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Chapter 4 | The voluntary carbon market

Despite growth in carbon dioxide removal (CDR) on the voluntary carbon market (VCM), its share of the market remains small. Future projections suggest a rapidly growing but uncertain demand for future CDR through the VCM.

Key insights

- The vast majority of carbon credits retired (used and thus no longer tradable) on the VCM relate to projects that avoid or reduce emissions, rather than remove carbon. In 2023, CDR credits accounted for less than 10% of total credits sold on the VCM.
- The market for novel CDR is nascent but growing, whereas the market for conventional CDR is more mature. Some VCM projects also adopt mixed methodologies, which generate credits from both CDR and avoided emissions.
- The number of credits issued for conventional CDR fell in 2023 from approximately 20.4 million to 13.3 million, while purchases of future novel CDR credits grew sevenfold from 600,000 to 4.6 million.
- The market plays a larger role in financing novel CDR than conventional CDR. Credits issued for afforestation/reforestation represent less than 1% of the total afforestation/reforestation CDR that occurred in 2023. By contrast, pre-purchases for novel CDR well exceeded the total amount removed through novel methods in 2023.
- The price per carbon credit is substantially higher for CDR than for other credit types. On average, credits from conventional CDR methods (which ranged from $12 to $16 in 2023) cost three times more than credits generated from emission reduction or avoidance projects. The average weighted price for novel CDR credits (which ranged from $111 to $1,608 in 2023) exceeds the price for credits from emission reduction or avoidance projects by a factor of 100.
- Despite emergent efforts to standardize and integrate CDR into compliance markets and the emerging regime under Article 6 of the Paris Agreement, there may always be a case for the VCM to exist as a niche market for CDR to facilitate innovation and experimentation and to supplement climate change mitigation efforts.

This chapter looks at the role of the VCM in expanding the deployment of CDR. The first section lays out the background of CDR in the VCM. The chapter then assesses the current state of play of CDR within the VCM and maps its future prospects.

4.1 The role of the VCM in expanding CDR

With novel CDR largely absent from government agendas, the VCM plays a key role in its deployment.

Economic theory is clear that climate change is a market failure – more precisely, the failure to take into account the external effects of emitting greenhouse gases. As long as emitting is not costly, nobody has an incentive to reduce emissions, causing damage for everyone in the world. Assigning emissions a price can help correct this market failure by internalizing the externality. This rationale is at the heart of carbon taxes and emissions trading schemes – or *compliance markets* – around the world (see Chapter 5 – Policymaking and governance). Not cleaning up the atmosphere by removing the carbon dioxide (CO_2) already emitted is presently also a market failure and thus may not occur without intervention. As a result, there is currently an undersupply of CDR, making it more difficult to meet the significant volumes of CDR required to achieve ambitious climate mitigation scenarios (see Chapter 8 - Paris-consistent CDR scenarios).

Beyond being included in national greenhouse gas inventories as part of accounting obligations, CDR has largely not been on government agendas. This is particularly true for compliance markets, with notable yet limited exceptions of CDR integration, for instance under California's emissions trading scheme. Inclusion of CDR within the VCM has thus been among the few factors contributing to CDR scale-up, especially for novel CDR. This section describes the background of CDR inclusion within the VCM.

Defining the VCM

While the VCM lacks a standardized definition, it is broadly understood as *a platform through which actors voluntarily finance projects that reduce or remove CO_2 emissions*. This report adopts a broad definition of the VCM, encompassing different types of transaction between buyers and suppliers: both those that occur via the voluntary marketplaces and those where CDR is directly procured from suppliers and publicly reported. This report explicitly includes the traditional registry-based VCM as well as niche markets that facilitate the pre-purchase of novel CDR within its definition of the VCM. This chapter considers the creation of credits in terms of their issuance (conventional CDR) or delivery (novel CDR) as well as their retirement (conventional CDR) and purchase (novel CDR). It is acknowledged that some CDR credits that buyers purchase may not be retired and could therefore also be used for compliance purposes in the future and thus may go beyond the purview of the VCM. Box 4.1 describes the VCM and how it works.

Box 4.1 How does the VCM work?

To understand CDR in the VCM, it is important to first understand the role of the VCM in climate change mitigation more broadly. The VCM is generally understood as *a platform through which actors voluntarily finance projects that reduce or remove CO_2 emissions*. The VCM is estimated to account for 2% of total carbon trade, with compliance markets (emissions trading schemes) covering the other 98%.[91] The vast majority of carbon trading is for *emission allowances* within emissions trading schemes, while the VCM only concerns carbon *credits*. Despite its small share in carbon trading overall, the VCM fulfils a role by enabling businesses to go beyond their mandatory decarbonization efforts.

Carbon credits are tradable certificates typically generated from projects developed and governed by private project developers and owners. One credit represents 1 ton of avoided, reduced or removed CO_2 or CO_2-equivalent emissions of other greenhouse gases. Such projects can occur in different sectors, such as forestry, agriculture or energy, and may come with co-benefits (e.g. improvements to biodiversity).

Carbon credits are typically *issued* (put on the market) by *registries* and *certified* according to one of several methodologies. Credits are issued after the mitigation activity has occurred; they are certified after the mitigation activity has been verified and validated by a third-party auditor (see Chapter 10 – Monitoring, reporting and verification).

A carbon crediting programme (i.e. the organization that hosts a certifiable carbon crediting standard) consists of recognized methodologies, approved third-party verifiers and an issuing registry. Carbon crediting programmes have methodologies that set the rules for different types of activity – including monitoring, reporting and verification procedures – that must be complied with for those projects to be certified as having either avoided, reduced or removed CO_2 emissions (see Chapter 10 – Monitoring, reporting and verification).

Carbon credits can be acquired directly by end beneficiaries (e.g. corporate buyers) or purchased via intermediaries (e.g. traders, brokers). Project developers and governments can also enter into bilateral *offtake agreements* and *pre-purchase agreements* with end beneficiaries, for example by arranging to sell portions of their planned future volumes of carbon credits.

Carbon credits are typically used (retired or cancelled) for voluntary or compliance purposes. After this, the credit is no longer on the market and cannot be traded anymore. However, not all credits sold end up retired, as some actors may hold on to them for future trade or use. Carbon crediting programmes allow each carbon credit to be retired or cancelled by only one single entity, to avoid the same credit being double counted in different organizational *claims*.

The largest carbon crediting programme is the Verified Carbon Standard (Verra), followed by the Gold Standard. Several other standards have also been developed, such as the Climate Action Reserve, Plan Vivo, the American

Carbon Registry and Puro.earth. In the absence of supra-organizational regulatory bodies, this array of standards has led to heterogeneity and complexity in the oversight of the VCM.

A brief history of the VCM

Although the first instances of carbon offsetting go back several decades,[92] the Clean Development Mechanism (CDM) under the Kyoto Protocol was the first international carbon market when it came into force in 2005, though crediting had already started several years before. The aim of the CDM was to assist higher-income countries in reaching their decarbonization commitments while providing access to new funding for climate change mitigation for lower-income countries. However, in the years after its launch, the CDM was the subject of severe concerns related to transparency and the overall climate impact of its projects.[93–95]

Despite these flaws, the CDM's procedures have served as a blueprint for subsequent market mechanisms, including the current VCM and the emerging market mechanisms under Article 6 of the Paris Agreement. Yet the central role that CDM methodologies have played in developing the VCM is problematic, because these methodologies have been widely documented as producing low-quality carbon credits that in some cases are also not additional to what would otherwise have occurred in the absence of such funding.[96]

Types of projects on the VCM in 2023

To calculate how much CDR is funded through the VCM, it is necessary to differentiate CDR projects – and credits – from the other kinds of projects on the market. Box 4.2 describes the different types of credit that are generated within the VCM.

The VCM today encompasses a wider range of project types than ever before: from emission reduction projects that target cookstoves and clean energy through to projects that destroy or remove greenhouse gases through various mechanisms. This range of project types is underpinned by an even more diverse suite of methodologies: some mitigation activities that are awarded carbon credits in the VCM involve only avoided emissions, emission reductions or CDR; some combine them. However, there are early signs of this changing, with registries such as the American Carbon Registry and the Verra Registry beginning to make the contribution of removal, reduction and avoidance techniques within the same methodologies clearer.[97,98]

Box 4.2 Carbon credits

Types of carbon credit. Credits tend to be *avoidance*, *reduction* or *removal* based. The distinction between activities that avoid emissions and activities that reduce emissions is not always clear, with *avoidance* and *reduction* often being used interchangeably. CDR activities, however, lower the atmospheric concentration of CO_2. As a result, their impact is determined independently of historical, current and future emission levels; conversely, avoidance or reduction projects peg their impact against a forward-looking counterfactual emission scenario.

It is not always clear which type of carbon credit projects may be generating. Some methodologies enable credits to be generated from a mix of avoidance, reduction and/or removal activities (see Chapter 4 Technical Appendix). Mixed methodologies are particularly prevalent in conventional CDR projects (e.g. forest management, sustainable agriculture) because such projects encompass activities that both reduce and avoid (as well as remove) emissions. For example, some conventional CDR projects foster practices that diminish natural disturbances – serving to reduce emissions – while also enhancing carbon storage, thereby removing CO_2.

It is also important to distinguish between *credits* and *offsets*: credits refer to the unit, and offsets refer to the specific use of the credit to compensate for existing emissions. Credits can, however, be used in many other ways, for instance as a contribution to climate change mitigation or in the form of results-based financing. Allowances issued within emissions trading schemes (described in Box 4.1) may also be considered offsets in some circumstances, although they are not credits.

Calculating the number of credits a carbon project generates. To calculate the number of credits a carbon project generates, a *baseline scenario* is required. This scenario acts as the benchmark against which the project's impact is measured. While various methods exist for establishing baselines, they typically entail using *counterfactual* assumptions, which reflect what would have occurred had the project not been implemented. This is referred to as the *business-as-usual scenario* and is predetermined within the methodologies of carbon standard setters (see Box 4.1 for a description of carbon standards). The difference between projected emissions in the business-as-usual scenario and those in the project scenario represents the *project's impact* and, consequently, the number of carbon credits it generates. Figure 4.1 illustrates how project impact is compared with the business-as-usual scenario for avoided or reduced emissions projects, versus conventional and novel CDR projects.

For *projects involving conventional CDR methods*, the project impact represents the additional number of removed tons of CO_2 compared with removal levels in the business-as-usual scenario (e.g. Verra's methodology VM0047 for afforestation, reforestation and revegetation projects).

For *projects involving novel CDR methods*, a baseline value of zero is often assumed, owing to the absence of such projects in the past (e.g. the Puro.earth methodology). The counterfactual reference scenario is subsequently based

on the assumption that these projects would otherwise not be implemented (e.g. for lack of finance). However, as novel CDR projects continue to expand, this approach may undergo re-evaluations to reflect the continual evolution of methodologies for determining business-as-usual scenarios.[99]

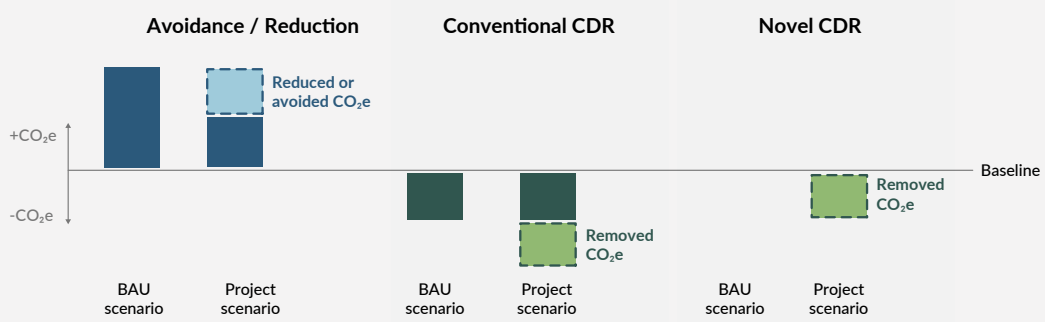

Figure 4.1 *Project impact in emission reduction projects, avoided emissions projects and carbon dioxide removal (CDR) projects on the voluntary carbon market. Avoided and reduced emissions (light blue portion of second bar in first panel: emissions that would have occurred under the business-as-usual (BAU) scenario, shown in first bar). Removed CO_2 via conventional CDR (light green portion of second bar in second panel: emissions removed on top of CDR that would have occurred under BAU scenario, shown in first bar). Removed CO_2 via novel CDR (light green portion of second bar in third panel: CDR that would not have occurred under BAU scenario, shown in first bar). Source: Walsh, forthcoming.*[100]

The like-for-like principle of using CDR credits – aligning the durability of sources with the durability of CDR. Different types of CDR credit may have differing use cases. As an example, the UNFCCC's Race to Zero campaign, among others, endorsed applying the "like-for-like" principle.[101] This principle postulates that CDR strategies must match the nature and permanence of the emissions they aim to neutralize. It posits that CO_2 originating from the long carbon cycle, such as that emitted from fossil fuels, should be sequestered in equally permanent storage (e.g. through direct air carbon capture and storage); emissions from more transient sources, such as from land-use changes or short-lived greenhouse gases, can be offset by CDR involving less durable storage (e.g. through soil carbon sequestration). Applying this principle ensures that CDR efforts align with the specific impact and lifespan of different emission types (see Chapter 1 – Introduction, for further discussion of durability).

Recent concerns about the VCM

After a rapid growth spurt in 2021–2022, the VCM was exposed to significant criticism in 2023. This included articles from *The Guardian* and *Die Zeit*, published in January 2023, which revealed that a study had shown "more than 90% of rainforest carbon credits [on the VCM were] worthless".[102] That criticism mainly related to two issues: first, the use of an inadequate baselining methodology by several REDD+ projects (see Box 4.2 for how baselines are used in VCM projects), which had resulted in an overestimation of the projects' impacts on emissions; second, questions about the additionality of the credits issued (i.e. whether they would have occurred in the absence of carbon

market revenue).[103,104] Projects issuing more credits than they should has also been an issue in energy-related emission reduction projects.[105] Some VCM projects are also heavily criticized for their infringement on, or displacement of, local and Indigenous communities.[106]

These concerns and criticisms have had a tangible impact on buyers' confidence in the VCM and prompted some companies to disengage from the market entirely.[107] The concerns have also led to guidance being issued on the appropriate design of an offsetting portfolio, considering these risks.[13]

Determining quality on the VCM

The increased scrutiny of the integrity of the VCM has triggered calls for better quality control and more consistent regulation. Stakeholders in the VCM have produced various criteria for what constitutes "high-quality" carbon credits. Examples of such criteria include the Core Carbon Principles developed by the Integrity Council for the Voluntary Carbon Market and the Carbon Credit Quality Initiative's carbon credit scoring tool.

While a uniform definition of quality has yet to be established across the market, the following characteristics are most commonly used as proxies for quality: robust third-party validation and verification; robust quantification of the emission impact; high durability; additionality; and the presence of sustainable development benefits and safeguards (see analysis of 28 key stakeholder documents in Walsh, forthcoming[100]). The absence of a uniform definition of quality may have been detrimental for carbon credit sales from projects with higher environmental integrity and higher attendant price points. While various organizations – from standard setters to agencies that rate the quality of carbon credits – offer guidance and assessments of quality, many are still in the early stages of applying their frameworks to CDR credits.

In parallel, governmental bodies are ramping up efforts to establish clear standards for activities on the VCM. For example, the EU Carbon Removal Certification Framework is emerging as a voluntary framework for the certification of CDR activities. The framework defines the fundamental principles and prerequisites for certification bodies to monitor, report and verify CDR generated in Europe (see Chapter 10 – Monitoring, reporting and verification). This is based on the quality criteria defined in the EU's framework.[108] Despite several shortcomings in this framework, it can be expected to become a crucial guideline in the further development of CDR activities.

The growing importance of co-benefits

To successfully scale up CDR methods within the VCM, it will be important to gain a solid understanding of the indirect environmental and social impacts of individual CDR methods and to promote these co-benefits to buyers. CDR activities are first and foremost valued for their ability to capture CO_2 from the atmosphere and durably store it (see Chapter 1 – Introduction, for a definition of durability). But if their full potential is to be accurately assessed, their broader impact on the world also needs also be considered. Deploying CDR, especially at a large scale, can produce various environmental and socioeconomic side effects, which can be beneficial or disadvantageous to third parties (see Chapter 8 – Paris-consistent CDR scenarios).

The extent to which CDR activities trigger intended or unintended effects depends on factors such as the type of CDR, the regional and site-specific context and, importantly, the way in which the activities are governed. Measures to oversee these are commonly referred to as *sustainable development benefits and safeguards*.[109] Several authors have examined these effects in more depth, but those studies differ in underlying context and assessment framework, resulting in diverging conclusions.[110–114]

In recent years, public interest has extended beyond merely considering the direct environmental impact of CDR in favour of a broader assessment of its implications. The main carbon credit standards have produced different frameworks to better outline a project's individual contribution to sustainable development.[91] Assessments show that projects with additional co-benefits can attract higher price premiums.[115–117] Further, different stakeholders across the market have developed guidelines or set clear recommendations for buyers that consider the broader impact of carbon projects.[91] In 2023, for example, the Science Based Targets initiative launched its first framework for companies to set biodiversity targets alongside their decarbonization ambitions.[118]

These developments can be expected to further prompt buyers to factor in the presence of social and environmental co-benefits in their decision-making processes. To successfully scale up CDR methods within the VCM, it will therefore be important to gain a solid understanding of the indirect environmental and social impacts of individual CDR methods and to promote these co-benefits to buyers. To inform such decision-making, systems for monitoring, reporting and verification need to be broadened to include the non-carbon impacts of CDR activities (see Chapter 10 – Monitoring, reporting and verification).

Understanding the demand for CDR credits

A systematic understanding of the factors that drive demand for different types of carbon credit on the VCM is currently missing. Initial surveys indicate that many buyers consider quality aspects within their purchasing decision and that buyers already engaging in the CDR market are predominantly motivated by their ability to support the early development of CDR (see Section 4.3 for further profiling of existing buyers).[117,119]

Despite there being no uniformly applied definition of "high quality" when it comes to carbon credits, the increasing public scrutiny of the VCM and the growing engagement of regulatory bodies appears to have motivated buyers to shift towards higher-quality credits.[120] Other independent guidance has also been released, such as the Oxford Principles for Net Zero Aligned Carbon Offsetting,[13] the ISO Net Zero Guidelines and the Integrity Council for the Voluntary Carbon Market's Core Carbon Principles,[109] all of which provide buyers with signals as to what may constitute high-integrity credits and credible claims.

However, the lack of consistency in the terms and guidelines used across the VCM still poses challenges for efforts to increase the volume of purchases of CDR credits. Current organizational standards and schemes for ensuring quality in CDR and emission reduction projects have not been deemed sufficiently rigorous by governments – both as buyers and as regulators – resulting in the development of their own monitoring, reporting and verification methodologies (see Chapter 10 – Monitoring, reporting and verification).

The role of the VCM in supporting CDR development

The VCM has been an important, yet insufficient, provider of finance for accelerating the scale-up and deployment of CDR, as will become clear from the data presented in Section 4.2, which demonstrate the low volumes traded. However, novel CDR credits, such as for direct air carbon capture and storage, fetch high prices on the VCM. Its role is rather that of a *niche market*. These exist when early adopters display a higher-than-average willingness to pay for a technology. The high prices that novel CDR credits command in the VCM could be an indicator of this willingness (see Section 4.2).[9] Thus, according to the model of CDR development posited in Chapter 1 (Introduction), the VCM will be most important in the early stages of CDR scale-up as a niche market.

4.2 Current status of CDR within the VCM

Most of the credits generated in the VCM are for avoided emissions or emission reductions, rather than for CDR. Conventional CDR continues to dominate novel CDR in the VCM in absolute terms, despite demand for novel CDR growing more quickly.

Various estimations exist of the size of the overall VCM, as well as of the projects within it. The findings depend on the coverage of the registry from which the data are drawn[121,122] and on the project classification system used. In this report, data for 2022 and 2023 have been aggregated from the six major registries and platforms: Verra, Gold Standard, the American Carbon Registry, CDR.fyi, Puro.earth and Climate Action Reserve. Box 4.3 details the methods used to estimate the current scale and characteristics of CDR within the VCM.

Box 4.3 Methods: Estimating the scale and nature of CDR within the VCM

Source data. Data for the years 2022 and 2023 were aggregated from the six major registries and platforms: Verra, Gold Standard, the American Carbon Registry, CDR.fyi, Puro.earth and Climate Action Reserve.

Classification of projects. As described in Section 4.1, carbon credits that have been generated through CDR are not clearly differentiated within registry data from those generated through emission avoidance or emission reduction. Credits may also originate from projects that employ a mix of these methodologies (see Box 4.2). To get as clear a picture as possible of the status of CDR within the VCM, projects from registries were therefore classified based on the methodology they employ: *emission avoidance*, *emission reduction*, *novel CDR* or *conventional CDR*, in tandem with the categories of *mixed (mainly avoided)* and *mixed (mainly CDR)* (see full classifications in the Chapter 4 Technical Appendix).

The registry data for novel CDR and for conventional CDR are not directly comparable.

Novel CDR. Most of the contracts within the VCM for novel CDR are for future deliveries (meaning the actual CDR will not take place until some months or years later). The mean projected delivery time for novel CDR

purchases in 2023 is three years; multi-year offtake agreements may include purchases where deliveries happen as far as 11 years in the future.[123] In the analysis, data are presented on purchase agreements for future deliveries (pre-purchases with upfront payment, or binding offtake agreements with payment on delivery) to measure demand, as well as for tons already delivered to measure supply.

Conventional CDR. In contrast, for projects involving conventional CDR only the volumes of credits issued and of credits retired are available (see Box 4.1 for definitions). Since there is very little data on potential pre-purchase for conventional CDR, and as offtake agreements are less common for conventional CDR, retirements are used here as an imperfect proxy for credit demand – alongside issuances, which measure supply.

Prevalence of project types within the VCM

The vast majority of projects on the VCM are emission reduction projects (see Figure 4.2). These projects tend to focus on decarbonizing energy or industrial systems. Of the project types that deploy a mix of methodologies (avoided emissions, emission reduction and/or CDR), *mixed (mainly avoided)* emission projects are the most common – and even more common than "pure" *avoided emissions* projects. These *mixed (mainly avoided)* projects include some types of REDD+ and forest management.

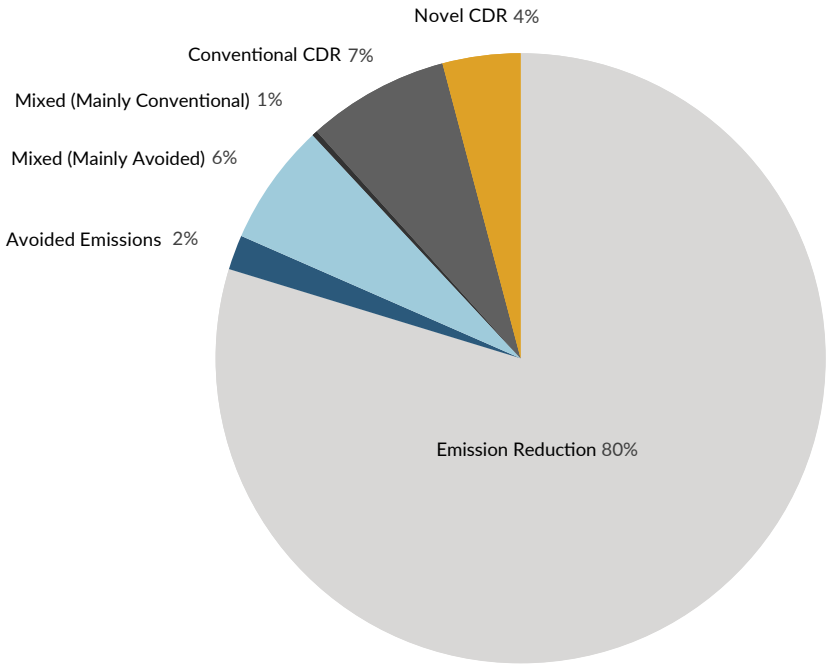

Figure 4.2 *Proportion of projects within the voluntary carbon market, 2022–2023, by project type (based on classification of project methodology). CDR = carbon dioxide removal.*

However, the prevalence of these projects in the carbon market differs considerably once the volume of carbon credits is analysed, instead of the number of projects.

As Figure 4.3 reveals, emission reduction projects dominated the VCM in both 2022 and 2023 in terms of the volume of carbon credits, both supply (measured in tons issued) and demand (measured in tons sold). These projects are followed in volume of carbon credits by avoided emissions projects and conventional CDR projects. Overall, issuances continue to outstrip retirements, resulting in a significant backlog of carbon credits from 2022 and 2023 that remain available to be retired, as well as from years prior.

2023 saw carbon credit supply decrease while demand increased, especially for CDR.

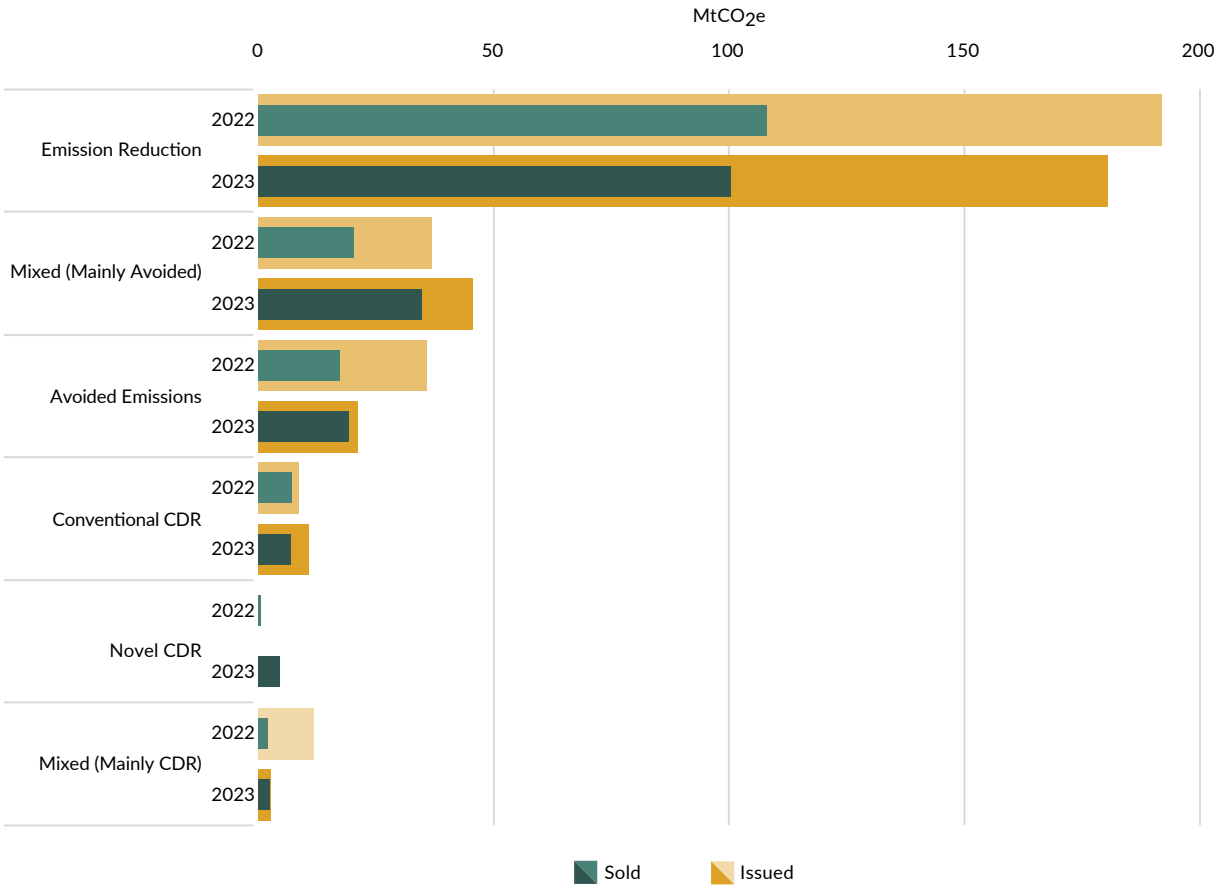

Figure 4.3 *Volume of carbon credits issued and sold on the voluntary carbon market, by project methodology type, 2022–2023. CDR = carbon dioxide removal.*

Table 4.1 breaks down the volume of credits for conventional and novel CDR in 2022 and 2023 (credits issued and sold (retired) in the case of conventional CDR, and credits issued and sold in the case of novel CDR. The results show that the VCM facilitates much more conventional CDR than novel CDR at present.

The total volume of novel CDR credits sold in 2022 – just over half a million tons – appears very small compared with the gigaton scale that may need to be reached in future (see Chapter 9 – The CDR gap). However, there has been vast growth in the VCM in 2023 – a sevenfold increase – led by large purchases by big enterprises. Microsoft, for example, purchased 3.2 $MtCO_2$.

Type of CDR credit	2022	2023
Conventional[a] CDR credits issued	20,360,212	13,255,438
Conventional[a] CDR credits sold (retired)	9,362,211	9,319,439
Novel CDR credits issued	47,905	83,180
Novel CDR credits sold	615,107	4,638,766

[a] *Includes projects that adopt a mixed methodology but are mostly conventional CDR; excludes those that are mostly avoided emissions.*

Table 4.1 *Estimation of carbon dioxide removal (CDR) volumes on the voluntary carbon market, 2022–2023. Issuance exclusively refers to ex post credits traded through the main offset standards. The majority of novel CDR credits are ex ante, meaning that the impact (removal activity) will occur in the future. This table reports issuances from Puro.earth, resulting in a lower volume than the overall novel CDR deliveries shown in Figure 4.4.*

There was also a significant shift in conventional CDR, which shrank in 2023 compared with its 2022 size. Another key difference between conventional and novel CDR is that most conventional CDR occurs without the involvement of carbon markets. Indeed, carbon credits issued for afforestation represent less than 1% of afforestation that occurred in 2023. The carbon market plays a more important role for the deployment of novel CDR, evidenced by the pre-purchase volume in 2023 exceeding the total amount of CO_2 removed through novel CDR methods in the same year (see Table 4.1 and Figure 4.4).

Prevalence of different CDR methods within the VCM

As Figure 4.4 shows, a much larger amount of conventional CDR (top panel) is facilitated by the VCM than novel CDR (bottom panel), the bulk of which is afforestation and reforestation. The figure also shows a surge in novel CDR tons sold between 2022 and 2023, but only a minuscule fraction of these sales has been delivered to date.

Box 4.4 reconciles the numbers on novel CDR in this section with estimates quoted elsewhere in this report.

The VCM facilitates much more conventional CDR than novel CDR at present

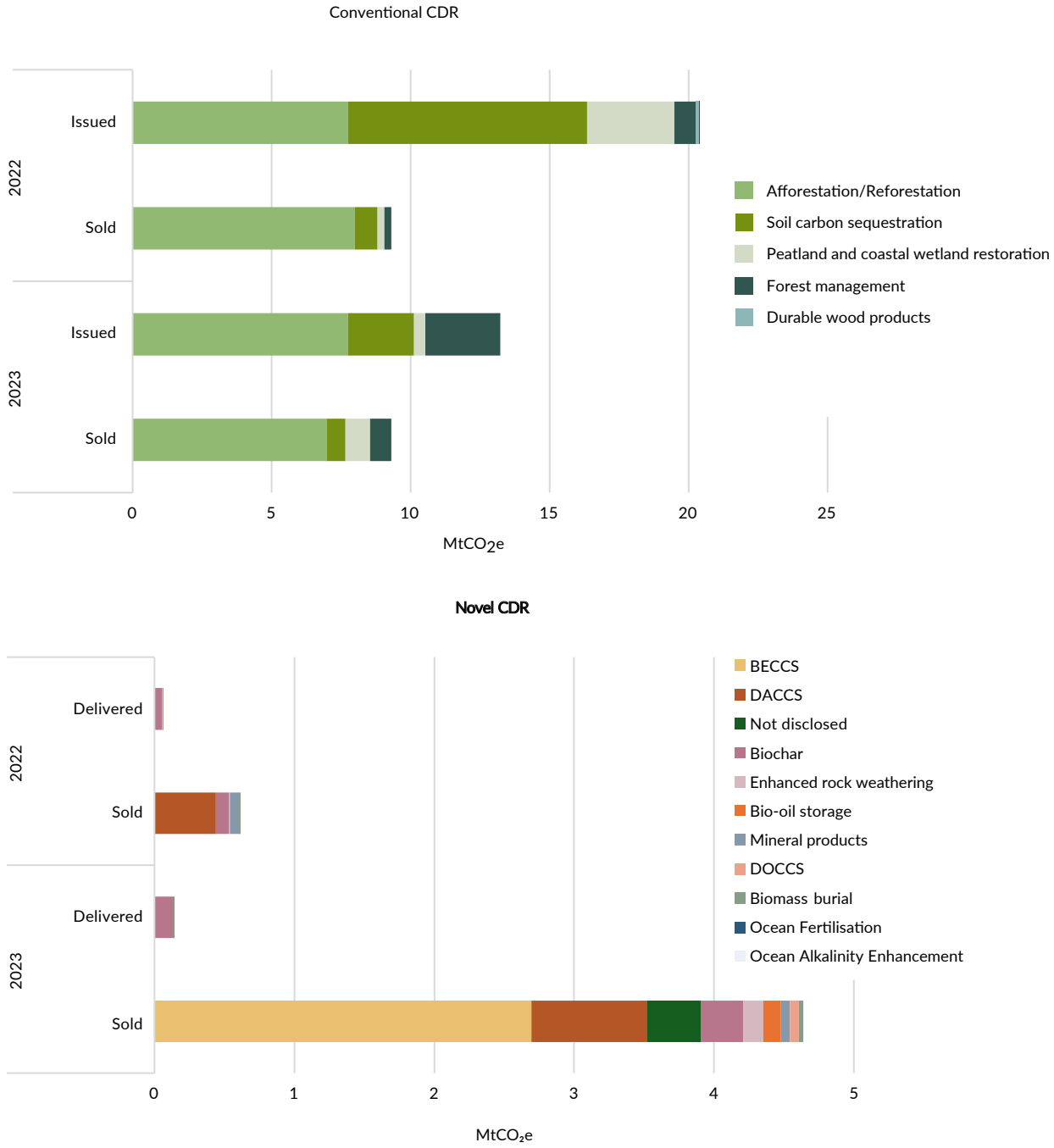

Figure 4.4 *Breakdown of the volume of carbon dioxide removal (CDR) in the voluntary carbon market (VCM) by CDR method, 2022–2023. Top panel: conventional CDR; bottom panel: novel CDR. BECCS = bioenergy with carbon capture and storage; DACCS = direct air carbon capture and storage; DOCCS = direct ocean carbon capture and storage.*

Box 4.4 The difference in estimates of current novel CDR volumes within this report

Chapter 7 (Current levels of CDR) cites 1.35 $MtCO_2$ removed via novel CDR in 2023. This chapter finds that only 139,202 tons were reported in VCM registry data as having been delivered through novel CDR in 2023. This discrepancy stems from the following:

Delivery of novel CDR outside the VCM. Most of the novel CDR by volume is occurring without the generation of associated carbon credits for trading on the VCM. The market data used within this chapter suggest that none of the removal from bioenergy with carbon capture and storage and about 17% of the removal from biochar reported in Chapter 7 were delivered as CDR credits in 2023.

Differences in methodology. Chapter 7 reports gross CDR quantities, meaning the amount of atmospheric CO_2 captured and placed in durable storage, without accounting for any emissions during the whole life cycle of the activity. In contrast, protocols for issuing VCM credits usually include at least some estimation of these emissions. Including these emissions can substantially reduce the net amount of CO_2 removal that can be claimed; for instance, the life cycle emissions of ethanol production together with bioenergy with carbon capture and storage are currently similar to, or even outweigh, the removals.[124] The exact distribution of these emissions between the CDR activity and co-products depends on the choice of allocation method.

Cost of carbon credits within the VCM by CDR method

Table 4.2 shows the prices per carbon credit for different methods of conventional and novel CDR, where the latter are an order of magnitude higher than the former. On average, credits from conventional CDR methods cost three times more than reduction or avoidance credits. The average volume-weighted price for novel CDR credits currently exceeds that of reduction or avoidance credits by a factor of 100.

CDR method	Weighted average price ($)	
	2022	2023
Afforestation/reforestation	12	16
Bioenergy with carbon capture and storage	No data	300
Biochar	212	131
Biomass burial	92	111
Bio-oil storage	600	505
Direct air carbon capture and storage	1,261	715
Direct ocean carbon capture and storage	984	1,402
Enhanced rock weathering	434	371
Forest management	15	12
Mineral products	471	No data
Ocean alkalinity enhancement	No data	1,608
Total	303	488

Table 4.2 *Volume-weighted average price per carbon credit from transactions where the price is known, by carbon dioxide removal (CDR) method, 2022–2023. Durable wood products are not included. Data sources: CDR.fyi, 2024;[123] Ecosystem Marketplace, 2023.[116]*

Geographical distribution of CDR projects within the VCM by project type

Figure 4.5 shows the number of active projects on the VCM that either are CDR projects or have methodologies that allow for CDR (i.e. are mixed), broken down by region/country (top panel). VCM projects with the potential to generate CDR are more prevalent in the northern hemisphere than in the southern hemisphere and are especially concentrated in North America (bottom panel). This distribution of CDR potential in Figure 4.5 is largely due to the sizeable presence of forest management projects in Mexico and the US. Europe has the highest volume of novel CDR projects, which are principally biochar projects.

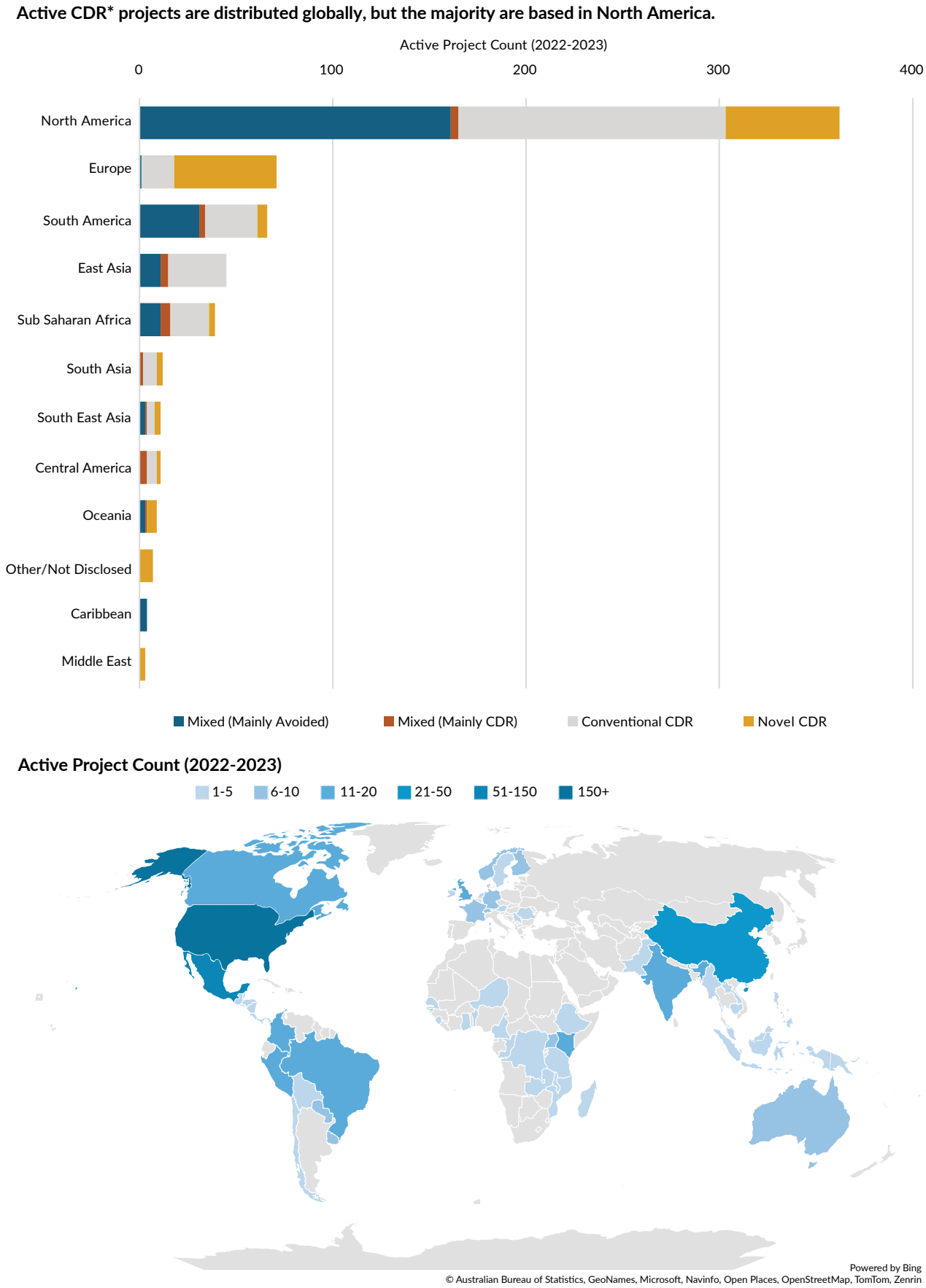

Figure 4.5 *Regional (top) and country distribution (bottom) of active carbon dioxide removal (CDR) projects in the voluntary carbon market, 2022–2023.*[91]

4.3 Future prospects of CDR on the VCM

The voluntary market for novel CDR is growing but uncertain. In the meantime, the VCM is currently leading the way in developing methods for measuring, reporting and verifying CDR projects.

As of the start of 2024, CDR is gaining increasing attention on the VCM at large. This attention has been supported by the development of new standards for novel CDR methods by the main carbon crediting programmes. It has also been promoted by revisions to existing methodologies that facilitate a clearer distinction between different credit types, thus increasing the visibility of CDR (see Box 4.2). But the increase in attention is perhaps most evident in the nascent but growing market for novel CDR, which saw a sevenfold increase in purchases during 2023.[123] This rapid development sets the scene for the analysis of the future prospects for market-based CDR.

CDR purchasers

The first step in understanding future prospects is to map who is driving the demand for CDR today. Because of the high number of credits that are purchased (retired) anonymously,[91] the visibility of corporate buyers in the VCM is patchy, and the way in which they use carbon credits is often opaque.[125] Investigations of buyer profiles and demand analyses can therefore only be regarded as an indication of the true nature of the buyer landscape.

Different assessments of the largest buyers on the VCM suggest that many of them are fossil fuel majors.[116,121,126] Therefore, doubts remain as to whether engagement in the VCM positively impacts actors' decarbonization efforts or whether it occurs alongside (and perhaps even promotes) continued high-emitting behaviours. As a result, it is important to consider not only *whether* actors are buying but also *why* they are buying.
Evidence from surveys of buyers engaging in the VCM (by purchasing reduction, avoidance or removal credits) indicates that purchase of credits is largely driven by the buyers' voluntary climate targets.[127,128] In comparison, CDR.fyi's recent survey of novel CDR buyers showed that these purchasers are driven to engage in the CDR market by their intrinsic motivation to accelerate the scale-up of the industry.[119] Transparency as to the identities of buyers of credits from novel CDR methods is higher than for buyers of conventional CDR credits. An assessment based on the number of unique buyers of novel CDR reveals that more than half of all such buyers (63%) share a background in the financial or service sector and are based in the US.[100]

VCM growth projections

Despite the recent criticism of project practices on the VCM, the volume of credits sold at the start of 2024 surpassed sales from the same period in previous years. This serves as an early indication that the VCM continues to grow.[120] Several predictions have been made of the size of the VCM in 2030 and 2050. Some predictions, such as by Bloomberg NEF, suggest that it could reach $1 trillion by 2050.[128] Other estimates are more conservative, predicting it to reach $100 billion in 2030 and $250 billion by 2050.[129] The Boston Consulting Group (2023)[115] estimates an annual demand of approximately 40–200 $MtCO_2$

for novel CDR in 2030, outstripping the announced supply of approximately 15–32 $MtCO_2$.

A crucial factor in these growth projections is the future price development of different types of credit. CDR, whether conventional or novel, tends to require more capital investment and thus attracts higher price points than credits from avoided or reduced emissions. Because of this, a more nuanced stocktake of investment, rather than an evaluation of credits sold, tends to more accurately capture the increasing willingness of buyers to support CDR projects. While CDR represents only a small portion of the total carbon credits generated through the VCM today (see Section 4.2), this proportion may shift, given parallel signals for greater demand for CDR in the coming years.[130]

Demand-side developments

Several pending developments on the demand side could also affect growth projections for the VCM. One such development is the continued operationalization of Article 6 of the Paris Agreement.[131] Article 6.4, for instance, establishes a new UNFCCC-facilitated mechanism for the validation, verification and issuance of high-quality carbon credits (see Chapter 10 – Monitoring, reporting and verification). However, the mechanism still appears several years away from operationalization, with the removals guidance being one of the most controversial elements of ongoing negotiations among the parties to the convention. As with the broader carbon market, the stringency of the multilateral rules established under Article 6.4 will heavily sway its overall effectiveness as a tool for financing CDR. A breakthrough on this could be instrumental in supporting further demand for CDR.

Another notable development is that several countries, including Colombia and South Africa, have taken steps to integrate carbon credits into compliance markets.[132] While these schemes are not limited to CDR-based credits, an overall shift from the voluntary to the compliance market setting could garner significant funding for CDR. Yet true fungibility – whether different CDR types should be treated as equivalent to emissions trading scheme units or other forms of carbon credit – remains an ongoing contention.

A continued role for markets in supporting the development of CDR

While carbon markets have been a part of the climate change mitigation toolbox for several decades, CDR remains a small part of the VCM. Conventional CDR continues to dominate novel CDR in the VCM in absolute terms, despite demand for novel CDR growing more quickly. As the VCM may not offer enough finance for scaling CDR, depending on how much will be needed, compliance markets will likely play an essential role in driving significant future demand for CDR. But as integration of CDR at scale in compliance markets is still far off, there appears to be a clear and ongoing role for the VCM in driving experimental and additional CDR in the years to come. In this way, the current VCM offers important insights for a transition of CDR into compliance markets – most notably in getting novel CDR methods tried out in practice and in leading the way in developing methods for monitoring, reporting and verifying CDR projects (see *Chapter 10*).

Box 4.5 Limitations and knowledge gaps

This report has identified areas on which future assessments can build, including:

- *Differentiating CDR credits from emission avoidance and emission reduction credits on the VCM:* As the distribution of avoidance, reduction and removal credits for projects remains indiscernible in many cases, the true market size for CDR credits remains unclear.
- *Broadening monitoring, reporting and verification* to capture the non-CO_2 impacts of CDR, which is increasingly gaining importance in buyers' decisions.
- *Developing a strategy for the transition from VCM to compliance markets* to identify the role the VCM will play in scaling CDR in the future.

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