for example. Displayed in Figure 6, such a mechanism would help navigate around the "chicken and egg" problem as it would incentivise buyers to invest now, to achieve significant cost savings in the long-term.

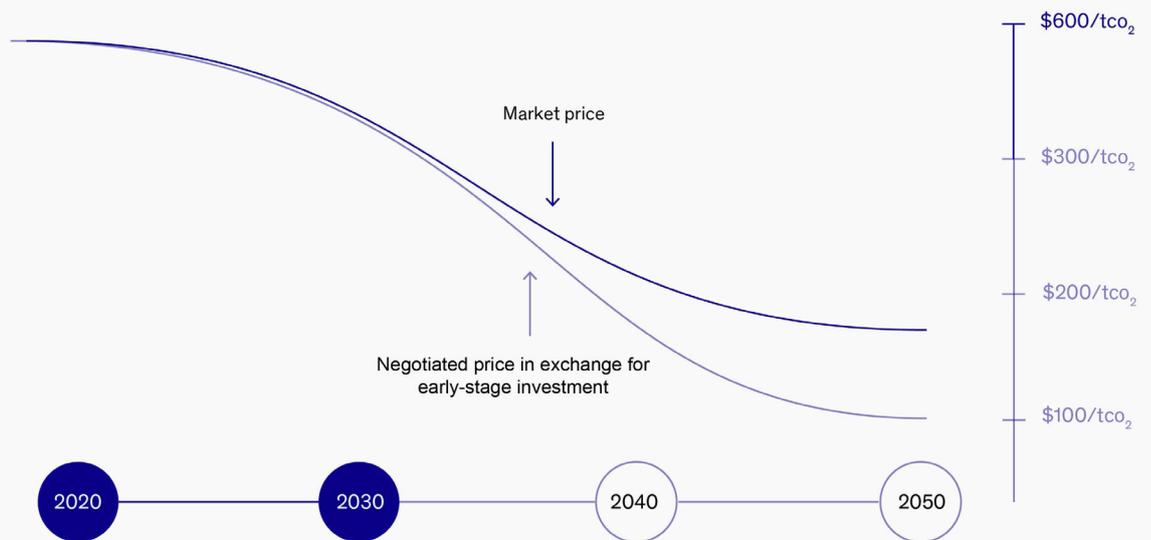


Figure 6. Diagram of potential investment mechanism for investing in early stage CDR.

Early investor case study: Airbus

Airbus is a global aviation company valued at \$72 billion (as of September 20th 2022) and emitting 827,000 tCO₂ annually in their Scope 1 and 2 emissions (in year 2021-22) ([Macrotrends, 2022](#); [Airbus, 2021](#)). In March 2022, Airbus made a 400,000 credit purchase from 1PointFive, a DAC supplier using Carbon Engineering's technology ([Airbus, 2022](#)). This is the largest purchase of CDR credits ever. Airbus purchased 100,000 tonnes of CO₂ for four years with an option to purchase more credits following the four year period.

Committed to the SBTi and financing research into SAFs, Airbus is driven to be an early decarbonisation actor in this high emitting sector. Pre-purchasing CDR credits at this early stage aligns the company to their climate goals while creating financial savings at the same time.

2. New business opportunities

There is a supply shortage of CDR credits at present. This shortage is felt by early CDR credit purchasers, as highlighted in CarbonPlan's July 2022 report on scaling CDR, influencing certain strategies of engagement ([Merchant et al, 2022](#)). Dartmouth University's May 2022 research reveals this misalignment between supply and demand could potentially see demand reaching 623 MtCO₂ but supply, at most, reaching 450 MtCO₂ by 2030 ([Kalra et al, 2022](#)). Creating a short-supply of 173 MtCO₂. If this growing demand can be met, there are large financial opportunities to be had. This reveals the next commercial opportunity: new business opportunities.

While there are a growing number of different carbon aggregators and marketplaces for CDR there is a significant undersupply of active projects. Only 4.6% of CDR credits in the market are ex-post ([CDR.fyi, 2022](#)). Thus, there is opportunity for new companies to develop into this space and help build CDR supply. Purchasing equity in these companies now, or developing corporate business models which include CDR, has potential for high returns.

This opportunity has been seen by a number of companies. Lowercarbon Capital, a descendant of venture capital firm Lowercase Capital, raised \$350 million in 2022 to invest solely in CDR companies. Klarna, partnered with Milkywire, set an internal carbon price of \$100 per tonne (\$10 per tonne for indirect emissions) that it is then using to invest in CDR. Stripe launched Stripe Climate and Frontier to develop business models around CDR. A recent report from BeZero Carbon found that the industry could be worth as much as \$8.5 trillion by 2050, up from around \$1.5 billion today⁸, demonstrating the high level of potential returns for early-stage investors who pivot towards CDR ([BeZero Carbon, 2022](#)).

⁸ This 1.5 billion estimation includes \$178 million in credit procurement, reported on [CDR.fyi](#), as well as non-credit CDR investments (such as \$925 million from Frontier, \$350 million from Lowercarbon Capital, \$100 million from the XPrize).

Early investor case study: Shopify

Shopify, a commerce platform, began purchasing carbon removal in 2020 and has helped kickstart a handful of CDR companies along the way. Shopify's contracts – which pay a premium for carbon removal and often include prepayments – have accelerated development, unlocked external financing and encouraged new buyers.

Carbon Engineering, for instance, has gone on to secure long-term offtake agreements since Shopify became its first DAC purchaser in 2020, including the aforementioned 400,000 tonne contract with aviation giant Airbus. Running Tide, which specialises in ocean sequestration, has leveraged Shopify's five-year, 32,500 tonne letter of intent to generate additional funding and purchases. Shopify was also the first carbon removal buyer for Planetary Tech, which used the money to fund a pilot project that helped bring Planetary's ocean air capture method out of the lab.

Shopify was one of the first early-investors. They have developed a new business model around CDR (2), created potential future financial returns (1), become a CDR leader (5) and developed significant networks and knowledge in this emerging industry (6).

3. To comply with regulatory requirements

Regulated carbon markets are nationally or internationally monitored markets that set carbon pricing and allow for trading of carbon credits to incentivise decarbonisation. Today, select regulated carbon markets include engineered CDR credits, such as the Californian Low Carbon Fuel Standard (LCFS).

As CDR credits become available and purchasable they will have increased presence in carbon markets. The Taskforce for Scaling Voluntary Carbon Markets (TSVCM) projects engineered CDR to represent 56% of the voluntary market by 2030 ([TSVCM, 2021](#)). While this is focused on the voluntary market, with time the regulated and voluntary markets will converge, owing to the overlaps in creditable activity. With increasing presence of engineered CDR in regulated markets in the near future, investing early in CDR can proactively position actors ahead of mandatory requirements.

Regulatory compliance via CDR: The Low-Carbon Fuel Standard (LCFS)

The California LCFS is a trading mechanism aimed to reduce the carbon intensity of the State's fuel mix, which allows DAC projects to generate credits. The LCFS was designed to reduce the carbon intensity of transportation fuels via a cap and trade programme. When activities in California have a carbon intensity higher than the LCFS target carbon intensity they create deficits that need to be offset by purchasing credits. Projects, globally, that are below the target intensity can generate credits to be sold. In 2018 it was amended to allow Carbon Capture and Storage (CCS) and DAC projects to generate credits. DAC projects anywhere in the world can generate credits by opting-in, assuming they adhere to the LCFS specific guidelines. This market is an early example of an opportunity to buy durable CDR credits that have long-term value, to trade within the LCFS.

Other compliance markets are laying the foundation to introduce engineered CDR credits:

- (1) UK ETS: In March 2022, the UK Government released a consultation on the UK ETS as a potential long-term market for Greenhouse Gas Removal (GGR). If removal credits were included, participants would be allowed to offset a portion of their emissions by purchasing negative emissions credits. In July 2022, the UK Government launched a consultation on Business Models for GGR to help develop a market for negative emissions in the UK. Within this consultation they highlight several opportunities, present and future, from integration into the UK ETS. These include: creating clear market signals for investors, providing liquidity, and options for hard-to-abate sectors to decarbonise ([BEIS, 2022](#)).

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- (2) EU ETS: The central scenario for meeting the EU-wide net zero target by 2050 has the EU ETS becoming net negative. This reflects the desire within the EU to include negative emissions into the market at some point. As a first step, the EU has launched an initiative to certify CDR, developing the rules to monitor, report and verify (MRV) their authenticity.
 - (3) CORSIA: The 'Carbon Offsetting and Reduction Scheme for International Aviation' is an industry based initiative for the aviation sector. By acting at the sector level and commitments not being mandatory until 2027, it is seen to be the first market blurring the line between regulated and voluntary ([EDF, 2021](#)). This hard to decarbonise sector will likely require CDR to meet net zero targets by 2050, as discussed in the above Aviation case study. Thus, CORSIA will see near term emergence of CDR requirements in their literature.

As more regulated markets begin to look towards CDR, investing and buying these credits now will ensure that any shift in regulation will not negatively impact companies and provide corporate resilience to changing circumstances.

4. To comply with voluntary standards

Climate action at the corporate level is not currently mandatory for all industries. Companies are under increasing pressure from investors, as well as motivated internally by employees, to make their own commitments to climate action. This motivation has been a significant driver of many companies choosing to align with voluntary standards.

Many voluntary standards do not have guidelines for CDR, owing to the nascent nature of the emerging industry. As CDR continues to emerge as a one of many solutions on a corporate's net zero roadmap, it is likely that these standards will begin to incorporate CDR specific guidelines. Corporates who invest early in CDR are likely to see these investments align to voluntary standards in the future.

There are a growing number of frameworks and standards that organisations can align to, such as:

		
<p>Launched in 2000 to provide guidelines for both corporate and state level environmental disclosures to manage climate related risks, opportunities, strategy, governance and performance.</p> <p>Over 13,000 companies (64% of global market capitalisation) and 1,100 cities or regions have disclosed to date. An increase of over 141% since 2015, which the CDP links to an increase in requests for information from investors with \$110 trillion in assets (CDP, 2021).</p> <p>In the CDP's 2022 guidelines for reporting, signatories are asked if they are planning to neutralise remaining emissions with CDR and if so to disclose such activities. For example, they are asked to disclose the purchase of CDR credits or insetting of CDR projects within their corporate supply chain (to be explored further in the next Section).</p>	<p>Launched in 2021, this industry-led alliance brings together 100+ banks, covering a total of 40% of global banking assets.</p> <p>Signatories set intermediate targets for 2030 or sooner, using robust, science-based guidelines. The commitment allows offsets to be purchased to align with climate targets, but specifies for CDR to be used to neutralise residual emissions as opposed to a total reliance on emission reduction and CDR credits to achieve targets, particularly for hard-to-abate sectors (NZBA, 2022).</p>	<p>Launched in 2015, prior to the Paris Agreement at COP21. Since then, its popularity has steadily grown with 3,671 companies taking action and 1,942 companies with approved targets, 351 of whom are UK-based, as of September 2022.</p> <p>The SBTi prioritises maximum decarbonisation before removing residual emissions, stating in its criteria that companies must achieve a 95% reduction in emissions from their own operations (their Scope 1 and 2 emissions), and 90% reduction in value chain emissions (total Scope 1, 2 and 3 emissions) before 2050. Only once these targets have been achieved can residual emissions be addressed through permanent CDR.</p> <p>CDR stakeholders have raised concerns with the SBTi. Arguing that they have "released guidance without saying anything clear on removal" (Merchant et al, 2022).</p>

Corporates can voluntarily choose to align to any number of these voluntary standards, whether required to by investors or by their own volition, with their commitment equating to specific targets. As CDR begins to shift to the forefront of decarbonisation discussions, voluntary standards are beginning to recognise its role and are likely to incorporate CDR literature into their guidelines in the near term. Companies are increasingly aligning to these standards, following a surge in interest for Environmental, Social, and Governance (ESG) goals at the corporate level. A desire to demonstrate commitment to climate action in an organisation has increased the role of these standards.

Corporates, ESG and CDR

ESG was first outlined in the United Nations' (UN) 2006 Principles for Responsible Investment (PRI) report, calling for ESG to be included within a company's financial evaluation. As of 2020 88% of publicly traded companies have ESG initiatives, which align to the UN's Sustainable Development Goals (SDG) ([Navex Inc, 2021](#)).

The shift towards ESG is pressured from both the bottom-up and the top-down. According to PWC 76% of consumers say they will stop buying from businesses that do not support their community or the surrounding environment ([PWC, 2022](#)). On the other side, 85% of asset managers say ESG is a high priority - demonstrating the priorities of corporate investors ([IIA, 2021](#)). ESG is now commonplace in corporate climate action.

As companies continue to push for climate action and setting ESG targets, this will see companies committing to purchase CDR credits as part of their transition roadmap. As with the first use of ESG initiatives in the 2000s, early corporate CDR investors will benefit from transitioning first. The voluntary standards they utilise to achieve their ESG targets will begin to catch up with them, and these early movers will be able to influence the rules for CDR within standards and wider ESG.

Investing in CDR can effectively position companies to align with these standards and publicly commit to a transition to be a low carbon organisation.

5. To be seen as a climate leader

The public are in favour of carbon removal. A 2021 poll by BeZero Carbon in the UK found that 87% of people support businesses investing in carbon removal ([BeZero Carbon, 2021](#)). 44% agree even if it impacts businesses revenue. This reveals the next commercial opportunity of early investment: leadership status.

The early movers in this space are seen as trailblazers that achieve high impact. Those that have already engaged are seen as key players in the CDR space and are often attributed to triggering the explosion of CDR from 2020 onwards. Investors can learn from those who have already acted and explore the significant public relations opportunity to be had through investment.

Early investors in CDR have the ability to create the pathway for CDR and wider corporate climate action. Acting as a model for their peers as well as for the public sector. They can better understand the CDR landscape through private investor actions or better understand appropriate engagement options for the public sector. Some early actors are cognisant of this and are utilising this leadership to advance the CDR agenda. In 2021, Microsoft published '[Carbon Removal: Lessons from an early corporate purchase](#)', and Shopify published a report called '[How to Kick-Start the Carbon Removal Market: Shopify's Playbook](#)'. Acting first gives companies the social licence to provide perspective and further cement their name in the foundations of this nascent sector.

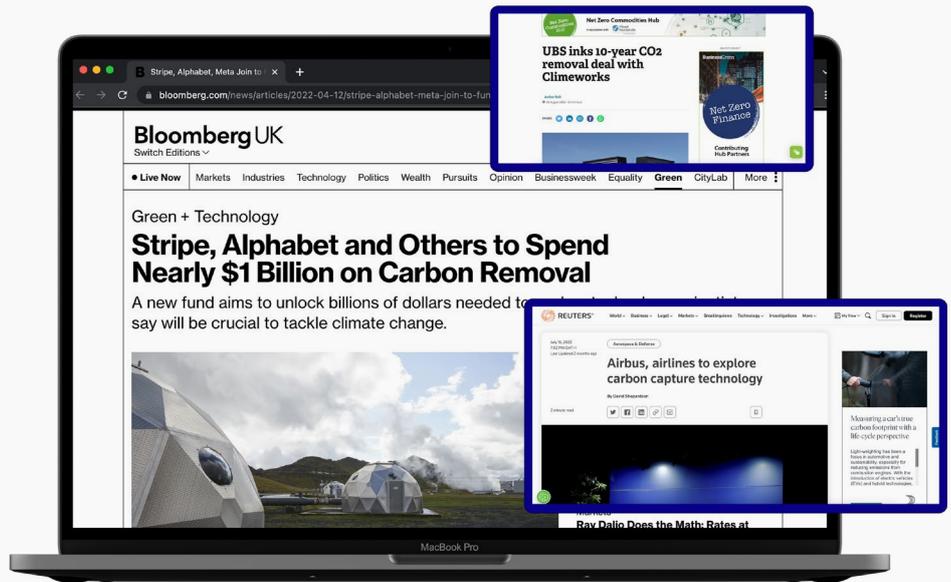
Early investor case study: Stripe

In 2020, Stripe launched Stripe Climate, a platform tool that allocates a percentage of business revenues to CDR investment. This scheme directs funding to a list of pre-selected suppliers chosen by Stripe's internal CDR-focused team. By December 2021, more than 5,000 companies from over 40 countries purchased CDR via Stripe Climate - one in 10 of their customers ([Stripe, 2021](#)). Stripe created a business that did not exist before and gave their customers an pathway to engage in climate action that for many was not previously an option.

Since then, Stripe partnered with other early CDR investors - Shopify, Meta, Alphabet and McKinsey - to launch Frontier, an Advanced Market Commitment (AMC) that has made \$925 million available for investment in CDR companies. Stripe acted first - now the market is following suit. Stripe has been a model that other corporate investors are choosing to follow.

Stripe is a leading early-investor. They are a clear pioneer in this space (5), developed a business model around CDR (2), created potential future financial returns (1), and created networks and knowledge for this emerging industry (6).

Corporate CDR leaders in the news:



Corporates can also be equally pioneering by being the first in their sector to look towards CDR. At present, most CDR early-stage actors are in the Tech sector, purchasing 66% of CDR credits so far.⁹ Early-stage investors of CDR are sparse, but some sectors are receiving greater interest, as seen in Figure 7. The Tech and Finance sectors are seeing growing interest, likely because companies are learning from their sector peers that moved first - for example Stripe in the Tech sector. Several other sectors have opportunities for trailblazing actors to develop their social licence and lead their peers, whilst advancing the CDR industry at the same time.

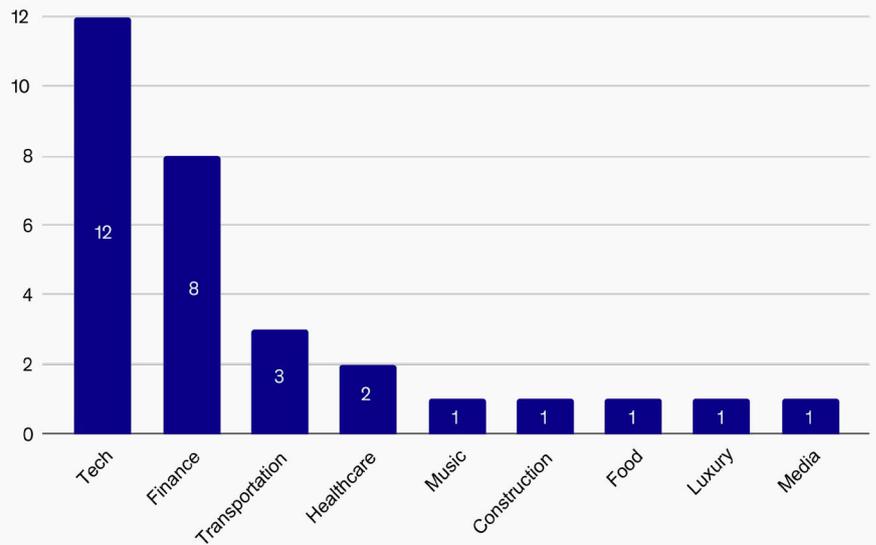


Figure 7. Number of investments via credit procurement by Sector. Excludes credit purchases on intermediary marketplaces owing to lack of transparency and clarity of buyers. Data from [Robert Høglund, 2022](#).

⁹ This calculation excludes Airbus' purchase of 400,000 credits in 2022.



Early investor case study: SwissRe

SwissRe was the first insurance company to buy CDR in September 2021, purchasing \$10 million worth of DAC credits from Climeworks. SwissRe stated three key reasons for investing in CDR: risk management knowledge sharing; capital provision as a long-term investor; and, helping the market to scale. Their unique position as an insurer has helped build their climate leadership reputation ([SwissRe 2021](#)).

Insurers have a potentially large role to play in the climate transition. A 2021 report from BeZero Carbon found that the nature-based carbon market alone provides a \$1.3 billion opportunity for insurers and reinsurers.

By leading their sector SwissRe received the resultant press attention and stature to show this, with several other financial institutions beginning to assess their opportunities and engagement options in CDR. Alongside this, they also were able to improve commercial knowledge and networks (6) and explore new business opportunities (2).

6. To improve commercial knowledge and networks

The growth prospects of this industry increase the value of market knowledge. Globally, up to 10 billion tonnes of CDR per annum will be needed by 2050 ([IPCC, 2022](#)). Early investors and participants in this market will gain insights and understanding that will be useful for growth of the sector and related activities.

There could also be positive network spillovers. The CDR industry is attracting a new and talented network of business leaders and employees. Involvement in such a fast moving market could provide positive network effects which expand beyond carbon credit generation and into other areas for commercial benefit.

Early investor case study: Microsoft

Microsoft has committed to be carbon negative by 2030 and to remove all historic emissions by 2050. This aggressive climate target has poised the company to explore and develop a CDR pathway, funded by their \$1 billion Climate Innovation Fund. Since 2020, Microsoft has contracted 2.8 MtCO₂ of removal from a portfolio of CDR suppliers and methods at various stages of technical development.

In developing their CDR strategy, Microsoft has become a key voice of knowledge in the CDR sector. They released their report '[Lessons learned](#)' as an early CDR investor. They also published '[Microsoft's million-tonne CO₂ - removal purchase - lessons for net zero](#)' in Nature, a leading academic journal, exploring new channels and communities with which to share their experiences and insights.

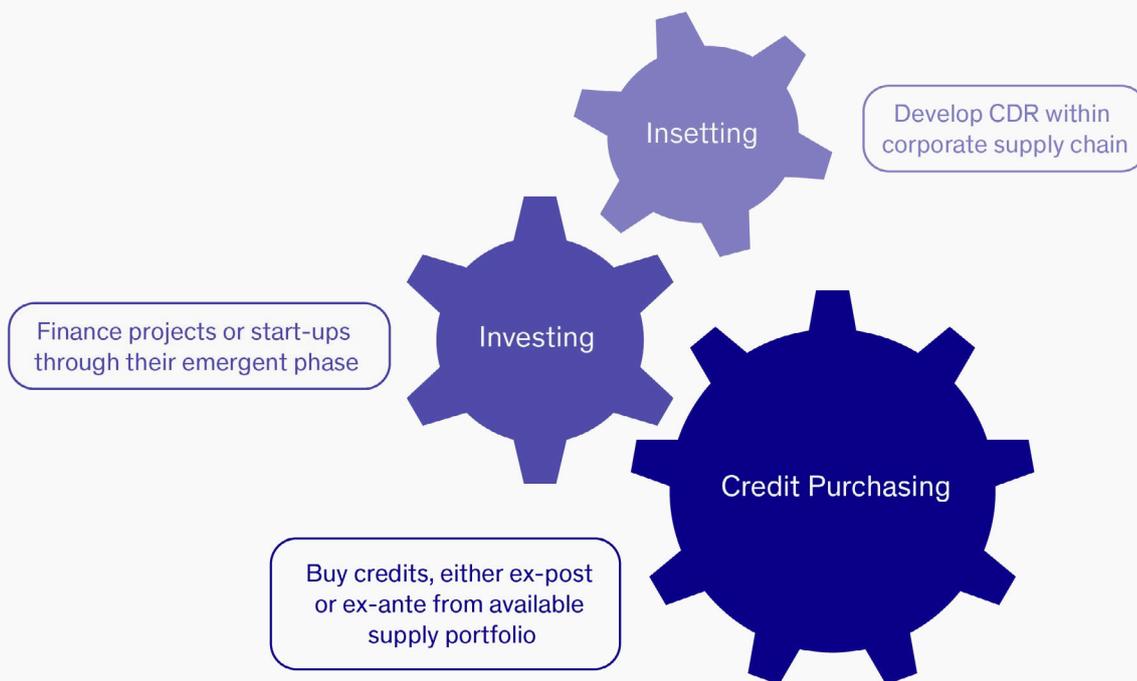
Microsoft has also partnered with Impact Observatory and ESRI to create a high resolution land cover map at a 10m resolution ([Planetary Computer, 2022](#)) This is a useful tool for analysis of nature based climate solutions. More recently they published '[Criteria for high quality carbon dioxide removal](#)' with CarbonDirect - a landmark report that provides scientific standards to the CDR industry. These two actions exemplify a move away from describing the activities to creating tools and generating new insights and tools for CDR and the wider climate landscape.

Microsoft started with a climate commitment, which led them to become a leading actor in this space (5). They have since developed new business ventures in this space (2) and created the potential for future financial savings (1). With their platform and status they have moved on to create new networks and provide novel knowledge to the CDR industry (6).

Engagement Approaches

Engagement approaches

Given the amount of noise in the climate technology industry, it is often difficult for investors to know how they should become involved in emerging climate technology industries. For the case of CDR, there are three key avenues for investment:



1. Credit Purchasing

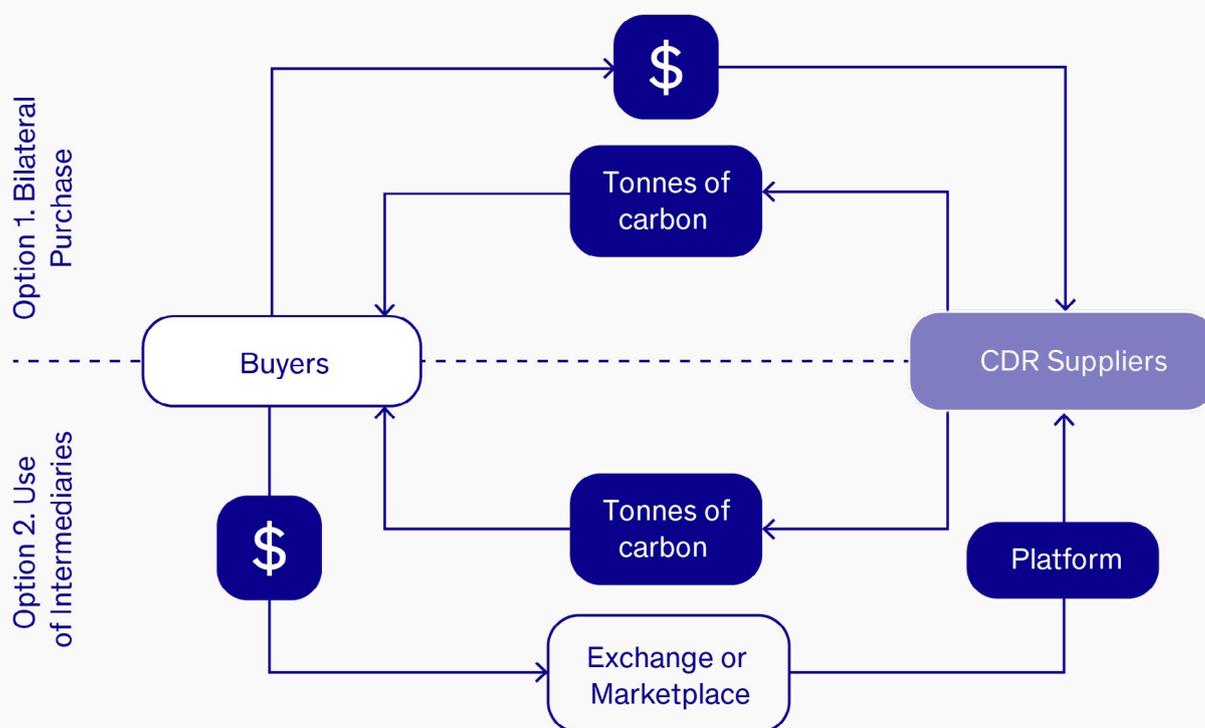
Carbon credits are at the core of business models for most CDR companies. For example, a DACCS company has no alternative revenue stream to fund its operations outside of selling credits. Future business revenue and climate impact is inherently linked with their ability to sell credits.

To help build demand and consequently supply, early-stage investors can buy CDR carbon credits. This can be done via two approaches:

- (1) Purchase of ex-post, retired credits. These can be bought from intermediary exchanges and marketplaces, which include but are not limited to Air Carbon Exchange (ACX), CBL, Cloverly and Patch.
- (2) Purchase into Advanced Market Commitments (AMC) such as Frontier or purchase of ex-ante credits. These correspond to credits that have not yet been retired but may be in the future once these projects are operational and sequester carbon. Some intermediaries are beginning to offer pre-purchase of these ex-ante credits.

This latter form of financing is an important lever to fixing the “chicken and egg” problem of CDR.

Credit purchasing can allow early-stage investors to (1) create future financial savings, (3) comply with regulatory and (4) voluntary standards, (5) be a climate leader, and (6) develop commercial knowledge and networks.



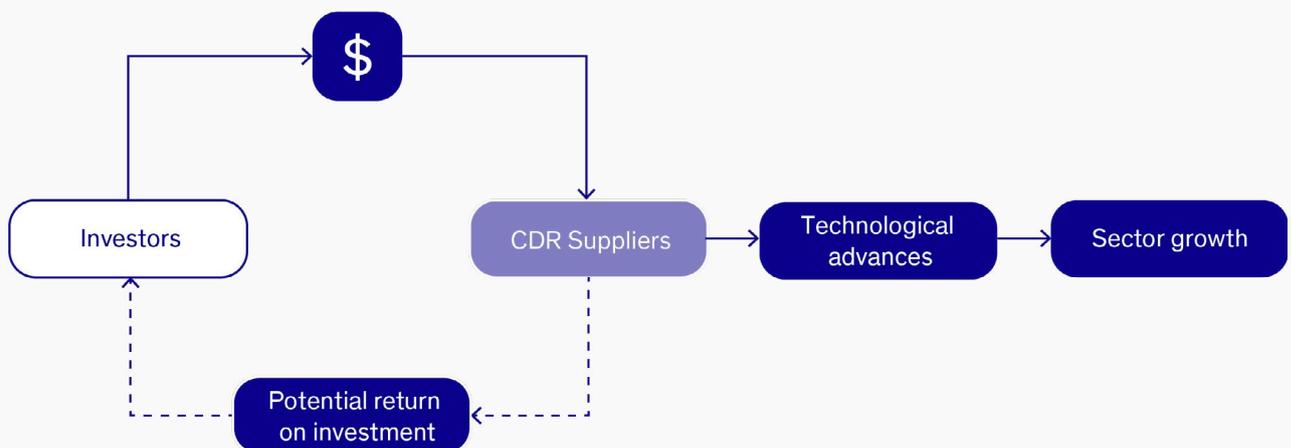
2. Investing

Funding start-ups is vital for the acceleration of any industry and CDR is no different. Several hundred CDR companies have entered the CDR landscape in the past few years. Of these only 69 companies have made credits available to purchase and 82% of credits purchased thus far have been bought from two companies – Carbon Engineering and Climeworks. This means there are many companies selling a small number of credits, and even more who are not even at a stage of making credits purchasable. These companies need funding to develop, employ staff and push research and development for their products.

Investing can take shape differently. Whether investing in equity, debt, philanthropically, as concessional capital or another blended format, these all aim to finance project development. Investment need not always be financial, and can be the provision of goods or services to help the project develop.

Some investors have already seen the potential in this approach. Lowercarbon Capital raised a \$350 million fund focused solely on investing in early stage CDR. Other funds focused solely on CDR are emerging, such as the Swiss venture capital fund Carbon Removal Partners.

Equity investing can allow early-stage investors to (1) create future financial savings for the wider CDR industry, (2) establish new business opportunities, (5) be a climate leader, and (6) develop commercial knowledge and networks.

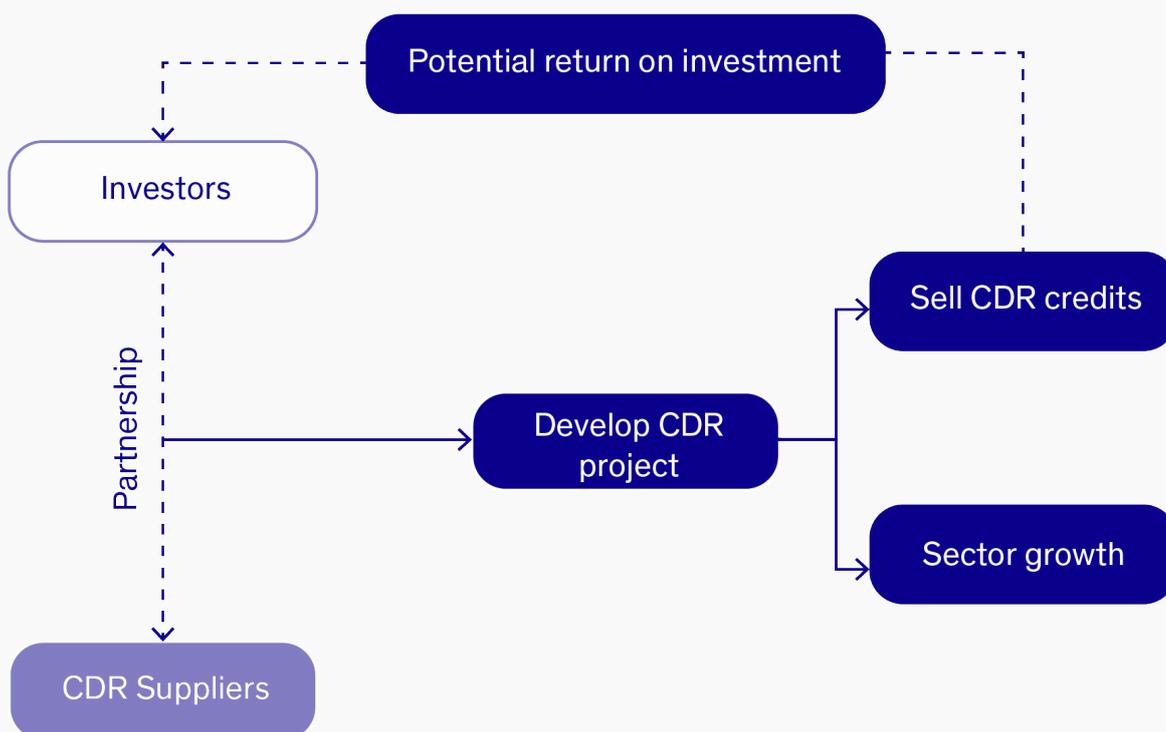


3. Insetting

Insetting is when a company offsets its emissions through a carbon project within its own value chain, rather than through buying credits from an external provider. For example, the company Nespresso has integrated regenerative agriculture within its supply chain to reduce their emissions ([Nespresso, 2022](#)). Integrating low touch nature based removal is an increasingly attractive insetting solution for industries related to the agriculture sector.

This same model could be used for more technological CDR. For example, companies could fix DAC units to their cooling towers or use biochar in the soil used for crops. Research into insetting pyrolysis and gasification processes has seen recent attention as a potential climate solution for the industrial sector ([Brown, 2022](#)). These processes are used in energy, fuel and bioproducts production, but they are also utilised in the production of biochar and other biological CDR. Companies could be shifting the way they carry out business operations to reduce and remove carbon emissions within their own supply chain.

Insetting can allow early-stage investors to (2) establish new business opportunities, (5) be a climate leader, and (6) develop commercial knowledge and networks.



Conclusion

There is a huge challenge ahead to scale the CDR industry. So far, roughly half a million tonnes of CO₂ have been removed from the atmosphere, with the majority of this from nature-based CDR. This number needs to climb to 165 billion by 2050 to keep us on a pathway to net zero. Engineered CDR, which thus far has only delivered a couple thousand tonnes, needs to develop in the near-term to contribute to global climate targets.

As clean technology success stories of the past have shown us, such as Solar PV, government support is crucial. But, alone this activity will not scale the industry within a net zero relevant timeframe. To unlock the potential of the industry, investment is needed from the private sector. The nascent nature of this industry, which lacks a dedicated market to aggregate demand, means that without catalytic early-stage investment it will not easily scale-up and subsequently bring down costs.

It is clear that some companies understand this. As this report has shown, leaders in Technology and Finance have seen that investing in CDR provides a number of commercial advantages. Whether it be becoming a climate leader amongst peers, seeking new business opportunities, or proactively aligning with voluntary or regulated climate standards, there are many commercial opportunities to be grasped.

The window to become an early-stage investor in CDR is still open. If we are to have any hope of hitting our climate targets, businesses and individuals need to harness the power of the voluntary carbon market and jump-start the carbon removal scale-up.

