PLOS CLIMATE

REVIEW

International carbon markets for carbon dioxide removal

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Abstract

International carbon markets are potentially a very powerful tool for mobilizing carbon dioxide removal in line with Paris Agreement ambitions to limit global warming to well below 2˚C. This requires reaching global net-zero emissions between 2050 and 2070. Yet, carbon market regulators have not approached removals in a systematic manner. This review assesses the highly fragmented treatment of removals under compliance and voluntary carbon markets, including baseline, credit and cap-and-trade systems. The Kyoto mechanisms and the large voluntary carbon market standards have long focussed on biological removals without inherent storage permanence and only recently started to develop methodologies for removals with geological storage, mineralization or biochar. Driven by high prices for credits from emerging removal technologies and advance market commitment initiatives targeting high permanence removals, various newcomers in voluntary markets are currently establishing their own approaches for generating removal credits. However, they disregard key concepts safeguarding market quality such as additionality, which risks triggering scandals and tainting the entire market for removal credits. Given the diversity of credit prices spanning three orders of magnitude from 1 to 1000, as well as of volumes ranging from a few hundred to tens of millions of credits, the current "gold rush" atmosphere of removal markets needs to quickly be replaced by a coordinated approach, ensuring credibility, and enabling removals to play the required role in reaching global net zero.

Introduction

The role of international carbon markets in international climate policy

Climate change mitigation is a global public good, as the physical effect is independent from the location in which efforts are undertaken. Thus, international carbon markets can improve efficiency as well as global distributive justice implications of net-zero targets [1], including the mobilization of carbon dioxide removal (CDR) [2]. Neoclassical economists have called for a worldwide carbon market with a global cap and single price that should serve as the only mitigation policy instrument [3,4], but Grubb [5] convincingly showed that a carbon market cannot mobilize technologies at early stages as carbon price signals fail to harness deep innovation

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and overcome the "valley of death" wherein technologies often fail before reaching "critical mass".

Hybrid bottom-up and top-down carbon market approaches have emerged on national, regional, and global levels since the 1990s [6]. They have taken the forms of cap and trade and baseline and credit systems; the former trade allowances, the latter emission credits. The Kyoto Protocol (KP) set the stage for global compliance markets through the three "Kyoto mechanisms" that prospered in the mid-2000s and have issued more than 3 billion credits [7,8]. However, NGOs and researchers after 2009 criticized various aspects of the Kyoto mechanisms, which led to a collapse of credit demand by governments. The newly emerging markets under Article 6 of the Paris Agreement (PA) show promise but have not fully taken off to date. The voluntary carbon market (VCM) is currently very fashionable but despite a multiplication of prices and volumes since 2019 its issuance volume remains below 1% of global emissions [9,10]. Regional cap and trade systems are flourishing, have reached surprisingly high price levels, and are increasingly indirectly linked through the possibility of using emission credits. Despite a rollercoaster ride depending on government engagement, non-governmental organisation (NGO) criticism and private sector supply and demand, baseline and credit systems have proven to be resilient.

Definition of carbon dioxide removal

CDR is a summary term for "anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products (. . .)" [11]. CDR and removal of other greenhouse gases (GHGs) are a form of climate change mitigation in UN climate governance [12]. Removal methods for other GHGs have been discussed [13,14], but CDR remains the main focus.

CDR is a summary term for a heterogenous group of methods. While differentiation into nature-based–i.e. those involving biological processes such as terrestrial or marine vegetation and organisms vs. technological removals, i.e. those involving non-biological processes such as chemical technologies is appealing, it lacks analytical sharpness and requires contested value judgements [15]. Basing policy on vague categories causes exploitable ambiguity, which is why we use Intergovernmental Panel on Climate Change (IPCC) [11] taxonomy. It distinguishes based on: a) the removal process and b) the inherent timescale of storage (see S1 Table). Despite many national net-zero or net-negative targets and the need to incentivize or mandate CDR given widespread lack of commercial revenues [16], policies to promote CDR are lagging [17].

Mitigation costs of different CDR technologies

CDR methods vary in their maturity, permanence, co-benefits, and cost. For some methods like afforestation and reforestation (A/R) experience is deep, while others like direct air capture with geological storage (DACCS) have just emerged and are at demonstration stage (see Table 1 below). Technology readiness levels (TRL), range from TRL 1 (basic principles observed) to TRL 9 (actual system proven in operational environment) [18]. Several methods with high inherent storage durability are less mature and costlier, yet might hold great cost-reduction potentials through technology learning and scaling associated with large infrastructure. Transportation and storage infrastructures may particularly allow for scale-related efficiency gains (e.g. dedicated ships and pipelines) [19–22]. Their feasibility is intimately tied into local socio-political and legal challenges (including siting and permitting of pipelines and storage sites).

Table 1. Overview of long-term marginal abatement costs of selected removal methods.

Removal method	Average marginal abatement cost estimates in 2050 (USD/tCO_2)	Technology readiness level
Accelerated mineralization	20–130	4–7
Afforestation/Reforestation	0–240	8–9
Bioenergy with carbon capture and storage (BECCS)	15–400	5–8 for carbon capture 5–9 for carbon storage
Biochar	10–345	6–7
Direct air capture and geological storage (DACCS)	100–300	5–6 for carbon capture 5–9 for carbon storage
Enhanced weathering	50–200	3–4
Ocean fertilization	5–500	1–2
Soil carbon sequestration	-45–100	8–9
Wetland / peatland restoration	Uncertain due to insufficient data	8–9

Source: Authors based on assessments and systematic reviews by [11,23,24].

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In contrast to many emission reduction technologies, co-benefits and product-related revenue streams are relevant only for some CDR methods [23,25], mostly land-based biological options. Understanding such revenues is critical for determining additionality–whether an activity would have occurred anyway without dedicated carbon revenues or supporting policies [26]. For example, soil carbon sequestration or biochar may increase yield and reduce fertilizer cost in the medium term [27,28]– though with a multi-year lag [29]. Removal methods without monetized co-benefits, (likely all relying on underground storage), may be automatically considered additional in the absence of carbon revenues or regulation [2].

Average long-term marginal mitigation costs are hard to estimate for CDR, given variability in the above factors. Cost structures and revenues are evolving and interlinked with technology readiness and infrastructure availability. Rapid (co-)learning and scaling of removal methods are likely to reduce costs but require adaptive and tailored policy [25,30].

For some methods mainstream carbon market price levels may remain insufficient for many years; they are currently operating through their initial scaling relying on a combination of public funds, niche VCM credit sales revenue and venture capital. Yet with growing expectations regarding inherent permanence, markets and voluntary funds might remain sufficiently supportive for scaling.

Key methodological issues in carbon markets specific to CDR

Permanence of storage is central for integer demonstration of mitigation results in carbon markets. While its definition might seem straightforward (permanence means that carbon dioxide is durably stored away from the atmosphere [31–33]) its operationalization is challenging. Not all storage comes with inherent physical permanence, and some forms are especially vulnerable–particularly land- (or ocean-)based removals where natural disturbances and human mismanagement activities can cause reversals [34–36]. Some activities even have built-in expiration dates of carbon lock-up including use of timber in construction.

There are several proposals for determining a minimum duration of guaranteed storage with conceptual justifications: Short guaranteed storage periods would be appropriate if marginal damages from climate change remain constant over time or if a backstop technology exists that could cap the abatement cost in the short term [37]. Very long periods would be required if marginal damages increase over time and no backstop technology can be found. Concrete proposed values range from 30 years [38], 55 [39], 1000 [40], or even 10,000 years

[41]. Baseline and credit mechanisms often apply 100-year periods, reflecting for 100-year horizons of global warming potentials. The issue extends as far as to challenge the very understanding of what constitutes a removal (as durable storage is part of its definition).

Practical concerns have also played into discussions: Protecting a forest over 30 years seems reasonably feasible; guaranteeing its protection over 1000 years is virtually impossible for any human institution. Limiting removals to physically permanent storage would on the other hand displace long-standing ecosystem-based removals. Options for dealing with probabilistic reversals include temporary credits that lapse in case of reversal, insurance, or buffer pools. Temporary credits were used under the Clean Development Mechanism (CDM) of the KP (see explanation below). Yet buyers have avoided temporary credits as too uncertain: Less than 1% of CDM credits were temporary [8]. Commercial insurances [42] are used by the American Carbon Registry (ACR): a private insurance agency insures a project and makes other credits available in case of reversal. The third approach is the creation of buffer reserves (used in most voluntary markets): these hold a fixed percentage of credits as they are generated–to be cancelled in case of a reversal. Their percentage is either generally set to a flat contribution to a pooled buffer or established individually based on a project-specific risk assessment [43,44]. Preconditions for these approaches' effectiveness are i) long-term contractual agreements and ii) measurement, reporting and verification (MRV) extending until long after the last credit issuance [31]. This can cause problems when institutions go bankrupt.

Some argue that permanence is not that important given the urgent need to buy time in the near future giving value even to very short-lived carbon storage of a few years [30]. This has given rise to tonne-year accounting, where credits correspond to volumes of carbon captured over a number of years [25,39,45,46]. The choice of equivalence period is crucial: once it is reached, issuance stops. Upon reversals, no further credits are issued. An inappropriate equivalence period cannot be remedied ex post, can give rise to false claims and generates perverse incentives to not maintain the storage reservoir once credits have been issued. Tonne-year accounting was proposed in the early 2000s but has never been really implemented due to these integrity problems, yet it has recently seen renewed attention, see section 4.1 below.

How to account for CDR in national inventories

A key component of many CDR methods– carbon capture and storage (CCS) has been addressed in IPCC guidelines for GHG reporting (mainly for the purpose of emissions reductions). Land-use related sinks have also been a part of GHG inventories since their inception [47]. Changes in net emissions through CCS at point sources are accounted for in the sector in which they are used (energy, industry, or waste) and negative emissions can similarly be achieved therein (when carbon is predominantly of biogenic or atmospheric origin). However, removals have not been systematically addressed in greenhouse gas inventories and IPCC guidelines still contain gaps and ambiguities [48,49]. Ambiguity especially concerns accounting of harvested wood products, which affects CDR results from biomass conversion with CCS at country and sector level (whether biomass is generally deemed as emissions neutral). Extending CCS related guidelines, removal results could similarly be accounted for in the corresponding sector: DACCS in *industry*, biomass-waste incineration in *waste*, and biomass-based power plants in *energy*. Any emissions from storage sites, however, are reported in the energy sector, both for emissions reductions and removals.

Activities relying on biomass processing face the challenge that some biomass sources are associated with upstream emissions, while the general assumption is that biomass is climate-neutral [50]. This affects the credibility of accounting for biomass-reliant removal methods such as biomass-energy use, biomethanation, or waste-incineration with CCS. Furthermore, Parties are free to choose one of several accounting formats for carbon flows embedded in harvested wood products [48]. This becomes especially problematic when such products (e.g. wood pellets) cross national boundaries and the two parties are not using the same accounting approach as this then can result in double counting of removals.

In the case of transboundary transport of CO_2 for storage there is ambiguity as to whether the mitigation outcome is achieved upon capturing CO_2 with intent of storage or solely upon having physically stored the CO_2. The emerging consensus appears to be the former. But it is not clear how the intent for durable storage can be established/demonstrated legally.

CDR in compliance markets to date

Some removal methods have been eligible in compliance markets over the past 20 years. This has been the case mainly in so-called baseline and credit systems where emissions credits are generated through comparing a baseline level of removals with removals achieved by a project or a programme of many activities.

The KP had two baseline and credit mechanisms: the Clean Development Mechanism (CDM) for activities in developing countries and Joint Implementation (JI) for activities in industrialized countries with binding emissions targets. While there was no general discussion on removals as such, the inclusion of both forestry-related removals and CCS was highly contentious. Afforestation and reforestation (A/R) projects were accepted, but would generate credits with a limited lifetime: Either temporary credits, expiring after five years, or long-term credits, expiring after the end of the crediting period of the underlying activity (maximum 60 years). Their use was restricted to 1% of industrialized country targets. While the CDM as a whole saw registration of over 7800 projects and more than 300 programmes of activities, to date only 68 A/R projects and programmes have been registered [8]. The only initiative dedicated to promotion of A/R under the CDM was the World Bank's BioCarbon Fund [50,51]. Less than 1% of the issued credits from the CDM come from A/R activities [8]. Similarly, only two A/R projects were implemented under JI.

These disappointing outcomes are illustrated by a case study [52] of eight A/R CDM projects that found that projects were unable to properly monitor development of carbon stocks, suffered from inequitable distribution of credit revenues, and generated unaccounted leakage. Further reasons are the complexity of baseline and monitoring methodologies, the lengthy registration process, and issues with land tenure [51].

CCS was at first not eligible under the CDM. Saudi Arabia, Brazil, Norway, the European Union (EU), Australia, the United Arab Emirates (UAE) and Kuwait pushed for its inclusion [53], until after six years of negotiations very detailed rules were adopted in 2011 [54,55]. These remain key for guiding CCS under the UNFCCC. The rules defined critical terms like "seepage", the transfer of carbon dioxide from beneath the ground surface or seabed ultimately to the atmosphere or ocean. They specified stringent governance requirements for host countries, covering site selection and characterization, access rights to storage sites, redress for affected entities, and liability. The permanence issue was addressed through a buffer reserve of 5% of credits, which would be allocated to the project developers after 20 years of post-crediting period monitoring showing absence of seepage; liability for reversals would then accrue to the host country. This would also be the case if a project participant was unable to continue the project. However, the CDM market already suffered from a decline in credit prices and thus no single CCS methodology was ever submitted [7,8]; the rules were therefore never applied in practice.

Article 6 of the PA allows for voluntary cooperation between Parties to achieve their national mitigation targets and is expected to become a key instrument for mobilizing removals [56]. Article 6.2 covers cooperative approaches involving the use of internationally transferred mitigation outcomes (ITMOs); Article 6.4 is a multilateral mechanism for mitigation building on the experiences of CDM and JI; and Article 6.8 covers non-market approaches. At the 26th session of the Conference of Parties (COP26), parties agreed on the specific provisions to govern these approaches. Technical negotiations on issues such as detailed reporting requirements, operationalizing the Article 6.4 mechanism registry, or the crediting period for removal activities are continuing.

Article 6 rules cover emission reductions and removals generated from 2021 onwards. Specific requirements for removals include "appropriate monitoring, reporting, accounting for removals and crediting periods, addressing reversals, avoidance of leakage, and avoidance of other negative environmental and social impacts" [57]. These requirements are particularly relevant for land-based biological activities due to the complexity of their socio-economic-environmental dimensions and their large spatial needs. Discussions for the spectrum of removal activities eligible under Article 6.4 have already started [58]; "conservation enhancement" of forests will be contentious due to, among others, multiple ecosystem services and interests related to the land-use and the low permanence of biomass-based solutions [59,60]. Furthermore, experience with REDD+, which includes conservation enhancement, raises questions regarding related projects meeting Article 6 requirements [61]. Piloting of Article 6 is underway [62], but Switzerland which is a pioneer excludes biological removals.

There have been several instances of (sub-)national market frameworks accounting for certain CDR activities, which provide useful lessons. The Australian Emissions Reduction Fund (ERF) allows institutions to earn emission credits, including through sequestration in living biomass, dead organic matter, and soil. Projects must guarantee storage for a period of 25 or 100 years [63], which determines the crediting period [64]. Projects with a guarantee period of 25 years receive a discounted credit volume but after the end of that period, there is no further obligation to maintain the project [62]. A 2021 amendment makes CCS (except for DACCS projects or projects involving enhanced oil recovery (EOR), gas or hydrocarbon recovery) eligible [65]. Projects eligible under ERF are prone to risks from draught, heat stress, and increased aridity due [66], indicating that hot, arid areas might not be well suited for biomass- and soil-based CDR methods.

The California Low Carbon Fuel Standard (LCFS) permits a wide range of CCS projects, including DACCS (anywhere in the world) and EOR to generate credits. Unlike the ERF, LCFS requires project monitoring for at least 100 years after injection. Eight to 16.4% of credits feed into a buffer account from which project developers must retire credits in case of any leakage [67]. In 2022, interactions between LCFS and new subsidy schemes triggered a price decline from 200 USD to 68 USD [68]. The example shows that interactions between policy instruments can deter incentives for CDR in compliance markets.

Cap and trade systems

Emission trading systems (ETSs) require emitters to surrender a pre-defined volume of emissions allowances, so removals do not naturally fit this policy instrument. Three possible approaches to incentivizing removals through ETSs exist: i) accepting removal credits instead of allowances, ii) allocating free allowances to installations achieving removals, or iii) using revenue generated through allowance auctions to offer grants for CDR pilot plants. While the EU ETS does not yet explicitly include CDR, it already covers carbon capture, transport by pipelines, and geological storage which are relevant for removals. It includes a requirement to surrender allowances for emissions from these activities [69] and thus monitoring seepage from storage sites is incentivized. Moreover, revenue of allowance auctions is redeployed through the Innovation Fund and out of 17 projects approved by the fund in 2022, four include a CCS component [70]. Rickels et al. [71] discuss how to adjust the current system to explicitly include removals.

The New Zealand ETS explicitly covers the forestry sector, and credits from A/R projects have been allowed both in the Chinese pilot ETSs [72] and the Californian and Regional Greenhouse Gas Initiative (RGGI).

CDR in voluntary carbon markets to date

Voluntary baseline and crediting mechanisms have emerged to satisfy private sector and individual consumer demand for carbon offsetting their emissions. In some ways they complement compliance markets through mobilizing credit demand and covering sectors and activity types sidelined by compliance markets [73,74].

A particular feature of the VCM is stiff competition of privately operated standards which leads to fragmentation [73]. Verra's Verfied Carbon Standard (VCS), Gold Standard (GS), ACR and Climate Action Reserve (CAR) have dominated the VCM in recent years [10,74]. Most of them apply CDM baseline and monitoring methodologies but also develop their own methodologies for mitigation technologies not covered under the CDM [75].

Rapid proliferation of private sector net-zero targets has led to skyrocketing demand for VCM credits since 2019 [74]. Standard providers have developed a suite of eligible project types for numerous kinds of mostly land-based removals. For removal approaches that rely on geological storage, mineralization and for biochar, methodologies are only beginning to emerge [76]. Some approaches such as DACCS, ocean fertilization, enhanced weathering or mineralization in recycling cement have not at all been addressed by mainstream VCM standards to date [77–79].

Standards for land- and ocean-based biological removals

Several voluntary standards address land-based removals. Potential uptake of carbon in land-based mitigation projects has sometimes been mixed up with emissions reductions in the context of avoided deforestation [79]. A/R, the most widely used project category faces various challenges notably regarding their lack of inherent permanence [80–83]. A/R is the main carbon removal project type in the VCM by volume and is eligible under all major standards. Verra's VCS addressed the project type by several methodologies (see S2 Table).

"Blue carbon" projects, i.e. activities that remove carbon through coastal and marine vegetation like mangrove and seagrass forests, can currently be developed under Verra's VCS. These project types are starting to gain momentum, as scientific evidence on the potential of carbon removal of these sites (e.g., mangroves) continues to emerge, and other standards such as the GS are also currently in the process of developing new methodologies [84–86]. In recent years, substantial advancements in monitoring technologies have allowed using satellite data, remote sensing, and digital reporting technologies toward more fine-grained monitoring and reporting of results of land-based projects, which has been reflected in voluntary carbon market methodologies.

Reducing Emissions from Deforestation and Forest Degradation (REDD+), Improved Forest Management (IFM) and Sustainable Agricultural Management, whose focus has mainly been on reducing emissions, can also encompass removal activities [80]. This is taken into account by some methodologies, such as those of Plan Vivo [87]. Yet they had difficulties in differentiating emission reduction credits from removal credits. ACR is currently developing tools for properly differentiating and labelling IFM removal and emission reduction credits [88]. Many standards apply a buffer reserve approach to address the permanence problem

[81]. The share of credits placed in the reserve varies widely between standards. As for Verra's VCS it is between 10 and 60% [89]. It pools all buffer reserve credits to provide maximum spread of reversal risks. As buffer approaches are increasingly contested, Verra launched a public consultation on tonne-year accounting as a possible alternative to the buffer, but has not further considered the approach [90]. The CAR's Mexico Forest Protocol already applies it [91], and the Quebec draft forestry protocol is considering its use [92].

Emerging high price removal niches in the voluntary market

Three sets of VCM initiatives have emerged to promote the uptake and scaling of removals, some of which achieve credit prices which are much higher than on the rest of the VCM. First, large technology companies such as Microsoft and Stripe as well as financial sector players like SwissRe started looking particularly for removal credits [73]. While most of these firms still rely on conventional emission reduction and non-permanent removal credits for a high share of their credit purchases, they seek to grow the share of inherently durable removal certificates purchased toward their net-zero ambitions. For example, SwissRe wants to buy solely removal credits from 2030 onwards. They purposefully target currently high-cost approaches for their expected cost-reductions and inherent storage durability. They earmarked significant resources for new types of transactions, so-called advance market commitments with fixed price forward contracts running for up to a decade at prices several orders of magnitude above average voluntary credit prices. They even commit to purchasing all removals that individual projects manage to generate up to a specific limit. This points to a price differentiation in favour of CDR with durable storage, which might be adopted more widely among actors that do not prioritize costs over quality and as the price-point of such certificates can gradually be lowered. Second, incumbent standards like Verra or GS have started removal-specific initiatives [80,93]. Verra has announced reduction- and removal-specific labels at their registry level [94]. To develop the necessary project-level methodologies with a high level of environmental integrity, stakeholder groups like the CCS+ Initiative or the Hydrogen for NetZero Initiative were set up that collected funding internally and hired world class methodology experts. Third, a whole ecosystem of removal-specific private standards and marketplaces has emerged. In this ecosystem, some private companies combine the functions of standard, credit supplier and marketplace. This is problematic as such companies have incentives to favour maximizing credit volumes and revenues over ensuring environmental integrity of the system. The company Puro. Earth, a spinoff of the Finnish utility Fortum, has developed its own set of methodologies for biochar, carbonated building materials, bio-based construction materials, and geologically stored carbon [95]. The US company Nori is applying a similar approach for soil carbon sequestration [96]. While both companies gained considerable attention as pioneers in this sphere, their methodological approaches have been criticised for lack of transparency and inadequate additionality assessment as well as definition of system boundaries [49].

Conclusions

Apart from A/R, CDR has played a limited role in international carbon markets to date. Only since 2019, high price niches in the VCM have developed. With the long-term goal of the Paris Agreement and the proliferation of corporate net zero targets, the attractiveness of CDR credits has increased. Some observers even claim that in a relatively short period international carbon markets will be limited to CDR credits, as is already envisaged by key voluntary carbon market initiatives [71,97].

Stringent approaches to permanence remain unattractive

Ensuring permanence is the elephant in the room for CDR (see the respective discussion in the key methodological issues section). The most stringent approach–temporary credits–has not worked under the CDM as demand was lacking. Voluntary markets have generally applied buffer reserves at varying percentages. Verra's global buffer reduced risks. However, it remains unclear how MRV and buffer administration can be ensured over many decades or beyond a century by private actors, given that their average lifespan is much lower. Could tonne-year accounting come to the rescue? Probably not, unless the equivalence period is chosen very conservatively. There is no overall convincing solution in sight and it can be feared that the first massive reversal will lead to a strong backlash against the involved CDR categories. CDR with inherent safe storage, such as basaltic mineralisation will thus have an advantage.

Different market tranches for technologies with different cost levels?

Credit prices of CDR methods under the VCM range between single USD levels for A/R credits and several thousand USD for DACCS, as shown in Fig 1. However, high price niches are very small and their growth path remains uncertain.

Compliance market regulators may design different classes of removal markets to also accommodate more expensive and more permanent solutions. The challenge will be to generate demand for these expensive classes (see Figs 2 and 3 below).

25 years from now: Will international carbon markets be restricted to CDR?

If CDR proponents have been able to approach international carbon markets in a credible fashion, CDR credits with inherently permanent storage will dominate the high end of international carbon markets in 2050. If sufficiently stringent approaches to setting of baselines, like

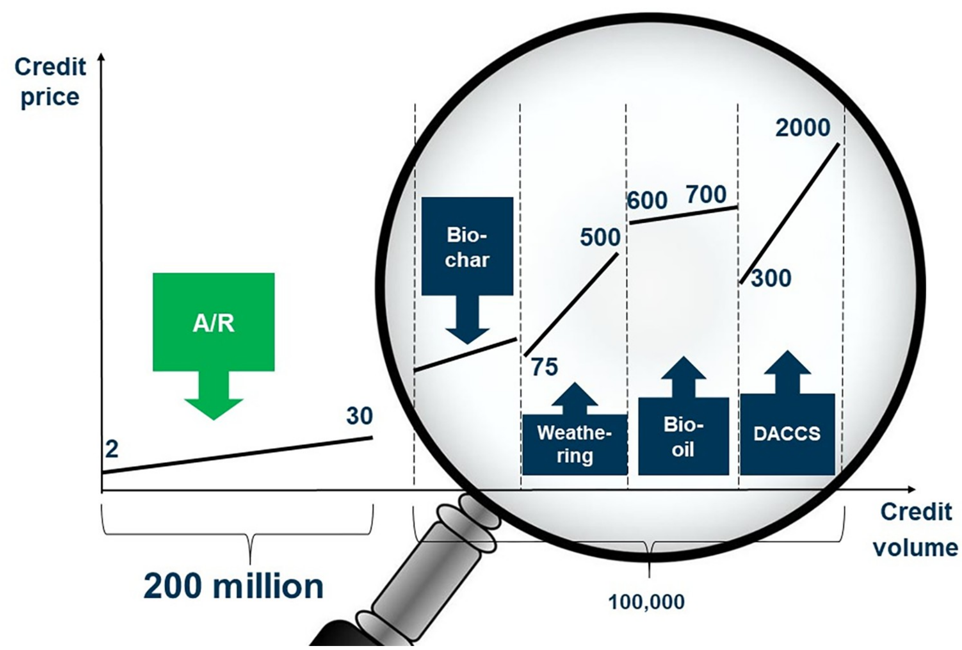

Fig 1. Current removal tranches on the VCM. Data sources: A/R volume (cumulative issuances 2015–2022): [10], other CDR prices and volumes: [98].

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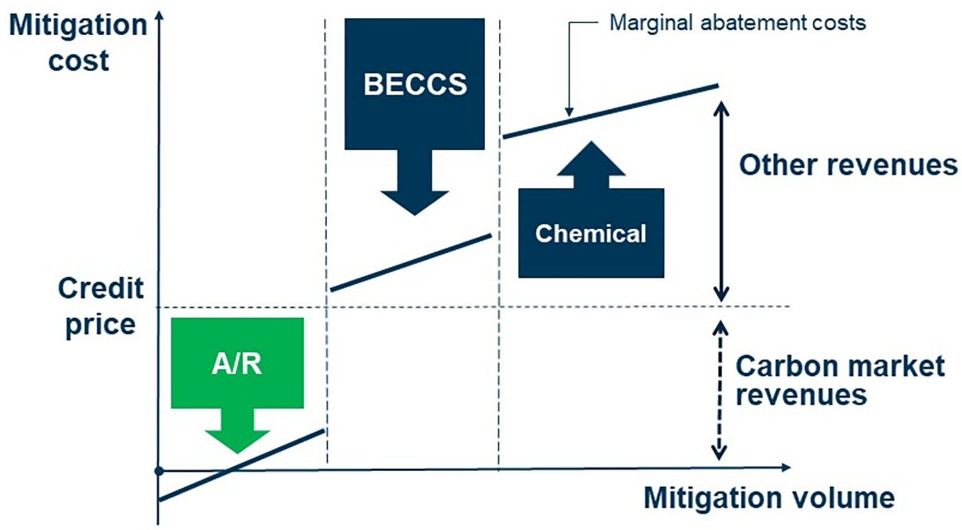

Fig 2. Covering removals in international carbon markets: A common market for all kinds of removals and reductions.

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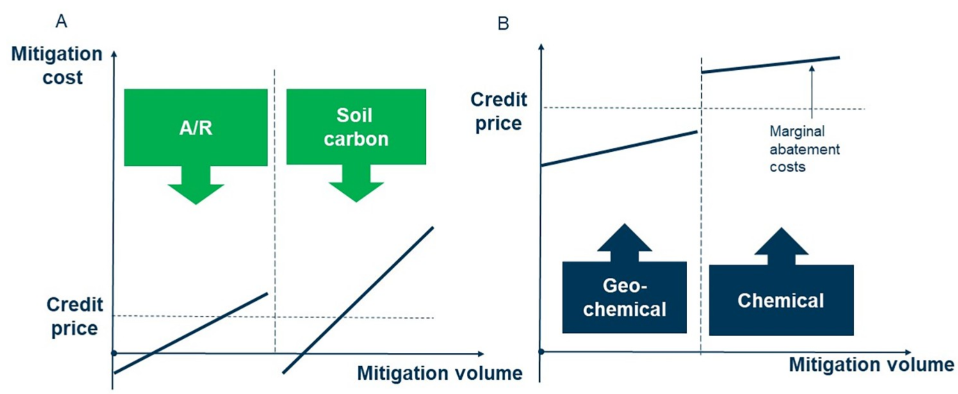

Fig 3. Covering removals in international carbon markets: Differentiated markets for biological (Fig 3A) and (geo) chemical removals (Fig 3B).

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the use of linearly declining ambition coefficients [99], and determination of additionality of emission reduction activities have been agreed, these will still play a relevant role, particularly if coming from activities in least developed countries.

Supporting information

S1 Table. Carbon removal taxonomy.
(PDF)

S2 Table. Land-based biological removal methodologies from the key VCM standards.
(PDF)

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