Carbon Direct

2024 State of the Voluntary Carbon Market

AN INFLECTION POINT FOR CARBON DIOXIDE REMOVAL

OCTOBER 2024

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ACKNOWLEDGEMENTS

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About Carbon Direct

Carbon Direct helps organizations go from climate goal to climate action. We combine technology with deep expertise in climate science, policy, and carbon markets to deliver carbon emission footprints, actionable reduction strategies, and high-quality carbon dioxide removal. With Carbon Direct, clients can set and equitably deliver on their climate commitments, streamline compliance, and manage risk through transparency and scientific credibility. Our expertise is trusted by global climate leaders including Microsoft, American Express, and Alaska Airlines, as well as by the World Economic Forum, which selected Carbon Direct as an Implementation Partner for the First Movers Coalition. To learn more, visit www.carbon-direct.com.

Disclaimer

Executive summary

In order to limit warming to 1.5°C in line with the goals of the Paris Agreement, the large-scale deployment of carbon dioxide removal (CDR) is now needed alongside deep and rapid emissions reductions.

CDR is also required to limit warming to 2°C in nearly all scenarios outlined by the Intergovernmental Panel on Climate Change (IPCC). This means that roughly 5–10 billion tonnes of carbon dioxide (CO_2) need to be removed each year by 2050. If global emissions reduction targets are not met, this need for CDR will increase. Achieving climate goals will require the rapid scale-up and deployment of all viable CDR pathways, for which trillions of dollars in capital investment will be required before mid-century.

The voluntary carbon market (VCM) provides an important vehicle for organizations to contribute to the scale-up of emissions reductions and CDR solutions outside of their value chain. For CDR in particular, the VCM provides a pathway for organizations to address their residual and historical emissions. The VCM also plays a critical role in channeling finance to early-stage CDR projects.

The VCM in its current form is small, with an estimated transaction value of US$1 billion in 2023. For the VCM to scale to levels needed to support IPCC targets, increased private sector demand is critical. However, many buyers are waiting on the sidelines due to concerns over credit quality and transparency.

Currently, CDR represents only 4% of available carbon credit supply in the VCM, but the CDR market is growing quickly and is poised to accelerate. Funding raised for nature-based CDR has sped up in the past two years, but remains far lower than needed to meet potential demand for nature-based CDR credits and global CDR goals. At the same time, high-durability CDR projects—such as those that store CO_2 geologically—have ambitious scale-up plans, but they require sufficient forward offtake from buyers in order to develop their projects. CDR scale-up can only be realized in the presence of robust, quality-oriented demand and financing. Today, forward offtake of CDR, particularly high-durability CDR, is extremely concentrated in a small handful of high-profile buyers. Many factors affect the likelihood of meeting long-term IPCC goals, but it is clear that investment in nature-based CDR and forward purchasing of high-durability CDR both need to accelerate.

Carbon Direct's *2024 State of the Voluntary Carbon Market* report provides a snapshot of key trends and developments shaping the VCM today, with a focus on CDR. It analyzes trends in the VCM, before providing an outlook on the CDR market through 2030.

Key takeaways

FOR BUYERS

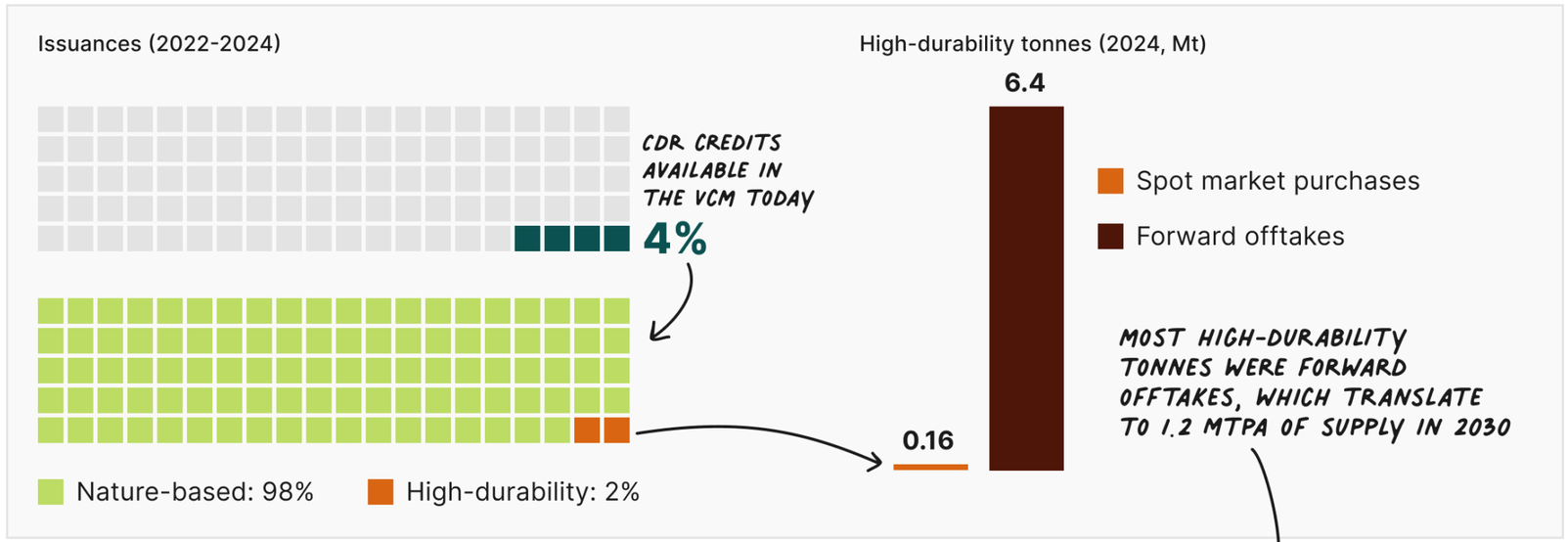
1. Both nature-based and high-durability CDR require essential funding now; nature-based projects will deliver the majority of CDR credits in the near term at accessible prices.
2. Forward offtakes are essential to scale a nascent CDR market, especially for high-durability CDR, but very few buyers are contracting at the level needed to meet 2030 CDR goals.
3. To reach climate targets, buyers and developers need to develop mature market structures for project development and project finance, backed by bankable offtake.

FOR SUPPLIERS

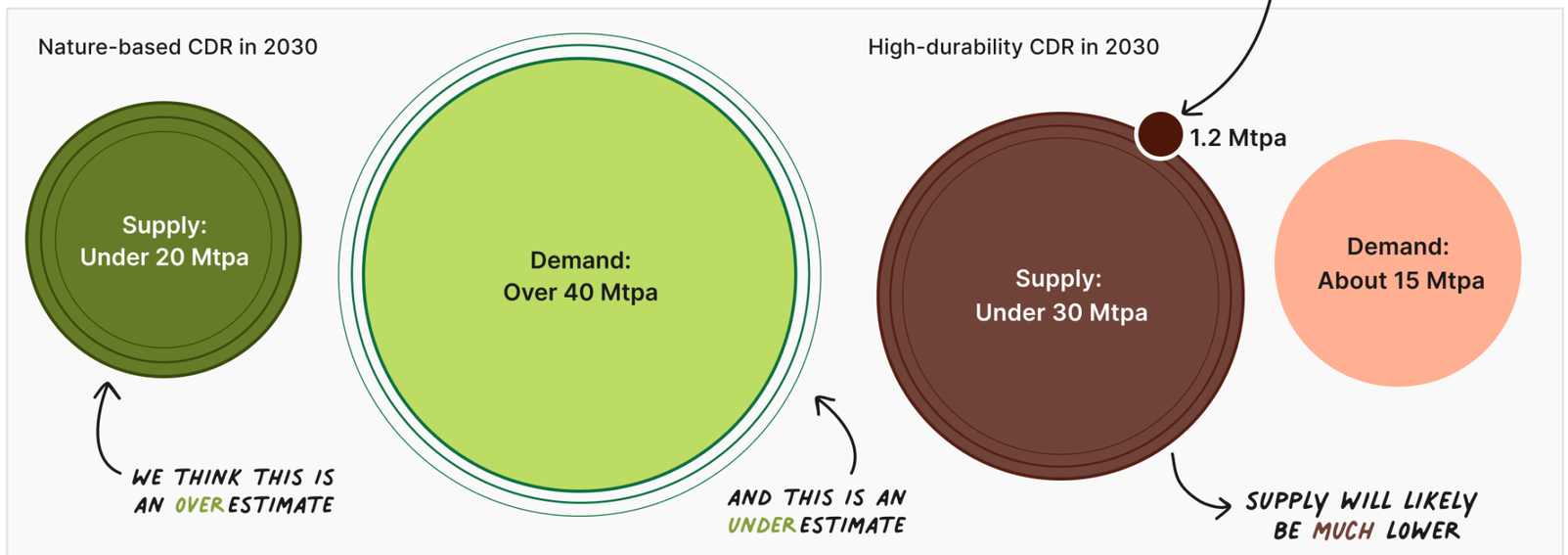
1. Projects must distinguish themselves on the basis of quality and transparency to reduce the reputational risks buyers face when purchasing carbon credits.
2. Nature-based CDR is likely underfunded and undersupplied. There is a critical need to increase project finance for nature-based CDR to meet demand.
3. Scale-up plans for high-durability CDR supply outstrip demand in the near term. High-durability projects need (a) high volumes of bankable offtake from buyers and (b) mature market structures to access project finance and turn scale-up plans into operational projects.

The CDR market at a glance

THE MARKET TODAY



THE MARKET IN 2030



High-durability CDR

Many first-of-a-kind projects are prepared to break ground, but need bankable offtake agreements to secure finance. Many of these projects will fail without these agreements in place.

Nature-based CDR

Investment into nature-based CDR is increasing, but remains short of what is needed to satisfy demand. More investment is required to meet expected demand in 2030.

Both need to accelerate quickly for markets to contribute meaningfully to 2030 CDR goals.

Note: CDR = carbon dioxide removal, Mt = million tonnes, Mtpa = million tonnes per annum, VCM = voluntary carbon market. Source: Carbon Direct.

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#1: The VCM needs to grow substantially

Over the last two years, demand in the VCM as a whole has been more-or-less unchanged. In 2023, total carbon credit demand, as measured in retirements, reached 164 million tonnes (Mt), **up just 3% from 2022**. Overall demand in 2024 has stayed consistent and will likely match or slightly exceed that of 2023. This contrasts with demand for CDR credits, which has been increasing quickly (see the **CDR Market Trends** section of this report).

Critically, the total value of the VCM remains small, with a market value of about US$1 billion. Small fluctuations in market performance obscure the fact that the market remains a long way off from long-term projections of total market value, with some estimates as high as US$1.1 trillion annually by 2050.

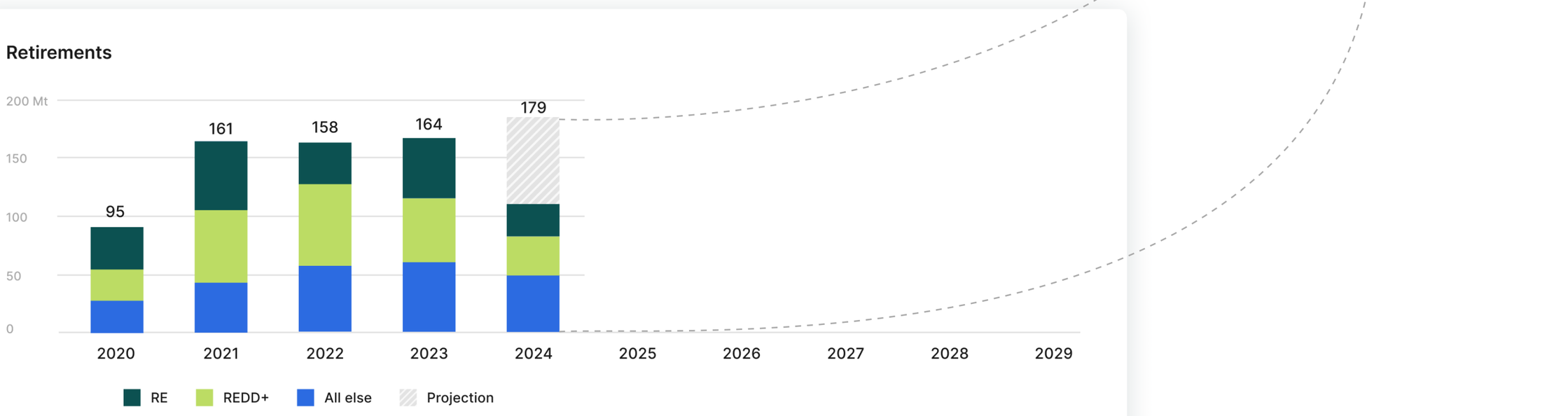

Figure 1: Carbon credit retirements by credit category from 2020–2024 across the five largest registries. Demand estimates aggregated from across six bottom-up market forecasts between 2021 and 2024, with the central estimate (1500 Mt) representing average estimated carbon credit demand in 2030 across all scenarios. Note: Mt = million tonnes, RE = renewable energy. Source: Carbon Direct.

#2: Quality remains a core challenge in the VCM

The last two years have been tumultuous for the VCM. Investigations and scientific studies revealing pervasive project-level flaws, particularly in carbon accounting, have chilled the market. These include high-profile reporting by The Guardian and the BBC, as well as research articles highlighting major accounting errors in avoided deforestation (i.e., REDD+) and cookstove projects that result in these projects delivering 90% less climate benefit than stated. These findings are consistent with Carbon Direct's assessments of carbon projects against the Criteria for High-Quality Carbon Dioxide Removal. We find that fewer than 10% of all projects we assess meet or exceed our quality criteria with minimal reservations.

In response to increased scrutiny and quality concerns, some buyers have reduced their budgets for credit purchasing or have stopped publicizing purchases in order to avoid potential reputational risks—a practice known as "greenhushing."

However, a growing number of quality-oriented buyers have begun taking steps to ensure the scientific integrity of their carbon credit purchases, through increased diligence and by focusing on project types that demonstrate high quality. In addition to voluntary and government initiatives (see spotlight), buyers are helping to increase trust and transparency in the VCM by demanding high-quality credits.

<10%

of credits are likely to meet a high-quality bar, according to Carbon Direct and academics

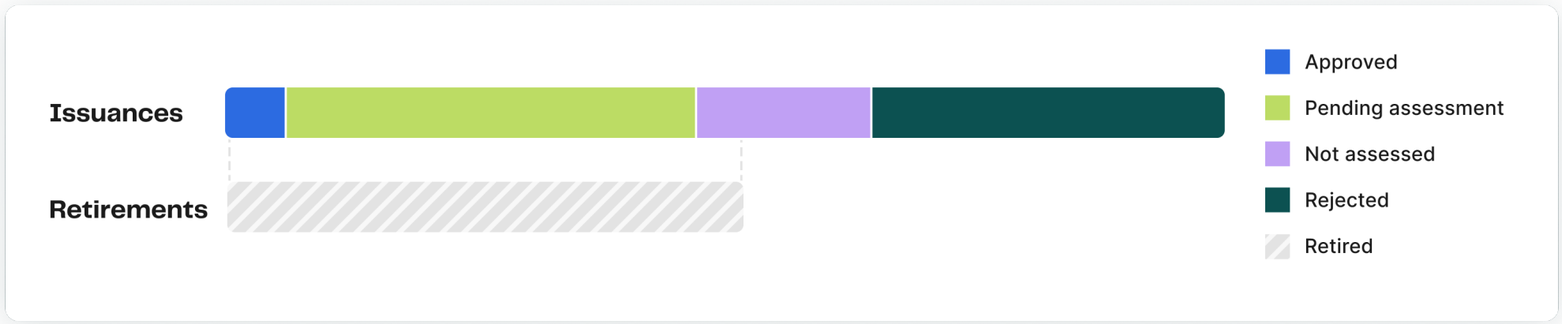

Figure 2: The fraction of cumulative carbon credit issuances from 2020–2024 by Integrity Council for Voluntary Carbon Markets (ICVCM) Core Carbon Principles (CCP) status across the five largest registries, compared to cumulative retirements in the same period. Existing unassessed REDD+ credits may be CCP eligible if they are upgraded to Verra's new consolidated REDD+ methodology. Source: Carbon Direct.

SPOTLIGHT

Supply-side integrity initiatives will raise the quality floor

Supply-side integrity initiatives—such as the Integrity Council for Voluntary Carbon Markets (ICVCM) and Europe's proposed Carbon Removal Certification Framework (CRCF)—are working to improve confidence in carbon credit quality through methodology-level assessment of carbon projects. While more work is needed to ensure consistent credit quality, these initiatives have the potential to serve as an important quality floor.

In August 2024, the ICVCM announced that credits issued under existing renewable energy methodologies would not be eligible to use their Core Carbon Principles (CCP) label, excluding nearly a third of all average annual credit issuances from CCP-eligible status. In addition, roughly 20% of average annual issuances come from REDD+ methodologies that were not submitted to the ICVCM for assessment, and therefore will not be CCP eligible unless they are able to transition to an updated methodology at a later date.

These announcements could cut out at least **50%** of available supply for buyers seeking to adhere to the CCP label, for example to make claims such as the Voluntary Carbon Markets Integrity Initiative's (VCMI) Carbon Integrity Claim. More announcements and potential exclusions are expected in the coming months, including for CDR credit types, which would further reduce the available supply of CCP-eligible credits in the market.

#3: Overall VCM supply is bifurcated by quality

Total issuance volumes for 2023 remained comparable to previous years, with renewable energy and REDD+ credits still the dominant credit types available on the market. Despite dramatic decreases in REDD+ issuances in 2024 (see spotlight), overall supply is expected to be similar to 2023.

Credit surplus in the VCM: Broadly across the VCM, carbon credit supply continues to outstrip demand. In 2023, issuances exceeded retirements by more than 70%, and the cumulative credit surplus reached nearly 800 Mt. Historically, this surplus has contributed to downward pressure on credit prices, but supply-side integrity initiatives may change this dynamic if new requirements reduce the pool of credits that clear a quality bar. Ultimately, this may result in further differentiation in the market on the basis of quality.

2:1

the average ratio of issuances to retirements over the past four years *but high-quality credits are in short supply*

Undersupply of high-quality credits: The broad market trend of oversupply obscures a key point: Carbon Direct observes that high-quality credits are in high demand and short supply. As recognition grows that the vast majority of credits in the VCM are low quality, buyers are increasingly competing for the limited high-quality projects, which often sell out quickly. **This dynamic is particularly evident in CDR.** CDR credits command higher, increasing prices, even within the same project (e.g., a project offering both CDR and emissions reduction credits). Until more high-quality credits enter the market, this trend is likely to continue.

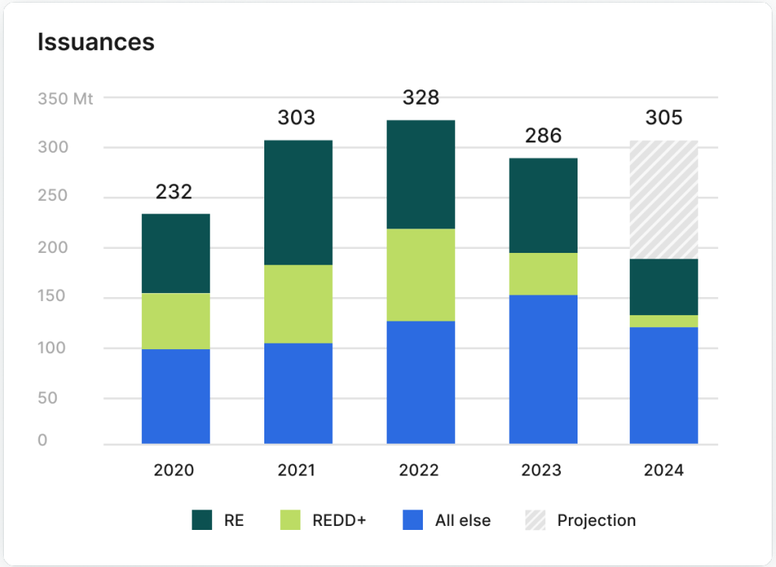

Figure 3: Carbon credit issuances by credit category from 2020–2024 across the five largest registries. Note: Mt = million tonnes, RE = renewable energy. Source: Carbon Direct.

SPOTLIGHT

REDD+ issuances and retirements continue to drop in anticipation of new methodologies, market concern

Issuances of REDD+ credits dropped to a low of 4% of total issuances in 2024, compared to 24–28% before 2023 (**figure 3**). However, the market is dynamic and supply could shift dramatically in coming years.

- Many project developers anticipate, and aspire to update their projects to, Verra's new consolidated REDD+ methodology. This is a primary driver of the drop in REDD+ issuances.
- Market demand is still in flux for REDD+ credits. Despite widespread criticism of historic REDD+ methodologies, retirements of REDD+ credits in 2023 remained comparable to previous years. Further, new methodologies from Verra and ART may assuage concerns about quality in REDD+.
- Rapid, multi-million-tonne issuances of jurisdictional REDD+ credits issued under the ART-TREES standard are likely in the near future. Noteworthy deals include:
  - The state of Para in Brazil will sell 5 million credits for US$180 million to LEAF Coalition members.
  - Since 2022, Guyana has issued 40.6 million jurisdictional REDD+ credits under the high-forest, low-deforestation method. These credits were contracted as part of a US$750 million deal with oil developer Hess.

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#4: CDR demand is growing, but market share remains small

CDR credits come from a diverse range of projects. These include projects focused on nature-based solutions such as afforestation, reforestation, and revegetation (ARR) and improved forest management (IFM), as well as high-durability solutions such as biomass carbon removal and storage (BiCRS) and direct air capture (DAC). In 2023, CDR credits accounted for a small share of carbon credit supply, making up only 4% of total issuances.

Despite its small market share, 2024 saw record retirements for both nature-based and high-durability CDR. By September, **nature-based CDR** retirements had surpassed 7 Mt. We project year-end retirements to be more than 50% higher than 2023. Similarly, we project retirements of **high-durability CDR** to be more than double those of last year, largely driven by demand for biochar credits. Still, total retirements were only 0.16 Mt by September 2024.

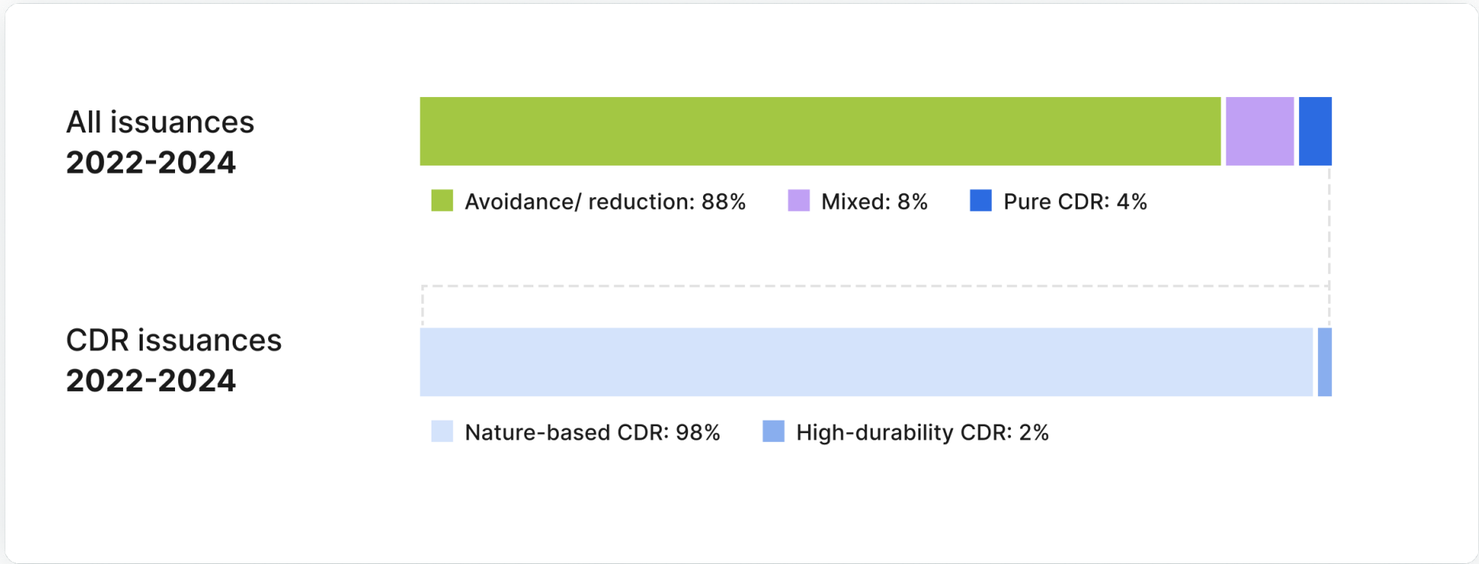

Figure 4: The fraction of CDR credit issuances from 2022–2024, across six registries: American Carbon Registry, Climate Action Reserve, C-Sink Registry, Gold Standard, Puro.earth, and Verra. Source: Carbon Direct.

In 2024 retirements of nature-based CDR are on pace to increase by

50%

But of all credits issued during 2022–2024, CDR accounted for only

4%

#5: Nature-based credits continue to make up most of existing CDR supply

Between 2022 and 2024, nature-based credits represented 98% of total CDR issuances. Growth in nature-based CDR supply was partly driven by a surge in Mexican IFM projects, which only generate CDR credits. Mexican IFM projects grew from 9% of issuances in 2022 to 27% of issuances in 2024. Based on a recent spike in registered projects, we expect this project category to continue growing.

While nature-based credits are the most available CDR credits on the spot market today, buyers have also begun signing forward offtake agreements for these credit types to secure sufficient volumes to meet their 2030 CDR targets. While these types of deals are not tracked centrally, large buyers like Microsoft and Meta have signed noteworthy agreements in 2024, and Symbiosis Coalition has emerged as the first advance market commitment specifically for nature-based CDR. The following high-value deals were announced in 2024:

- Microsoft signed offtake agreements for reforestation and restoration projects totaling 16 Mt over 10–30 years. These include deals with Mombak, re.green, Ponterra, and BTG Pactual Timberland Investment Group.
- Meta announced its own agreement with BTG Pactual Timberland Investment Group for the delivery of 1.3 million nature-based CDR credits through 2038.
- TotalEnergies invested US$100 million in US IFM projects developed by Anew for an unspecified number of credits. Anew has been noted for developing non-additional IFM projects.

98%

of all CDR issuances during 2022–2024 came from nature-based projects

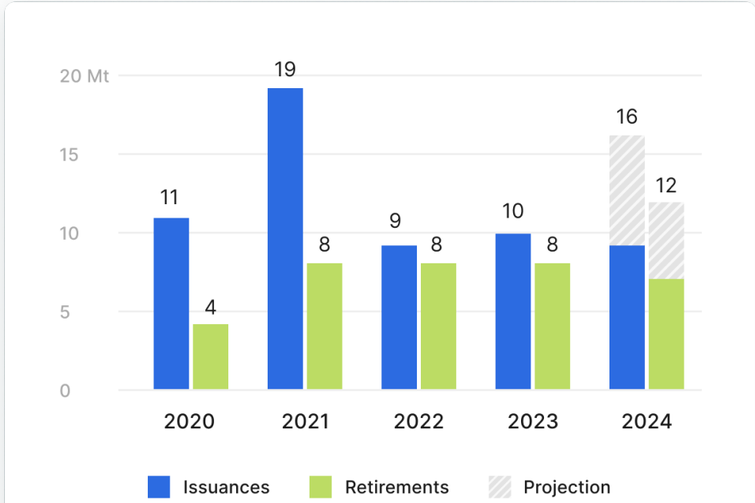

Figure 5: Nature-based CDR credits issuances and retirements from 2020–2024, across the five largest registries. Note: Mt = million tonnes. Source: Carbon Direct.

SPOTLIGHT

Spot purchasing versus forward offtake

Spot purchasing, often referred to as ex post procurement, means buying credits that have already been issued and are ready for immediate delivery. Because the CDR has already occurred, the credits can be retired immediately on the buyer's behalf and the buyer can claim the environmental benefit against their emissions. Spot purchasing, or ex post procurement, is particularly important for meeting near-term goals like an in-year, net-zero claim.

Forward offtake, also referred to as ex ante procurement, involves contracting for credits that have not yet been issued—either because the CDR has not yet occurred or because the issuance process has not been completed with the credit registry. In a forward offtake agreement, the buyer signs a contract with a project developer to purchase credits and take delivery of them on a specific schedule. As they are delivered, the buyer can retire the credits and apply them toward their climate claims. Forward offtake can include near-term or long-term purchase agreements, and can cover a single issuance of credits or multiple years of future credit offtakes.

To learn more, read the blog: How to develop a carbon credit purchasing strategy.

#6: Forward purchases make up the bulk of high-durability contracting

Due to the limited issuances of high-durability CDR credits, forward offtake contracts for credits far outweigh spot market retirements. In 2024 so far, 0.16 Mt high-durability credits were retired on the spot market, versus 6.4 Mt in pre-purchases and offtakes. Forward purchasing is thus the most significant indicator of demand for high-durability CDR. Several large offtake agreements were announced in 2024, including:

- Microsoft announced two large purchases from bioenergy with carbon capture and storage (BECCS) projects, Stockholm Exergi and Ørsted, for a total of 4.3 Mt.

It also announced a 0.5 Mt purchase from 1PointFive, the largest offtake agreement for DAC ever. These credits are expected to be delivered starting before 2030, for periods ranging from 6–10 years.

- Equinor signed a 0.33 Mt offtake agreement with Ørsted, with credits to be delivered over a 10-year period starting in 2026. Ørsted's CO_2 storage partner is Northern Lights, which is partly owned by Equinor.
- Frontier announced a deal with Vaulted Deep to remove 0.15 Mt, with credits delivered before 2030.

40x

more high-durability tonnes were contracted through forward offtake than were retired in 2024, indicating a highly forward-looking market

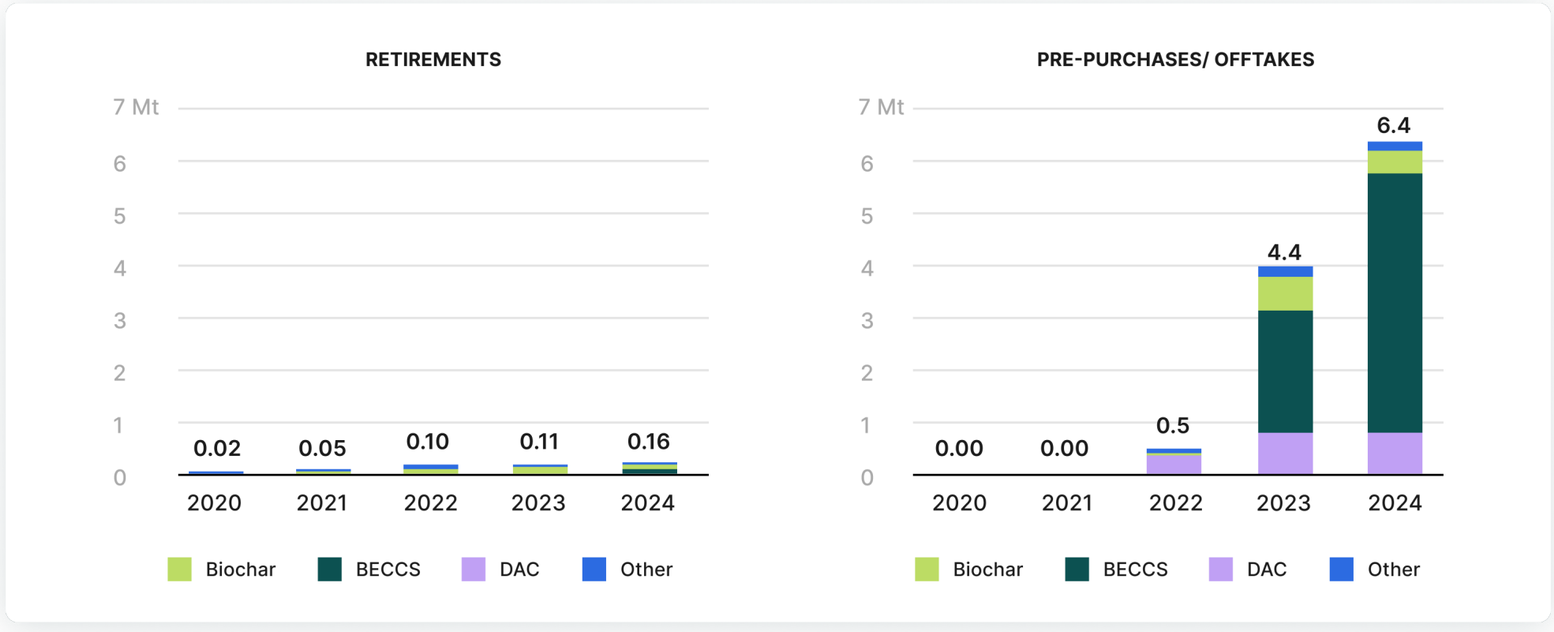

Figure 6: Retirements of high-durability CDR credits as compared to pre-purchases and offtakes from 2020–2024, across two registries: Puro.earth and C-Sink Registry. Data for pre-purchases and offtakes is provided by CDR.fyi under license. Note: BECCS = bioenergy with carbon capture and storage, DAC = direct air capture, Mt = million tonnes. Source: Carbon Direct.

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#7: Companies with public CDR commitments promise meaningful demand

...but market-based contributions to global CDR goals require much greater ambition.

Forward-looking CDR demand today is primarily driven by a small group of market leaders that are looking to deliver on specific near-term climate commitments. We analyzed companies with explicit commitments to purchase over 1,000 tonnes of high-quality CDR annually by 2030. These commitments range from 1–100% compensation of residual emissions in 2030. Together, they represent a total demand of about 30 million tonnes per annum (Mtpa) of CDR in 2030. Carbon Direct estimates that there could be additional demand of 15 Mtpa when accounting for a potential gap between companies' projected emissions reductions and their actual performance, as well as additional demand from buyers without public commitments. Of the total, we estimate at least 80% represents demand for nature-based CDR.

In addition, the Science Based Targets initiative (SBTi) is exploring further guidance for setting interim CDR targets as part of longer-term net-zero commitments. We estimate that this could add about 5 Mtpa in demand for high-durability CDR by 2030, representing less than 1% of current corporate emissions covered with SBTi targets or commitments. Finally, excluding publicly committed CDR demand from baseline demand for nature-based CDR, there could be an additional 20 Mtpa of nature-based CDR demand in 2030 if current market growth rates continue.

Together, these values represent a five-fold increase from 2024 CDR retirement levels. Still, demand is far too low to make a meaningful contribution to global CDR goals. It represents a tiny fraction of the CDR needed by 2030 in IPCC scenarios that limit warming to 1.5°C. For market-based mechanisms to meaningfully contribute to scaling up CDR, private sector demand must accelerate quickly.

30–50 Mtpa

Projected 2030 demand from companies with explicit high-quality CDR commitments

This is a tiny fraction (e.g., less than 5%) of new CDR needed in 2030 to meet IPCC 1.5°C-consistent scenarios.

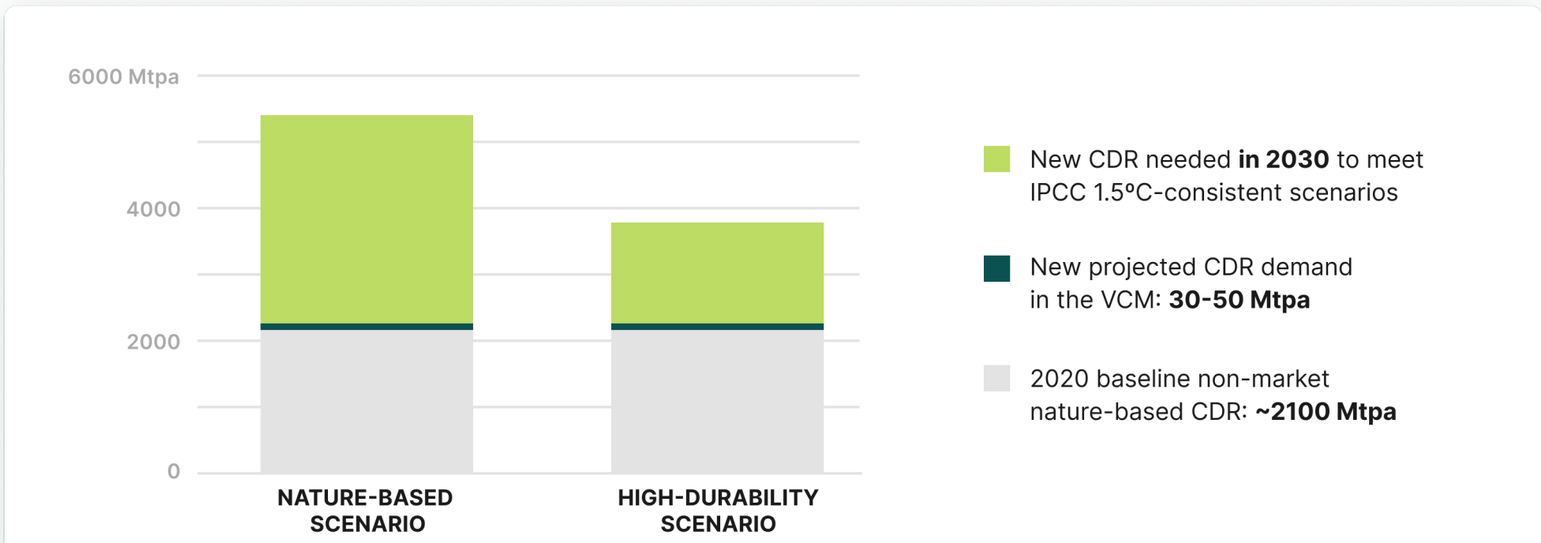


Figure 7: Projected demand for nature-based and high-durability CDR by 2030, compared to CDR needs in two IPCC scenarios that limit warming to 1.5°C. Note: Mtpa = million tonnes per annum. Source: Carbon Direct and adapted from The State of Carbon Dioxide Removal, 2nd Edition.

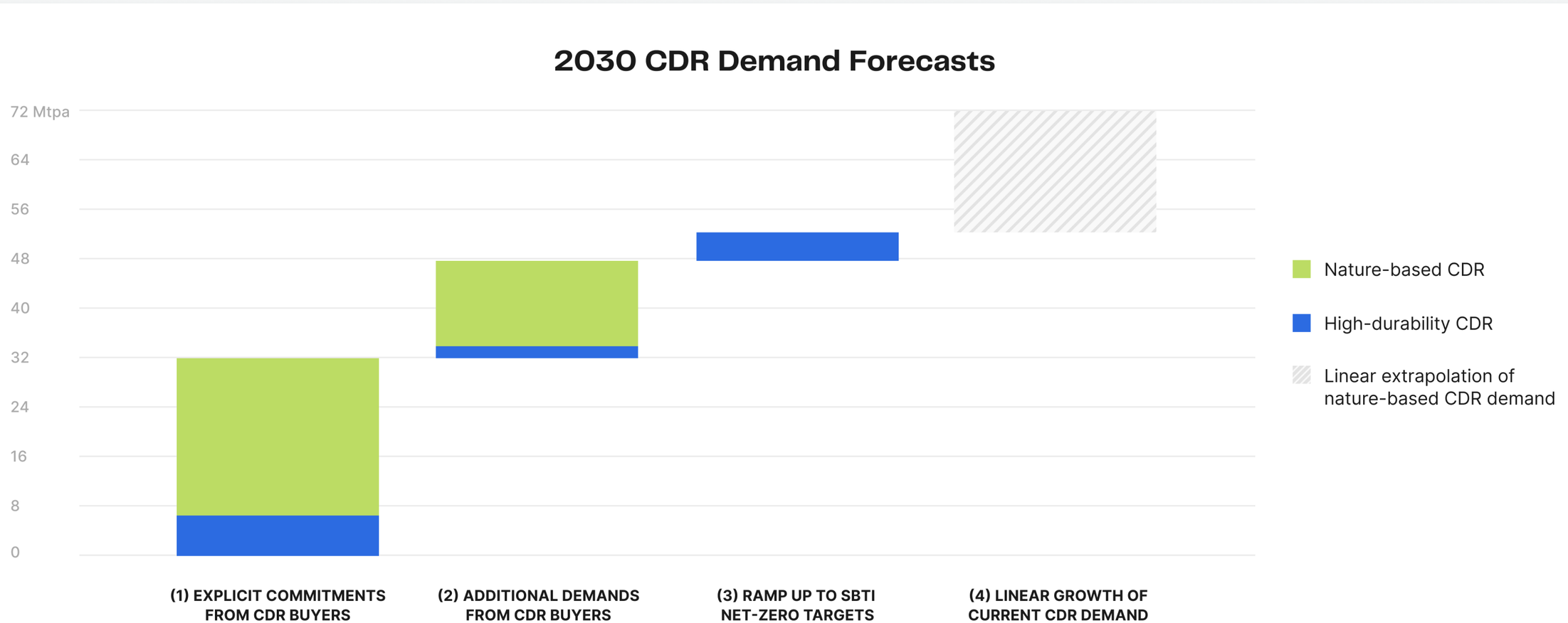


Figure 8: (1) Demand in 2030 from companies with explicit public commitments to purchase >1,000 tonnes of high-quality CDR annually over the same time frame. **(2)** Additional demands from companies with explicit commitments to purchase high-quality CDR in 2030 that accounts for a potential gap between companies' projected emissions reductions and their actual performance, as well as inferred demand from buyers without public commitments. **(3)** Demand from companies with SBTi-aligned or committed net-zero targets for 2050 or earlier, assuming a ramp up of CDR purchasing ahead of the net-zero target year to meet interim CDR targets ("neutralization milestones"). **(4)** Linear forecast of current retirements of nature-based CDR credits, extrapolated from 2022-2024 growth rates, from companies not accounted for in other sources. The linear extrapolation excludes the sample of companies included in explicit and additional demand forecasts who currently make up about 25% of current nature-based CDR retirements based on public retirement data.

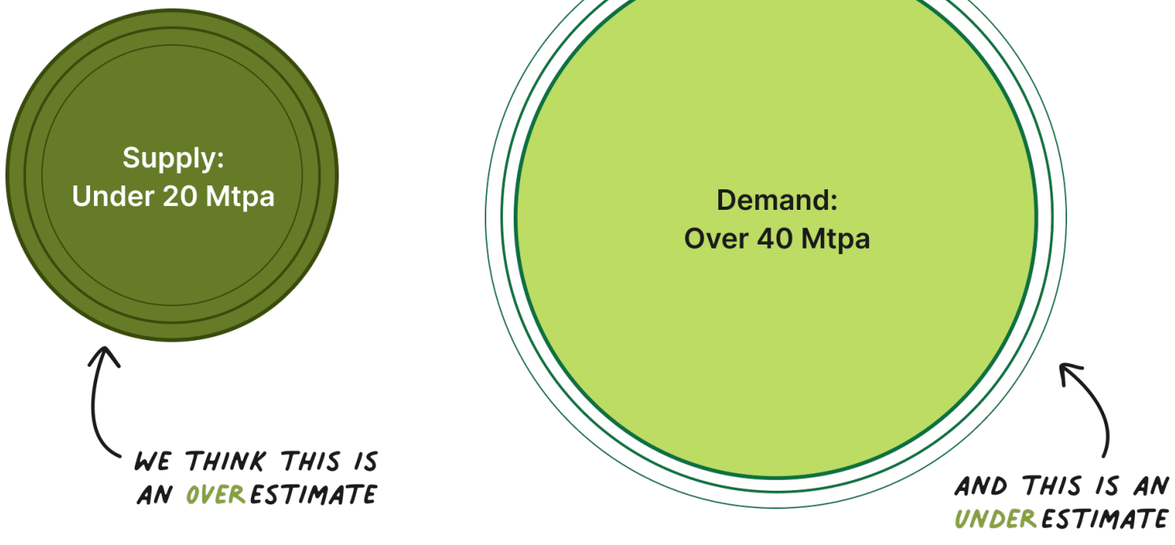
Note: Mtpa = million tonnes per annum. Source: Carbon Direct.

#8: Nature-based CDR needs far more investment than has been committed

Based on publicly available investment fund data, about US$11 billion in total funding for nature-based CDR has been announced since 2018. Most of this funding is from project finance funds announced from 2023–2024. Around 60% of these funds have a specific mandate to invest in either IFM or ARR. This significant concentration of capital in funds for nature-based projects highlights investor confidence in the effectiveness and scalability of forest-based CDR projects. However, this is far from enough to create the volumes of nature-based CDR required to meet climate targets. Overall, this level of funding is expected to result in sustained scarcity of high-quality nature-based CDR.

Carbon Direct's projections indicate that currently announced funding could translate to approximately 190 Mt of cumulative high-quality supply through 2040. Using generalized credit issuance curves for CDR credits from high-quality projects of each project type, this capital could contribute to around 20 Mtpa of nature-based CDR in 2030. This is significantly below our forecasted nature-based 2030 demand (40 Mtpa) and even farther from delivering the billions of tonnes of CDR needed to meet IPCC goals that limit warming to 1.5°C. Additional capital commitments in the coming years could serve to close this gap, alongside expanded government support.

Figure 9: New nature-based CDR investment based on public capital allocations. Source: Carbon Direct.



This is likely an overestimate of high-quality nature-based CDR supply.

These projections purposefully assume rapid, effective deployment to illustrate the best-case scenario for supply based on investable capital. In practice, deployment is likely to be slower and some will be low quality. Multiple factors will influence the actual number of credits generated. Key factors include credit quality, unspecified funds, fund deployment, and land acquisition.

CREDIT QUALITY

We calculate credit generation based on our estimate of the cost to produce high-quality credits and generalized credit issuance curves for these project types. The price to generate credits from low-quality projects (e.g., those with poor additionality) is much lower than the price used here. Credits generated from such projects are also less relevant to the market and represent more volatile investments for funds. For these reasons, we do not run scenarios for low-quality credit generation.

UNSPECIFIED FUNDS

A large portion (~40%) of funding is not publicly allocated to a specific type of nature-based CDR project. We have captured three different scenarios of capital allocation for these unspecified funds. The base scenario represents investment into a representative mix of nature-based CDR project types on the VCM (see the **Methods** section of this report). The ARR scenario is an upper bound for ARR, in which 100% of unspecified funds are allocated to ARR. The IFM scenario is, similarly, an upper bound for IFM (100% of unspecified funds go to IFM). Through 2040, these scenarios yield roughly equivalent total credit volumes. However, the production of credits over time varies substantially, due to the differences in issuance timing for IFM and ARR projects.

FUND DEPLOYMENT

To outline the highest volume scenario for projects, we have assumed that all funds deploy immediately and begin activating projects. In practice, this will not take place, as funds are deploying across their investment window.

LAND AQUISITION FUNDS

Land acquisition funds make up about three quarters of all capital allocated to nature-based CDR today. In these funds, a major driver of returns is land value, in addition to returns realized from carbon credits. These funds are currently marked for investment into carbon projects, but if demand or prices for nature-based CDR fall, this capital could be re-allocated to non-carbon end uses.

Importantly, this is a snapshot in time, not a projection of funding. Looking ahead, we need more investment in nature-based CDR. The recent rise in funding indicates a growing recognition of the importance of nature-based CDR and of the overall scarcity of high-quality credits. However, future investment will depend on factors such as policy support, carbon market developments, and the performance of existing projects. While the current trend shows a surge in capital allocation, funding could plateau or even decline if challenges arise in project implementation, carbon credit pricing, or investor confidence. As in the rest of the VCM, demand for high-quality CDR is paramount to the continued allocation of capital to nature-based CDR projects.

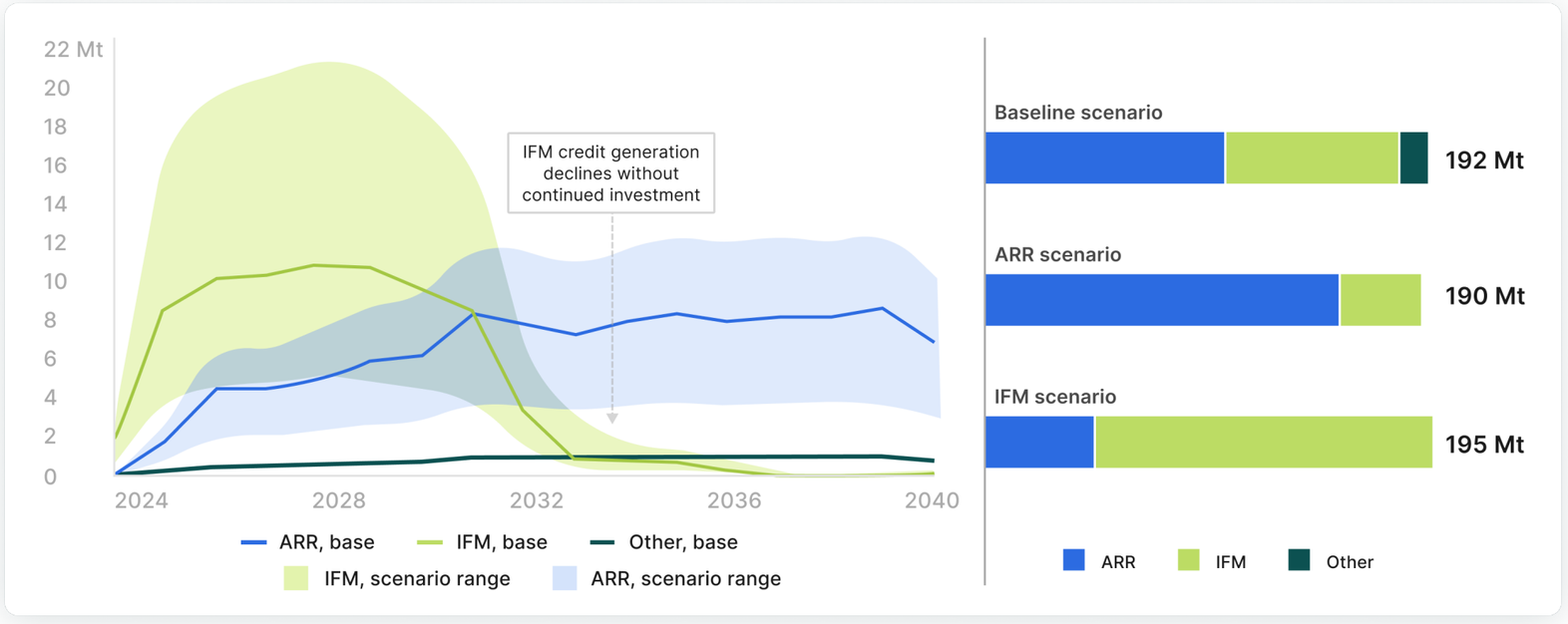


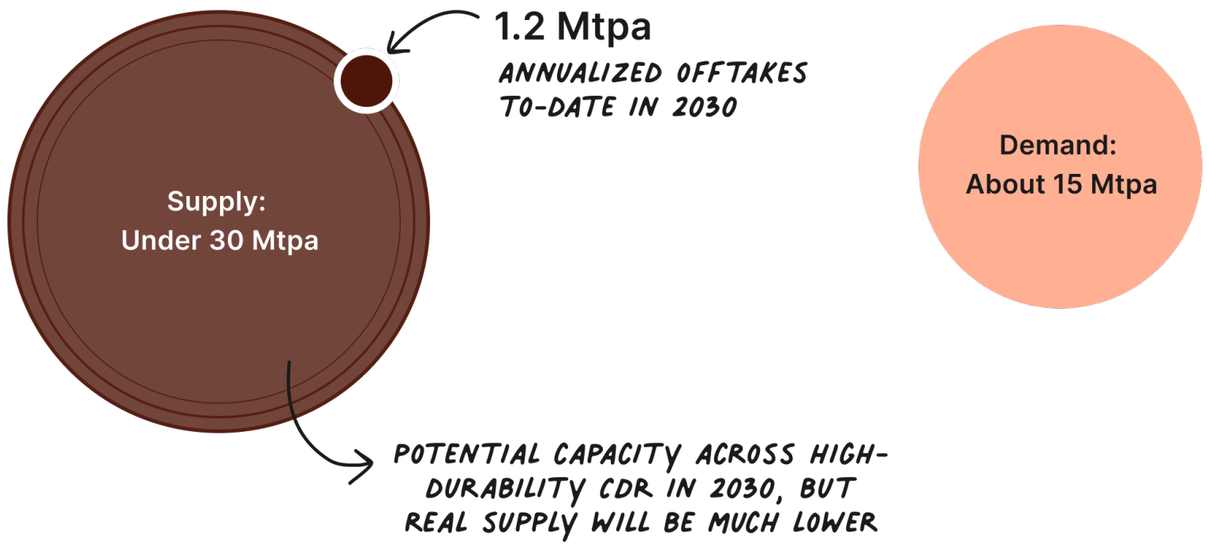
Figure 10: Projected new, nature-based CDR credit supply originating from 2024 capital allocations across three scenarios. In generalized CDR credit yield curves, IFM projects issue more credits in a project's initial years, whereas ARR projects take more time to ramp up credit generation. Note: ARR = afforestation, reforestation, and revegetation, IFM = improved forest management, Mt = million tonnes. Source: Carbon Direct.

#9: High-durability CDR requires mature project finance to scale

Carbon Direct's analysis of public and anonymized data from ~140 high-durability CDR project developers show scale-up plans for 30 Mtpa of supply. This is possible only with sufficient offtake and funding. This growth depends on real demand in the form of bankable forward offtake agreements, increased project equity investment, increased access to lending, and high-quality project development.

Based on developer scale-up plans, BiCRS projects make up most potential high-durability CDR in 2030 (20 Mtpa), excluding ethanol with carbon capture and storage (CCS) (see spotlight). This is closely followed by DAC, at 10 Mtpa. Other pathways, such as marine CDR and enhanced rock weathering, could offer significant tonnage by 2030, although scale-up across these pathways is more uncertain.

Our analysis indicates that prices for high-durability CDR credits will remain above US$100/tonne in 2030 across the vast majority of planned capacity. For most project types, prices are projected to stay above US$200/tonne. While we anticipate DAC prices will decline, DAC is very likely to remain the most expensive credit type.



Many of these projects will not go forward unless buyers and lenders move quickly. These volumes are highly contingent upon sufficient demand in the form of contracted offtake at prices that secure risk adjusted returns, and in bankable contracts that match the payback periods required for project finance. Announced annualized offtake volumes—1.2 Mtpa by 2030, representing roughly 5% of planned capacity—are far from realizing the scale-up plans of high-durability CDR project developers.

Unless offtakes for these projects accelerate very quickly, **much of the announced high-durability CDR will not come online by 2030.**

As projects rapidly approach final investment decisions, a few key factors will enable their success:

- **Bankable offtake:** Ensure that bankable offtake agreements cover the payback period and cost of capital for project finance.
- **Mature deal structures:** Adopt standardized and proven contractual and financial frameworks to reduce uncertainties and enhance project bankability.
- **Risk mitigation strategies:** Plan to allocate risks, secure necessary guarantees and insurance, and engage experienced partners to bolster investor confidence.

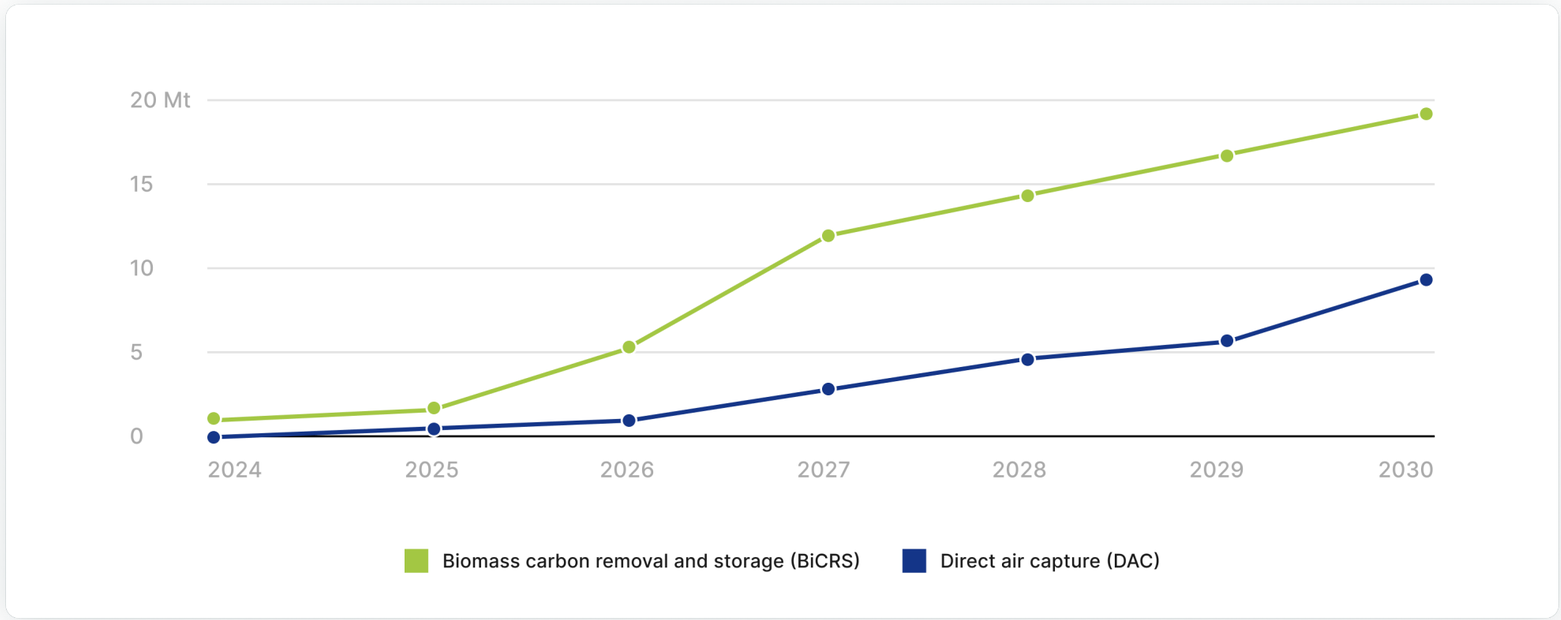


Figure 11: Potential supply of high-durability CDR by 2030 based on supplier scale-up plans. Note: Mt = million tonnes. Source: Carbon Direct.

SPOTLIGHT

Ethanol with CCS

Retrofitting corn ethanol facilities with CCS has been the focus of multiple project developers due to low cost and proximity to planned pipelines in the US Midwest. Planned ethanol with CCS projects could increase the total supply of high-durability credits by many millions of tonnes before 2030 at relatively low credit prices. However, the following factors may limit demand for these credits in the VCM:

- **Life cycle assessment (LCA) boundaries:** Specific assumptions around LCA boundaries can determine whether ethanol with CCS is treated as a CDR pathway or an emissions reductions pathway. Critical factors include land-use change, allocation of upstream emissions to fuel and CDR, and differences between retrofit and greenfield projects.
- **Financial additionality:** Due to the very low cost of capture, some ethanol with CCS projects may be financially feasible and profitable without the sale of credits on the VCM, due to 45Q tax credits and state low-carbon fuel policies.
- **Resource allocation:** Ethanol with CCS is a mature technology with finite deployment potential, making it a less attractive option for buyers seeking to make catalytic investments in CDR pathways with deeper learning curves.

#10: Forward purchasing of CDR is highly concentrated

Procurement of high-durability CDR via long-term offtake agreements is increasingly concentrated among a few buyers. In 2024, Microsoft represented 80% of high-durability CDR pre-purchases and offtakes (5 Mt). The next largest offtakers were Airbus at 0.4 Mt and Equinor at 0.33 Mt. The same trend of market concentration, with many of the same buyers, is also apparent for nature-based CDR. Forward offtakes of nature-based CDR are not centrally tracked, so this conclusion is qualitative.

These trailblazing buyers and partnerships will help facilitate the early scale-up of high-quality CDR supply. At the same time, this concentration implies that only a small number of buyers are currently executing contracts on the scale needed to meet their stated climate commitments. We expect the buyer pool to diversify as more companies shift from spot market purchasing to forward offtake. This is a key transition in the market as CDR buyers accelerate toward 2030 targets. That said, these companies are still catching up to market leaders like Microsoft.

For high-durability CDR projects in particular, buyers with near-term goals need to engage with projects now to ensure projects reach final investment decisions in time to deliver credits by 2030. Companies with longer-term net-zero targets can also start engaging in the market to help it grow.

80%

of all high-durability CDR pre-purchases and offtakes in 2024 came from just one buyer

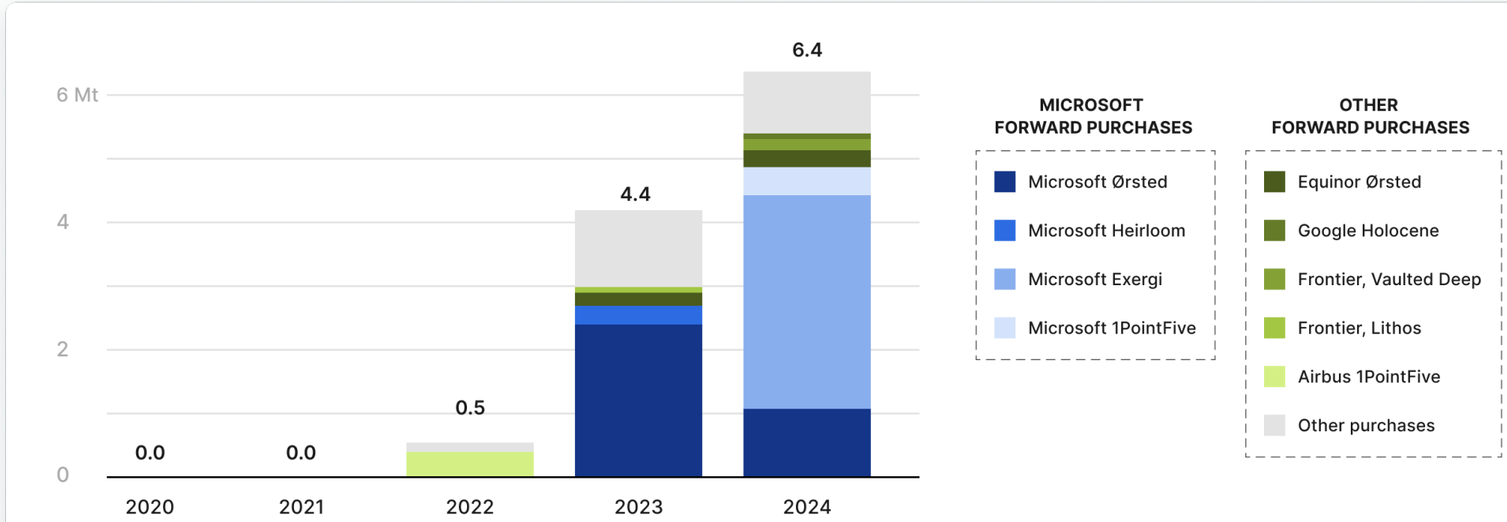


Figure 12: Pre-purchases and offtakes of high-durability CDR from 2020–2024. Data provided by CDR.fyi under license. Note: Mt = million tonnes.

#11: CDR market growth depends on the execution of stated demand

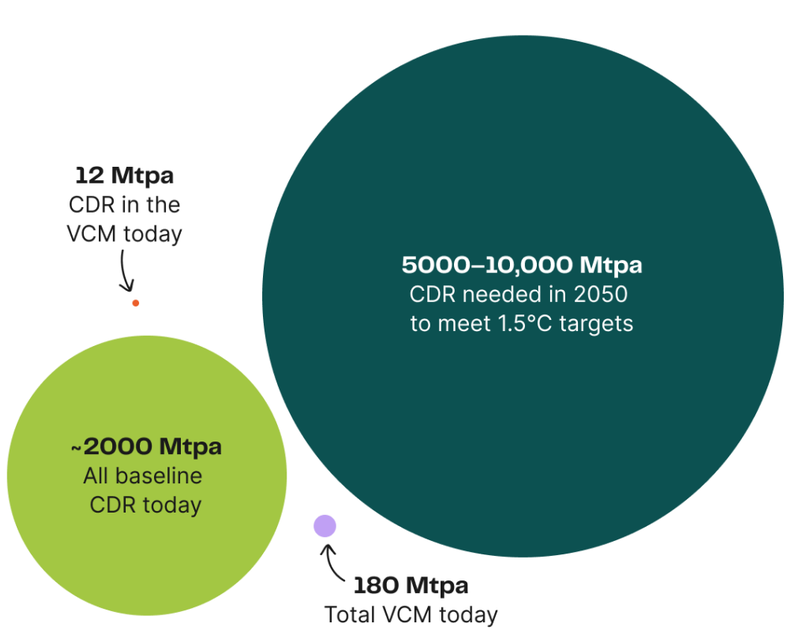
While near-term and medium-term climate commitments can help signal demand to project developers, the only way to ensure that needed supply comes online is through making investments and forward offtake agreements now. While a handful of companies have begun executing longer-term offtake agreements for high-durability CDR, these contracts represent a small fraction of expected demand volume for 2030. More buyers have executed large-scale nature-based CDR contracts. Still, project finance for nature-based CDR projects needs to accelerate to meet stated demand and to contribute meaningfully to climate targets.

The VCM can play an important role in helping to scale up CDR to billions of tonnes per year in 2050. The CDR market is still in the early days of scaling up, but this moment is an important inflection point.

- **High-durability CDR:** Many first-of-a-kind projects are prepared to break ground, but need bankable offtake agreements to secure finance. Many of these projects will fail without these agreements in place.
- **Nature-based CDR:** Investment into nature-based CDR is increasing, but remains short of what is needed to satisfy demand. More investment is required to meet expected demand in 2030. Substantially more investment is needed to be on track to meet IPCC climate targets for CDR.

To support these goals, organizations such as the SBTi, the International Organization for Standardization (ISO), and other standard setting organizations must develop coherent and actionable approaches that clarify the responsible use of high-quality carbon credits, alongside emissions reductions, as part of comprehensive climate strategies. Their leadership is critical to unlock demand for high-quality credits.

Buyers and funders have a central role to play in ensuring that the VCM can deliver on laying the foundation for large-scale CDR deployment when we need it.



Key takeaways

FOR BUYERS

1. Both nature-based and high-durability CDR require essential funding now; nature-based projects will deliver the majority of CDR credits in the near term at accessible prices.
2. Forward offtakes are essential to scale a nascent CDR market, especially for high-durability CDR, but very few buyers are contracting at the level needed to meet 2030 CDR goals.
3. To reach climate targets, buyers and developers need to develop mature market structures for project development and project finance, backed by bankable offtake.

FOR SUPPLIERS

1. Projects must distinguish themselves on the basis of quality and transparency to reduce the reputational risks buyers face when purchasing carbon credits.
2. Nature-based CDR is likely underfunded and undersupplied. There is a critical need to increase project finance for nature-based CDR to meet demand.
3. Scale-up plans for high-durability CDR supply outstrip demand in the near term. High-durability projects need (a) high volumes of bankable offtake from buyers and (b) mature market structures to access project finance and turn scale-up plans into operational projects.

SECTIONS

Supply methods

To calculate forward-looking CDR credit supply, we conducted separate analyses for nature-based and high-durability CDR.

Nature-based CDR

Across nature-based verticals, we conducted a scan of publicly committed capital allocations to nature-based credits, including any information related to the geographic distribution or vertical commitments associated with each source of capital. This pool of committed capital includes nature-based project development funds and developer commitments. It excludes philanthropic capital, government grants, and development finance institution capital unless specifically allocated to a given nature-based project development fund. Where sources of capital did not mandate investment in a specific type of nature-based credit, we assumed a historical distribution of credit generation based on nature-based CDR retirements in major registries for 2023 and 2024. We then applied adjustments to this pool of identified capital to account for fees, expenses, and broken deals. We then calculated operational capital by applying an additional adjustment to account for land acquisition spend where applicable, depending on the vertical mixture.

To translate operational capital into credit generation, we divided each nature-based vertical's capital allocation by a per-credit de-risking cost, based on a proprietary suite of models. The de-risking cost represents the minimum per-credit investment required to activate credits given the nature-based CDR vertical. The total credit generation from this process was then fit to a generalized credit-generation timeline created by averaging a set of real-world IFM and ARR credit generation models.

High-durability CDR

For high-durability CDR, we aggregated anonymized data on capacity and pricing. We refined the data by focusing on projects with demonstrated technologies and clear development pathways. This leverages our broader understanding of market trends. The result is a more selective aggregation of potential supply, avoiding inflated projections often found in supplier announcements (e.g., on websites or in promotional materials), which can overestimate capacity and underestimate development timelines.

Demand methods

Bottom-up, near-term demand in 2030

To calculate the demand for **CDR credits** in 2030, we utilized a methodology that incorporates both publicly-available data and proprietary insights. For the base case, we relied on **public disclosures by companies**, focusing exclusively on compensation and contribution carbon credit commitments that explicitly refer to CDR projects. Where companies do not state specific high-durability CDR procurement goals, we assume that 15% of their procurement for 2030 will be high-durability. This assumption is highly uncertain but has little effect on our conclusions.

Additionally, to create a more comprehensive estimate, we introduced a **buffer** that accounts for the potential gap between companies' projected emissions reductions and their actual performance. This buffer analysis is based on an examination of companies' real emissions, factoring in the likelihood that many will fall short of their decarbonization targets by 2030. As a result, companies may require a significantly higher volume of CDR credits than anticipated to offset these excess emissions. To further refine this estimate, we incorporated the buffer, which was based on our unique view into the market and provides what we feel is a more realistic view of future demand not fully captured through other means. This combination of disclosed commitments, actual emissions trends, and Carbon Direct's expert insight enabled a more accurate and nuanced projection of the total demand for CDR credits by 2030.

To break down the projected **CDR demand by 2030** into two categories (**nature-based CDR** and **high-durability CDR**), we relied on both public disclosures by companies and Carbon Direct's understanding of the market. By analyzing company commitments that specify the type of CDR they intend to use, and using our market knowledge, we were able to estimate the demand for each category.

SBTi demand in 2030

We analyzed data from CDP, BloombergNEF, and SBTi. For companies with SBTi net-zero targets, we assumed residual emissions equate to 10% of baseline emissions and a linear ramp up to neutralizing those residual emissions in the target year.

Registry analysis methods

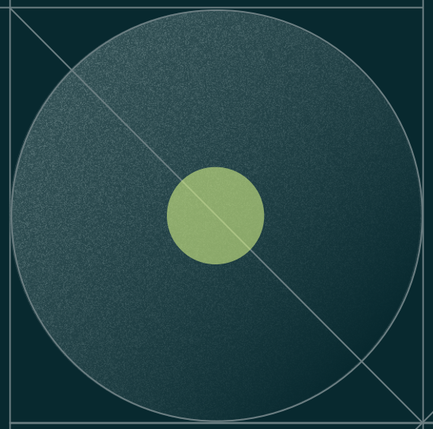
For the registry analysis of the VCM, we employed a methodology that integrates multiple data sources to ensure robust coverage. The core of the analysis was built around data from several established databases and registries that track carbon credit issuances, retirements, and cancellations. Data across different sources was extracted between September 9, 2024 and September 16, 2024.

The Carbon Plan Offsets Database served as one of the foundational sources, offering detailed information on carbon credit issuances, retirements, and cancellations. This was complemented by the Voluntary Registry Offsets Database, developed by the Berkeley Carbon Trading Project, which provided an additional layer of verification.

We also incorporated data from the Puro.earth registry, which focuses on high-durability CDR credits. C-Sink registry was another source of data we used to track issuances and retirements of biochar projects. Finally, we used the CDR.fyi database to track offtake agreements for high-durability CDR solutions.

In addition to leveraging various data sources, we incorporated the ICVCM Assessment Status to conduct a **CCP eligibility analysis**. By cross-referencing projects with the assessment status available on the ICVCM platform, we were able to identify the CCP assessment status of each project.

To complement these databases, we relied on **public disclosures** from various carbon credit issuers, buyers, and project developers. These disclosures provided additional insights into the specifics of each project, including methodologies used and project timelines.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