CARBON MARKET WATCH

The bare necessities: essential principles to design sensible carbon removal policies

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SUMMARY

Carbon removals are necessary to reach climate neutrality and net-negative emissions. However, they **must play second fiddle to emission reductions** and be implemented **sustainably**. The increasing political, scientific and corporate interest in CDR has resulted in various approaches being implemented (or theorised) in various jurisdictions, or in voluntary schemes that aim to scale up investments and foster innovation in the sector.

This paper reviews a variety of those regulatory (including emissions trading systems, tax incentives and public direct subsidies) and voluntary approaches, and, building upon failures, promising concepts and lessons learned from the reviewed frameworks, sketches a blueprint for sensible CDR policy design.

All assessed governance systems for removals fail to satisfactorily respect key environmental concerns. The greatest shortcoming is allowing or even encouraging mitigation deterrence - the use of offsetting mechanisms is widespread across both regulatory and voluntary approaches. Emissions and removals are not equivalent, and should not be approached as such in any policy framework. Furthermore, many frameworks unsatisfactorily differentiate between temporary or vulnerable sequestration, and permanent removals.

Blueprint for sensible carbon removal policy design

Fundamentally, both public and private sector support to CDR should be based on a sound definition of carbon dioxide removals (CDR) and robust monitoring, reporting and verification (MRV).

In the short term, room for trial and error may be necessary. But several overarching principles should be respected to ensure 'trial and error' does not lead to real damage - to the climate or to other social and environmental priorities. Therefore three principles should be at the heart of any CDR policy system to minimise mitigation deterrence and ensure sustainable removals supplement emission reductions: the **precautionary and 'Do No Significant Harm' principles, and the primacy of emissions reductions.**

These fundamental guidelines can be operationalised by **separating emissions and removals**, including in targets and carbon markets. There should be no room for offsetting.

Inclusion of removals in carbon markets is considered by many as the best road ahead, but it is an inherently flawed approach that does not aid the fight against climate breakdown. Depending on how it is done, it can result in either mitigation deterrence if

bargain-priced units (usually low quality with potential major sustainability concerns) are introduced, or a lack of demand or support for removal methods with higher environmental integrity.

There is no 'silver bullet' removal method that promises environmental integrity, affordability, scalability and permanence of storage. **This hard truth must lie at the basis of removal policies**.

In the long term, meaningful and sustainable long term climate policy frameworks should aim to reach **climate neutrality as soon as possible with residual emissions as low as can be realistically achieved** (to limit the reliance on CDR as sustainable removals must be assumed to stay scarce and expensive), and **enable deep and sustained net-negative emissions**.

Climate neutrality entails removals balancing out the last remaining residual greenhouse gas emissions that are deemed too important to society or too difficult to abate. This balancing act **should be done at the economy or society leve**l, rather than be considered an imperative for individual companies or sectors to be given access to removals to balance their own emissions. **Polluters must remain focused on their emissions** and be subjected to meaningful carbon pricing mechanisms, rather than look to offsetting mechanisms.

In addition, any policy framework should be geared towards deep net-negative emissions as soon as possible to deal with any temperature overshoot and to start repairing the damage humans have done to the atmosphere.

For both those goals, reducing emissions still plays the central role, continuing far into the second half of this century, and determining how much removals will be needed.

In the EU, the first opportunity to set a long term vision that encapsulates the complementary role of removals and the primacy of emission reductions is during the **2040 target setting process** and then implementing that new target across the EU climate policy architecture. **Policymakers should take heed of the bare necessities. This is an opportunity that must not be squandered**.

INTRODUCTION

Why do we need CDR and at what scale

Drastically reducing emissions is the most important political, social and environmental priority to limit the severity and impacts of the ongoing climate breakdown. In addition to urgent, deep and sustained decarbonisation, the removal of CO2 from the atmosphere and its permanent storage (so-called Carbon Dioxide Removal, CDR) will be required for countries and the globe to reach climate neutrality and a net-negative emissions future thereafter. CDR will be needed to balance out the very last emissions that are too expensive or deemed too important by society to cut (so-called hard- or impossible-to-abate residual emissions) and to actively reduce the concentration of greenhouse gases in the atmosphere.

Reaching net-negative emissions will likely be necessary as current day emission reductions measures are insufficient to restrict global heating to 1.5°C, and overshooting this important geophysical threshold is a real danger. Both carbon removals functions, however, can only be meaningfully executed if levels of residual emissions are depressed enough - there are significant limitations to a sustainable scaling up of removals.

The Intergovernmental Panel on Climate Change (IPCC) has stated that CDR will be "unavoidable" to even reach net-zero emissions, but there is less certainty over the estimated amount that will be needed. A key determinant of required CDR volumes is the speed and depth of emission reductions in the first half of the century - which further underlines the priority that should be given to emission reductions. The IPCC's 2022 Working Group 3 report models that, on average, to limit global warming to 1.5°C by 2100, around 3 GtCO2 per year of permanent removals will be required by 2050 and 10 GtCO2 per year by 2100. The IPCC modelling, however, likely presents a severe overestimation of the potential sustainable scale of removals, as it doesn't sufficiently take potential limitations into account. Bergman and Rinberg (2021) have lower estimates, ranging between 1.5 and 3.1 GtCO2 per year around 2050 and plateauing thereafter until 2100, to offset just the hardest-to-abate emissions.

What is CDR?

CDR should have an important but limited and separate role in strategies and policy measures to mitigate global warming. Limiting CDR to a supplementary function is, however, not enough. To avoid undermining climate action, we need to make sure that only 'real removals' are used to balance out our residual emissions. Real CDR are those processes that extract CO2 from the atmosphere and store it in a manner intended to be permanent, with the carbon taken out of the air outweighing the emissions linked to the removal process, as set out by Tanzer and Ramirez (2019). CO2 can be considered permanently stored only when it is put away as long as the significant percentages of CO2 emissions last in the atmosphere (up to 25%), that is up to 1,000 years. At the very minimum, the bar for storage with significant climate benefits is several centuries.

Labelling short term or highly vulnerable storage as a removal entails considerable risks. Balancing out residual emissions with storage that could only last years to decades would need ironclad liability mechanisms and robust MRV - both are complex and expensive whilst shifting responsibility to future generations. In addition, they are currently not in place and significant political will is required to implement them.

In addition, the complexity of CDR methods and their potential negative environmental and social repercussions (related to, for example, land usage, the uses and sources of energy, the rights of local communities, land grabbing, and human health) requires robust governance frameworks with accurate measurement, reporting and verification (MRV) methodologies, and rigorous certification and quality criteria (including on additionality, quantification, environmental and social sustainability) to be respected.

CDR is not equivalent to emission reductions. This false equivalency ("a tonne is a tonne") is often used to justify compensation-based offsetting and its linked climate-neutrality or net-zero claims. One tonne removed - now or in the future - means that a tonne can supposedly be emitted without impact on the climate. This assumption is scientifically incorrect and morally ambiguous. A tonne of CO2 removed may have up to 10% less impact on the climate than a tonne emitted due to interaction with land and ocean carbon stocks. In addition, most impacts of emissions and the climate emergency itself (such as rising sea levels, destruction and damage to ecosystems and/or human societies, such as health

impacts, or tipping points) cannot be dealt with or undone through removals. Finally, removals are an inherently weaker form of climate mitigation compared to emission reductions: each emission that doesn't happen will permanently stay out of the atmosphere, as geological reserves of fossil fuels are carbon stores that are safe and stable (if humans do not interfere of course), while removal processes demands sustainable operation and permanence of storage with continued MRV for leaks. There are potential exemptions to this rule, potentially removal methods that lead to rapid mineralisation, but these play a minor role in the current removal scene.

CDR deployment so far

Even though interest in CDR is increasing,a truly comprehensive governance framework for CDR does not currently exist in the world. Many countries and companies are making net-zero pledges or claims that are either partially or fully based on CDR. Despite the rising enthusiasm in the field – often based on an attempt to avoid and delay much needed emissions cuts – today, high-quality carbon removal generating projects are extremely scarce. With high-quality carbon removal we mean methods that deliver real removals in an environmentally and socially sustainable way. This means that they remove the CO2 directly from the atmosphere and store it permanently (meaning from several centuries to millennia) with a net-negative emissions balance and by positively contributing to environmental and social protection.

According to an estimation presented in 'The State of the Carbon Dioxide Removal' report, the amount of all carbon being extracted from the atmosphere occurring today (including short term and vulnerable storage) – roughly 2 GtCO2 per year – is almost all (99.9%) land-based, primarily based on afforestation and reforestation projects. The removal and storage of CO2 through vegetation and soils has many constraints (including its vulnerability to natural and human disturbances; the long period it takes to deliver actual removals; and its difficulty to monitor and verify) and, as mentioned above, should not necessarily always be considered real CDR.

Novel CDR technologies (such as Bioenergy with Carbon Capture and Storage, biochar and Direct Air Capture and Storage), which are, overall, more reliable at least in terms of

permanence (but not necessarily in terms of sustainability), represents only 0.002 GtCO2, very far from the potentially multi-gigatonne scale we might need globally to deal with residual emissions in the not too distant future.

Current CDR approaches to incentivise removals

At present, various approaches to incentivise removals, foster technology development and initiate the expansion of this small sector are employed or under discussion by countries, regions and private actors - with varying quality and environmental effectiveness. These include regulatory mechanisms, such as the incorporation of CDR-based carbon credits or offsets in emissions trading systems, or public support such as tax incentives and direct subsidies. Voluntary approaches have also been tested or implemented to generate funding for removals and increasing the land sink.

On the land-based carbon sequestration side, Voluntary Carbon Markets (VCM) have historically turned over significant volumes of carbon offsets. Forestry and land-use credits are the largest type of offset registered and/or issued by the five largest VCM registries and standards. While forest and land-use based credits represent approximately 40% of the total issued by those five registries, only a fraction of those credits are solely focused on removals, and the vast majority supposedly deliver emission reductions, or activities that combine reducing emissions with increasing carbon sequestration on or in land. While the focus of the VCM remains on non-permanent land-based removals, there has been a rapid scale up of more permanent CDR recently. A total of 4.8 million tonnes of 100+ year permanence CDR have been purchased since 2020 (although only 2.4% has been actually delivered, mostly biochar with questionable permanence). Of this amount, 3.4 million tonnes were purchased in the first half of 2023, soaring from the 609.7 thousands of the full year 2022.

In this paper, we analyse a few currently implemented or proposed types of both regulatory and voluntary categories. Examples of currently active or proposed schemes are used to illustrate current thinking among policymakers and other stakeholders on CDR policy. Examples are selected according to their prominence in policy discussions, their

real-world importance or their maturity. In addition, for the regulatory examples we built upon previous work assessing 20 global, EU, national and subnational case studies.

We draw conclusions on the suitability of the various types of CDR schemes for supporting removals in a sustainable and environmental manner. In the final section, these conclusions are used to sketch a blueprint of what a satisfactory policy framework should include.

1. An overview of regulatory approaches for CDR

This section provides an overview of regulatory approaches for CDR that either exist, or are being discussed by policymakers and other stakeholders. It is not meant as a comprehensive overview of all possible CDR policies, but rather to show the variety and complexity of such systems, including major drawbacks or advantages that must be kept in mind.

1.1. Emissions trading or cap-and-trade systems

In a cap-and-trade scheme, the most prevalent of which are emission trading schemes (ETS), an upper limit or cap on emissions is set. Covered entities need to surrender pollution permits (often called “allowances”) to cover their emissions. Covered entities can usually acquire allowances through various means, including receiving them for free, buying directly from the regulator (at auctions) or through trade with other actors.

ETSs could play a role in delivering removals in three different ways.

Direct and limitless inclusion of CDR in an ETS

The first method corresponds to the direct and limitless inclusion of removal credits in the system, which can be surrendered for compliance purposes by entities to “offset”

(compensate for). The lack of limits would mean that the market itself will determine how much of which removal types is procured by ETS compliant installations.

Directly including carbon removals in an ETS without differentiating them from emissions reduction units is highly problematic for several reasons. Primarily, the existence of only one type of unit for emissions and removals is based on a false equivalency between removals and emission reductions.

This false equivalency slows down polluters' efforts to reduce their emissions, as they can buy carbon sequestration-based units to get out of their reduction obligations, without actually reducing the amount of carbon they pump into the atmosphere. Economic logic would dictate that the cheapest option available be used by compliance actors under the ETS: reduce emissions or buy offsets. The cheapest, and therefore most attractive from a financial perspective, are likely the lowest quality units. This risk is most prevalent if units representing land sequestration are allowed in, the inclusion of more expensive removals (such as DACS) are unlikely to lead to significant mitigation deterrence.

Allowing for the compensation of emissions with land-based carbon sequestration is also dubious because of the very different permanence timeframes of the two activities: emissions will stay in the atmosphere forever, while carbon sequestered by, for example, trees can be released back into the atmosphere very quickly, due to human and natural disturbances.

Direct inclusion of removals in an ETS and allowing their use to offset emissions may significantly undermine the aim of an ETS: reducing, and eventually eliminating, emissions.

Conditional or limited inclusion

A second option is to include a "conditional supply" of carbon removal credits into the ETS. These conditions or limits could take many forms - quantities or types of removals, but also the timing of release of CDR units into the ETS. The New Zealand ETS, introduced in 2008, allows for CDR to be used for compliance, but limited to only forestry credits. Eligible forest owners (i.e. owners of post-1989 planted forests, considered new or 'additional' carbon sinks compared to pre-1990 forests) can voluntarily enter the market and earn New

Zealand emissions units (NZUs) thanks to the absorption of CO2 by trees. These carbon sequestration-based NZUs earned by foresters can be sold to polluters who, in turn, can surrender them for compliance purposes.

A very different type of condition inclusion relates to the quantity and timing of bringing CDR units into an ETS. This idea has been set out by Rickels et al. (2022), and suggest removal credits could be generated for the EU ETS through, for example, methods like Direct Air carbon Capture and Storage (DACS) or Bioenergy with Carbon Capture and Storage (BECCS). A stock of such units would be built up, and released into the EU ETS when certain conditions are deemed met by the regulator - the main objective for the authors would be price containment, or as the authors put it "organize price stability".

This "limited inclusion" approach would avoid the direct exchange of credits between the buyers, which are the emitting companies under the EU ETS, and the suppliers, or the carbon removal companies, during an initial phase. Organising the supply of the credits would be assigned, instead, to a regulator. Which, according to the aforementioned proposal, could take the form of a "carbon central bank".

Such a bank would manage advanced purchases and the reserve of removal credits, to support removal providers of those methods that are currently not mature or economically viable (such as DACS and BECCS), via, for example, technology-specific tenders funded through the ETS revenues. As per the authors' perspective, the bank could also address leakage and non-permanence issues of carbon removal methods. In this way, the authors think that carbon removal would be procured, converted into a corresponding number of credits and a portion of it could be auctioned to the market at a later stage, provided that the market prices exceed a certain ('dynamic' in the words of the authors) price cap. This approach would both help the EU ETS transition from a positive to a net-negative emissions trading system and stabilise the price cap without introducing additional emissions allowances, thereby keeping net emissions unchanged.

This suggestion is risky for a number of reasons. First, it still turns the ETS into an offsetting scheme. The intention of an ETS is not to create a net zero market, but to abate emissions and minimise the residual ones as much as possible. It can create mitigation deterrence by signalling to compliance actors that there will be removals they can use in the future to

offset emissions - stalling decarbonisation efforts in a context where there is no time to waste in tackling the climate crisis. Furthermore, it effectively inflates the gross emissions cap: more emissions are allowed to happen under such a system.

Introducing a price cap is a political decision - the functioning of the carbon central bank would necessarily be subject to political interference, and it would de facto become a price-containment mechanism. It is important to note that when EU ETS prices were low, regulators and many market actors refused to seriously consider the implementation of a price floor. High ETS prices are necessary to maintain pressure on reducing residual emissions as deeply as possible. By setting a maximum price, more expensive abatement options are made unattractive. These abatement options might become cheaper over time as experience and scale increases, but that becomes more difficult if a price ceiling is implemented.

Indirect inclusion: ETS as a funding mechanism

A final, less direct, way to address CDR through the ETS is to use its revenues, based on the polluter pays principle, to fund high-quality carbon removal methods, as mentioned in the "conditional supply" theory commented on previously. But the funded removals would not be integrated into the EU ETS.

This approach would respect the polluter pays principle, incentivise removals through a predictable demand without disincentivising decarbonisation efforts, minimise mitigation deterrence and, ultimately, allow our society to reach negative emissions in a sustainable way. The EU already has an institutional vehicle, the Innovation Fund. Estimated to be worth approximately 40 billion euros over the 2021-2030 period it awards grants in a supposedly technology neutral fashion through project tenders. It has, however, mainly been used to fund CCS projects. CDR-focused tenders could very easily be implemented and set up in relatively short notice.

Using ETS revenues would enable investment in the short term - while direct inclusion would mean that expensive removal options (such as DACS - estimated to cost between 600 and 1000 USD per tonne by 2030) are unattractive. In addition, indirect inclusion could

help society at large reach climate neutrality, rather than just the sectors covered by the ETS if direct inclusion is used. It could be a prime funding mechanism for separate, dedicated and societal-level rather than sector-specific removal targets.

1.2. Existing hybrid regulatory market frameworks including CDR: the Californian LCFS

The Low Carbon Fuel Standard (LCFS), as amended in 2018, allows certain types of CDR projects to generate credits to support compliance with its carbon intensity benchmarks on transport fuels. Provided they meet the requirements specified in the CCS Protocol - including, storing the CO2 for at least 100 years (corresponding to permanence for the regulator California Air Resources Board) and delivering net greenhouse gas emissions reduction after accounting for all emissions associated with the capture, storage and land use change of the project - developers of Direct Air Capture (DAC) and other CCS applications (e.g. ethanol production with CCS) projects can sell credits to fuel providers who need to meet their yearly carbon intensity reduction obligations.

In a similar way to the New Zealand ETS, the inclusion of removals in the LCFS, even if technology-based, allows polluters to offset their continued carbon emissions instead of reducing them, deterring mitigation. Though the focus on more expensive and permanent storage options makes the LCFS less likely to lead to significant mitigation deterrence, especially in the short term.

1.3. Non-market regulatory approaches

Non-market regulatory approaches to policy refers to establishing rules and obligations and using penalties or subsidies to enforce or incentivise compliance. In the EU, the Common Agricultural Policy (CAP) 2023-2027 incentivises carbon sequestration in land and soils through the so-called “conditionality” or “greening requirements”. In practice, all farmers receiving subsidies from the CAP have to respect a basic set of standards (e.g. on

maintenance of permanent grassland, protection of wetland and peatland) or they will receive reduced funding reflecting the number of hectares identified as non-compliant. In reality, the CAP contains many incentives to not implement sustainable agricultural practices.

In a similar vein, the EU Land Use, Land Use Change and Forestry (LULUCF) Regulation obliges member states to balance emissions and removals in the sector until 2025, and to reach specific targets for the contribution of net removals to the EU-wide removal target of -310 Mt of CO2 equivalent.

While aimed at encouraging land-based carbon sequestration, these two EU policies do not comprehensively address CDR as a distinct concept, and they don't provide a robust definition nor put in place a flawless MRV system dedicated to removals. These policies should be used, however, to incentivise good practices in the land sector that enhance biodiversity and encourage ecosystem restoration.

1.4. The Carbon Takeback Obligation

Carbon Takeback Obligation (CTBO) could be deemed to fall in the basket of non-market approaches, but it could also lead to the creation of a market based on tradable carbon storage units. Many different proposals or ideas have been floated as a CTBO - this assessment will skirt through many of the common themes.

A CTBO applies extended producer responsibility (EPR) principle to fossil fuel producers. Its proponents would use the CTBO to oblige companies that extract or import fossil fuels to permanently store an equivalent amount of carbon to what the production and use of the fuels has generated - returning to the geosphere what has been pumped up and emitted. Alternatively, a progressively increasing percentage of CO2 equivalent to what the fuels have generated would be stored, by using a combination of geological storage and nature-based solutions in the near term, and only high permanence geological storage in the longer term.

This would force the fossil fuel industry to support CDR technologies and reach net zero emissions, independent of the geopolitical context, the cost of renewables or fossil energy - factors which could have significant impacts on policies such as carbon taxes or cap-and-trade systems. According to some academics a CTBO could achieve quicker emissions reductions compared to depending solely on a global carbon price, even with conservative cost estimates. Moreover, this approach would be cheaper both per tonne of CO2 generated and in total, due to the accelerated establishment of CO2 storage infrastructure resulting from increased investment certainty.

Ultimately, for the authors, such an approach is focused on stopping the continued use of fossil fuels from resulting in additional emissions, and internalising the cost of pollution from fossil fuels into their production.

While the CTBO seems a reasonable way to support removals by making the fossil fuel industry responsible for its deployment, the approach might have several disadvantages.

It is uncertain that polluters' profits would be severely impacted by the cost of sequestering and storing the CO2 generated by their fossil fuels. Instead, they would likely shift the entire expense onto consumers, leading to an increase in fossil fuel prices which could, however, have impacts on demand. The impact of the price on that demand reduction will depend on many factors, including the stringency of the CTBO and the availability of alternatives in the short term.

If the CTBO would include (quite cheap) nature-based solutions in the near term such a price increase would most probably not be high enough to discourage the utilisation of fossil fuels, let alone their production. A CTBO should thereby be accompanied by a credible obligation to phase out fossil energy. It can play a role as a complementary policy tool, but should not be implemented instead of energy efficiency, renewable energy and direct polluters pays instruments. Also because without a clear phasing out of fossil fuels, the CTBO would need a quasi unrestricted volume of CDR to rely on to offset uncaptured carbon emissions.

In addition, as conceived by the authors of the paper referred to above, the CTBO does not seem to differentiate between Carbon Capture and Storage (CCS) activities at a point

source and CDR, which have completely different roles as the first represents emission reductions, and only the second can lead to negative emissions.

Finally, the CTBO would not make removals complement emission reductions on its own - and would need to be part of a wider climate framework which also ensures phase out of fossil fuels on the one hand, and implements varied sources of demand for removals on the other. Linking removals development to fossil fuel exploitation is therefore a risky strategy, as emissions need to decrease rapidly - and independent sources of finance for removals will be needed once fossil fuels are finally phased out.

2. Public funding mechanisms for CDR

2.1. Tax incentives and direct subsidies

A tax credit - a financial incentive which allows for a reduction in the taxpayer's liability - is often used to promote certain behaviours or activities. The most relevant currently in operation is the US 45Q tax credit for CO2 storage - which is not designed specifically for CDR, but since 2018 it contains tax credits for direct air capture as well. More specifically, section 45Q of the US internal revenue code was introduced in 2008 and provides a tax credit for each ton of CO2 captured both at point source or directly from the atmosphere and injected for sequestration, enhanced oil recovery or other uses. The scheme was expanded in 2018 to include Direct Air Capture (DAC), and the tax credit itself was further increased by the Inflation Reduction Act (IRA) in August 2022.

The tax credit was increased for carbon captured both at point source (from the previous $35 to $60 per tonne if the carbon is used - for example, in enhanced oil recovery - and from $50 to $85 if it is stored) and directly from the atmosphere (from $50 to $130 per tonne if used, from $50 to $180 if stored). While supporting DAC and DACS, the measure is only based on carbon injection without using a life cycle assessment or requiring climate considerations. This means that the tax credit could be used to support projects that

actually increase emissions due to high direct or indirect emissions related to the process. In addition, 45Q promotes the problematic practice of enhanced oil recovery.

In addition to the 45Q tax credit, the US has recently introduced a series of direct subsidies for certain carbon removals technologies. In particular, the Bipartisan Infrastructure Law (BIL, also referred to as Infrastructure Investment and Jobs Act - IIJA) enacted at the end of 2021, while largely focused on CCS and transport and storage infrastructure for CO2, includes $3.5 billion for building four regional DAC hubs across the country and $115 million for the DAC Technology Prize Competition. In August 2023, the US Department of Energy (DOE) announced up to $1.2 billion to advance the development of two commercial-scale direct air capture facilities in Texas and Louisiana, the first two selected regional hubs.

One of the two projects will be run by 1PointFive, a subsidiary of the oil giant Occidental Petroleum, who publicly admitted considering CDR as a leeway for investments in fossil fuels and whose CEO views DAC as a way to extend the lifeline of fossil fuels. While representing significant public investment in CDR, the measure does not prevent using the technology in unconstructive ways - potentially doing more harm than good by letting oil companies greenwash their activities.

Norway is considering a "reverse fee" for DAC. The Norwegian Environment Agency has suggested a subsidy of 2,000 NOK (177€) to reward DAC companies for each tonne of CO2 removed directly from the atmosphere over a period of 10 years. The measure would allow the state to guarantee an income to businesses in the sector, provide predictability and facilitate the implementation of the projects, according to the agency. The agency also stated that the reverse fee should be combined with sales in the voluntary carbon market (VCM). This last element is particularly worrying, as it is currently unclear if this could lead to double counting between the Norwegian UNFCCC inventories and private registries. In addition, it could incentivise and publicly subsidise compensation claims if it is not clarified that a contribution approach would be required, i.e. companies buying them to contribute to climate action, and not to offset their own emissions.

2.2. Procurement schemes and reverse auctions

Procurement schemes or reverse auctions could represent a more efficient and transparent way to allocate public subsidies to CDR projects. In this type of auction, participants present bids to offer their goods and services, and the buyer selects the most suitable pitch. Applied to CDR, a reverse auction mechanism would determine which participant can remove CO2 from the atmosphere at the lowest cost and allow the government to buy directly from that company. This could be done in a technology-neutral way, or reverse auctions could be held for specific subsections of the CDR field: different types of removals, different technologies within a type of activity or specifically for start-ups or R&D programmes. This would enable investments based not just on price but also on other factors such as future scalability or environmental and social co-benefits.

Sweden is in the process of introducing a reverse auction scheme to support the deployment of bioenergy with carbon capture and storage (BECCS). Suggested in 2021 by the Swedish Energy Agency, the first auction was supposed to take place at the end of 2022, but was postponed until 2023, or likely 2024. The Swedish Energy Agency expects bids from, for example, the pulp and paper industry or from combined heat and power plants in the district heating sector. The agency also suggests allowing those who receive government support for their BECCS project to sell negative emissions on a voluntary carbon market, by using a contribution approach (the topic is addressed in the next section).

In the US, two legislative proposals would make use of reverse auctions to support the deployment of CDR.

The US Federal Carbon Dioxide Removal Leadership Act, introduced in the US Senate in August 2022, would require the Department of Energy (DOE) to enter into contracts to remove an increasing amount of carbon dioxide emissions, aiming for 10 million tonnes annually by 2035, with funds derived from a fee on aviation fuel. The Fiscal Year 2023 Consolidated Appropriations Act actually supported that direction of traffic, by reiterating

the need for the DOE to start a "competitive purchasing pilot program for the purchase of carbon dioxide removed from the atmosphere or upper hydrosphere".

In May 2023 another bill was proposed, The US Carbon Removal and Emissions Storage Technologies (CREST) Act, which would require the establishment of new research programmes for carbon removal approaches and introduce a reverse auction purchasing programme for removals. The latter would allocate 30% of funding to medium storage (from 100 to 1,000 years) and 70% to long-term storage (more than 1,000 years).

If used to reach a specific and dedicated CDR target at national level without allowing for offsetting, and if coupled with strong environmental and social integrity criteria, a reverse auction for CDR has a twofold benefit. First, it can help commercialise more expensive but also more sustainable or permanent carbon removal types and technologies. Second, it allows public ownership of CDR, and thereby provides an alternative to voluntary carbon markets and offsetting with all their drawbacks as funding mechanisms.

3. Examples of voluntary approaches for CDR

3.1. CDR in the voluntary carbon market

Interest in voluntary purchases of carbon credits based on removals by companies is increasing steadily, often as part of a corporate social responsibility (CSR) or public relations (PR) plan. The "voluntary carbon market" (VCM) is as a whole, however, still dominated by credits based on avoided emissions. According to BeZero, a VCM rating agency, in 2022 93% of the market was emissions avoidance credits and the remaining 7% was nearly all land-based removals credits (forest management is included as a removal in these numbers, while it is often instead classified as avoidance). Of this 7% share, 66.3% were credits based on afforestation and reforestation, 24.5% on improved forest management, 7.3% carbon sequestration in agriculture and less than 1.5% in ecosystem restoration. This matches global trends: 99.9% (or 2 $GtCO_2$ per year) of global sequestration

comes from conventional management of land, (primarily afforestation and reforestation - and only 0.1% (or 0.002 $GtCO_2$ per year) from the results of 'novel' CDR methods.

While the focus of the VCM remains on non-permanent land-based removals, there has been a rapid scale up of more permanent CDR recently. A total of 4.8 million tonnes of 100+ year permanence CDR have been purchased since 2020 (although only 2.4% has been actually delivered, mostly biochar with questionable permanence). Of this amount, 3.4 million tonnes were purchased in the first half of 2023, soaring from the 609.7 thousand for the whole of 2022. The main buyer up till now has been Microsoft (3.1 million tonnes), followed by Airbus (400.000) and Amazon (400.000) - other large-scale purchases have been announced, but have not been fully concluded (most notably JP Morgan - 800.000). Mainly BECCS units have been procured, accounting for 88% of total purchases. Bio-oil accounts for 4% of the purchases, DAC 3% and biochar 2%.

Offsetting versus climate contribution approach

More and more companies want to use CDR to offset their emissions so as to reach their net-zero or carbon-neutrality targets. According to the data collected in the Corporate Climate Responsibility Monitor 2023, a report conducted by NewClimate Institute in cooperation with Carbon Market Watch assessing the quality of companies' climate pledges, at least 14 of the 24 big corporations assessed plan to use carbon removals to offset their continued greenhouse gas emissions. This situation is deeply concerning as carbon removals are primarily intended to decrease the levels of greenhouse gases in the atmosphere, not as a counter-balance for continued emissions. Offsetting emissions with removals is at best a zero-sum game. While offsetting is inherently troublesome, the use of low-quality, non-permanent removals which do not lead to an actual climate benefit (as it is mainly the case in the VCM today) exacerbates the issue even further.

Companies could instead choose to support CDR by adopting a "climate contribution approach". This would mean providing finance to removal projects to support climate actions beyond a company's own value chain without claiming to offset, or neutralise, any actual emissions, but as a complement to reducing the company's own climate footprint. In 2023, the Finnish government suggested going in this direction with a publication on "good

practices for supporting voluntary carbon markets" by stating that organisations making climate claims should prioritise their own emissions reductions and have a climate target and roadmap in place to do so. According to the Finnish government, organisations should ensure that the use of credits will supplement their own emissions reduction measures.

Advance Market Commitments

Typically applied to the vaccines market, an Advance Market Commitment (AMC) is used to financially support products which are too costly to scale up in the short-term. Frontier is the first and most prominent example of AMC applied to the CDR market, on the basis of which a group of companies (including Stripe, Alphabet, Shopify, Meta, JP Morgan Chase, H&M and McKinsey) committed over $1 billion to purchase permanent carbon removal between 2022 and 2030. As a R&D investment measure, the initiative is meant to send "a strong demand signal to researchers, entrepreneurs, and investors that there is a growing market for these [CDR] technologies", according to the founders.

The group is committed to facilitating purchases of "scalable and permanent" CDR solutions from "high-potential carbon removal companies" on behalf of buyers. In particular, Frontier will focus on technologies that meet a set of criteria, namely: durability (they can store carbon for more than 1,000 years); physical footprint (e.g. do not compete for arable land); cost (are affordable at scale); capacity (more than 0.5 gigatonnes per year); net negativity (i.e. maximise the net removal); additionality (result in new carbon removed); verifiability (using scientifically rigorous and transparent methods for monitoring and verification); safety and legality (highest local environmental standards).

Two aspects of Frontier are evidently positive. First, it finances removal projects selected on the basis of quite robust quality criteria. This, in theory, should help spread awareness of the distinction between false and real removals, the latter leading to actual negative emissions. Second, such a commitment provides certainty to removals suppliers, creates a market for the most expensive technologies and fosters innovation.

Nevertheless, these benefits are counterbalanced by potential and substantial drawbacks. The founders of Frontier do not make explicit if and how the credits generated by the

supported removals projects will be used by buyers. Offsetting emissions with removals does not seem to be ruled out. For example, Shopify states that carbon removals will be needed for companies to reach their net-zero or carbon negative goals. H&M Group, also a member of the fund, plans to use CDR to reach net-zero emissions but, following the SBTi standard, only to balance out any emissions that cannot be avoided (the portion of which is not yet disclosed) and after trying to reduce GHG emissions as much as possible. Moreover, while the contribution of the private sector in kick-starting the market for permanent removals is welcome, this support is unpredictable in the medium term.

The SBTi Net-Zero Standard

The Net-Zero Standard of the Science-Based Targets initiative (SBTi) is a guidance framework for companies to set science-based net-zero targets consistent with the Paris Agreement temperature increase limit of 1.5°C. It is a partnership between CDP, the United Nations Global Compact, World Resources Institute (WRI) and the World Wide Fund for Nature (WWF). The SBTi standard requires companies to reduce emissions in their value-chain by around 90% before using permanent carbon removals to "neutralise" residual CO2 emissions. Furthermore, the SBTi urges companies to increase "beyond value chain mitigation". This type of contribution claim would incentivise supporting removals and emission reduction outside of companies' value chains, supplementing their near and long-term emission reduction targets. The partnership launched a public consultation in summer 2023 to gather input for the development of further guidance.

While SBTi builds upon a good premise, the standard currently lacks specific guidance on carbon removals. As highlighted by CarbonPlan, the standard does not provide a thorough definition of CDR with specification on permanence.

3.2. Government-run voluntary schemes

To date, there are several examples of publicly-owned or government-run voluntary schemes to certify carbon removals activities that can, consequently, create tradable carbon credits.

The Australian ACCU scheme (formerly known as the Emission Reduction Fund) was established in 2011 as the Carbon Farming Initiative to cover activities in the land sector and was later fully integrated with the broader Emission Reduction Fund. The scheme allows project owners to earn carbon credits - known as Australian Carbon Credits Units - ACCUs - for each tonne of CO2 reduced or removed by their activity. Today, a number of activities can be eligible under the scheme to earn ACCUs, including in the industry sector (CCS, energy efficiency, waste treatment, transport etc.) and, in line with the former CFI, in the land sector (agriculture, fire and vegetation management).

There are three main groups of actors purchasing ACCUs for different purposes: the Australian government, through reverse auctions to comply with its emissions reduction commitments; the biggest Australian polluters, to stay below the emissions limit imposed on them by the Safeguard Mechanism; and private individuals or businesses who voluntarily decide to offset their emissions.

A large share of the ACCUs are generated in carbon farming projects, which can have a permanence period of either 25 or 100 years and include a variety of activities (such as vegetation management and agricultural practices that increase carbon sequestration, reforestation, afforestation, restoration of blue carbon). Since 2012, 47.8 million ACCUs have been issued for projects focused on soil carbon sequestration, afforestation and reforestation and forest management, representing 35% of total issued ACCUs (136.7 million). As a typical offsetting scheme, the policy equates emissions reduction and (very short-term) carbon sequestration methods, thus encouraging mitigation deterrence by allowing for the use of very cheap and vulnerable sequestration units to cover (permanent) emissions. The integrity of several methods to certify projects has also been disputed.

Another case of a national voluntary scheme very much focused on carbon farming is the French *Label Bas-Carbone*. Created in 2019 by the French Ministry for Ecological Transition, it certifies projects in France that reduce emissions and improve carbon sequestration, and it allows certified projects to sell credits representing tonnes of carbon avoided or sequestered. In addition to lacking rigorous certification methodologies, the scheme does not distinguish between emissions reduction and carbon sequestration and permits the buyers of carbon credits to offset their emissions without an obligation to adopt a credible decarbonisation strategy that complies with the Paris Agreement 1.5 target, according to RAC France.

Another example is the proposal for a Portuguese VCM, presented by the country's government in March 2023. The proposed national VCM would allow companies to buy carbon credits as a way to voluntarily offset their carbon emissions. As ZERO Portugal reports, the proposed scheme is very much based on forest carbon sequestration projects and has the aim to contribute to the country's climate action. This means that the scheme would allow the use of short-term vulnerable storage for offsetting. Secondly, the scheme's projects would have doubtful additionality as the forestry sector is already covered by the EU LULUCF Regulation. Finally, double counting of forestry sequestration between the aforementioned LULUCF Regulation and voluntary claims is a real risk: the same forestry unit will likely be used by two different actors for two different purposes. The government, in turn, stated that the initiative has the opportunity to bring income to the forest sector and protect ecosystems.

The final example is the EU Carbon Removal Certification Framework that the European Commission proposed in November 2022, which is still going through the EU's legislative process. While the proposed law is, in theory, only meant to certify carbon removal units and does not create a voluntary scheme for trading credits nor governs the use of the units, it does not explicitly rule out the possibility of using certified units to offset emissions. There are other significant shortcomings: the proposal confuses emissions reduction and carbon removals, defines short-term carbon storage as removal, does not differentiate sufficiently between very long term and very short term storage, and has vague quality criteria.

3.3. UN mechanisms

The carbon market mechanisms under the United Nations Framework Convention on Climate Change (UNFCCC), established under the Kyoto Protocol and the Paris Agreement, also include removal and/or sequestration activities in their scope.

The Clean Development Mechanism (CDM) was set up under the 1997 Kyoto Protocol to let developed countries purchase carbon credits from developing countries. Over two decades, the CDM certified afforestation and reforestation projects (A/R), the only activities it labelled as 'carbon removals'. The quantified removals resulted in two types of credits, created to take into account the risk of the forests releasing carbon back into the atmosphere:

1. **Temporary emissions reductions credits (tCERs)** expiring at the end of the Kyoto Protocol's commitment period and requiring to be replaced in the next period. However, the holder was not asked to redress any reversals, and;
2. **Long-term emissions reductions credits (lCERs)** expiring at the end of the project's crediting period (from 20 to 60 years) which did put liability on the holder for any reversals.

This approach disincentivised entities to use those temporary credits to compensate for their permanent emissions, but even then the CDM was often criticised for not respecting the principles of additionality, permanence, sustainability and accurate quantification, as reported by Carbon Market Watch in 2012 and 2018 and in an analysis by the Öko-Institut.

Negotiators on Article 6 of the Paris Agreement are in the process of establishing two new markets for countries to voluntarily cooperate to achieve their climate commitments through trading emissions reductions and removals. The role and functioning of these two markets are set out in Article 6.2 and Article 6.4 of the Agreement.

Article 6.2 allows countries to buy or sell to one another any extra emission reductions or removals they have achieved relative to their climate target (NDC), known as internationally transferred mitigation outcomes (ITMOs). There is no independent body with enforcement power over its implementation, which means that a country can self-define environmental

integrity, social safeguards, and other core criteria for the credits exchanged, such as additionality.

Article 6.4 on the other hand is more like the Clean Development Mechanism, except that it will not be restricted to projects implemented in developing countries. In this market, project developers will reduce or remove emissions through specific actions in a country, and sell these emissions reductions or removals to another country, company or person. The process will be administered by a "Supervisory Body" tasked with establishing detailed rules and requirements that projects and credits, including on removals, must comply with in order to be eligible. The negotiations on those detailed rules are ongoing, and will be particularly interesting for the CDR community, as detailed rules on definitions and crediting of removals may influence the way removals are treated in the voluntary carbon market or national and regional jurisdictions, potentially including the Article 6.2 market.

4. The CDR policy blueprint

4.1. Key shortcomings of existing approaches

The previous sections have discussed a wide variety of approaches (both policy- and voluntary market-driven) and their respective benefits and downsides. Based on that overview, this section will attempt to present a blueprint of what a good CDR policy pathway should entail.

While lessons can be learnt from some best practices, none of the approaches covered earlier in this paper are perfect - the most common shortcoming is allowing or even encouraging mitigation deterrence. This concern must be a central focus in any CDR policy framework: the science is clear that we urgently need emission reductions across all sectors, and removals or land sequestration cannot be allowed to undermine that. Overreliance on land sequestration or future technical removals can let polluters off the hook, or even be abused to extend the lifetime of fossil fuels.

Emissions and removals are not equivalent, and should not be approached as such in any policy framework. As raised in the previous sections: this is already happening. For example, the EU's member state targets for reducing emissions across the Effort Sharing Regulation sectors (among others buildings, road transport and agriculture) are undermined by a loophole which allows limited amounts of land-sequestration units from the LULUCF regulation to be used to reach emission reduction targets. This loophole is an example of path-dependencies that are already in place, and should be halted.

A secondary shortcoming of many frameworks is insufficient differentiation between land sequestration (i.e. storage in soils or vegetation) and permanent removals (high degree of certainty of multiple centuries of storage). These two types of storage or sequestration are commonly referred to as 'removals' without further differentiation, but there are key distinctions that must be made between them. To complicate matters further, there are also carbon sequestration activities that straddle this divide, most commonly due to mid-term storage. A line needs to be drawn between the activities that likely lead to multiple centuries of storage, and those that do not. Where that line is placed will be subject to extensive lobbying - but science must prevail, and where questions on storage duration remain, the precautionary principle should be followed.

On the one hand, land-based carbon sequestration is vulnerable to human or natural disturbances, but if enhanced through sustainable activities, it has multiple benefits for biodiversity and ecosystems. Sustainable activities could include nature restoration, but also sustainable agriculture and forestry practices. The non-climate benefits of sustainable land practices arguably surpass the carbon sequestration benefits of such activities - land sequestration should therefore be done for non-climate reasons: biodiversity, adaptation, climate resilience, and soil health for example.

In addition, robust accounting of the land use sink is extremely challenging: robust MRV may be impossible or unaffordable for many land managers, additionality is difficult to test and setting baselines is a complicated process. If the land use sector is focused through a carbon lens, then those challenges do indicate that activity based finance would be better

suited than carbon crediting approaches. Plus activity-based finance would be cheaper and more easy to implement for both public authorities and land managers.

On the other hand, removals with longer term storage (at least several centuries, but hopefully quasi-permanent) might be more effective supplements to reducing emissions due to long-term storage, but its deployment at scale can be limited due to technological constraints, and energy and/or land requirements. These activities are also less likely to lead to social or environmental benefits similar to those provided by land sequestration activities.

Both types of activities can negatively affect biodiversity, the rights of local communities and indigenous peoples.

4.2. Way forward in the short term - overarching principles

In the short term, room for trial and error among the various jurisdictions that are moving forward with removals policy, may be needed. But several overarching principles should be respected to ensure 'trial and error' does not lead to real damage - to the climate or to associated social and environmental priorities. Therefore three principles should be at the heart of any CDR policy system: the precautionary and 'Do No Significant Harm' principles, and the primacy of emissions reductions.

Environmental and social safeguards are critical to ensure removals are actual solutions, and trust and public licence to operate is earned. Climate action must not come at a cost to biodiversity, ecosystems, or local or indigenous communities. Governance frameworks must also assess impacts and risks beyond the domestic jurisdiction as impacts can easily occur in third countries. For example, any removal type that needs significant quantities of land or biomass may lead to land use changes (such as deforestation) or land grabbing abroad. Uncertain and risky removal types that may do immense damage to ecosystems and communities that depend on them (such as ocean fertilisation) should be ruled out from the start - ideally at the global level. Any linkages to Enhanced Hydrocarbon Recovery must also be banned from the onset.

Explicit prioritising of emission reductions means tackling mitigation deterrence in earnest. Ruling out all possible mitigation deterrence is not an easy task: any resources spent on researching or deploying CDR, or even designing relevant policies, are resources not spent on bringing down gross GHG emissions . But on the other hand, the IPCC is clear that some CDR will be unavoidable - so a balance must be found: CDR must not distract from emission reductions, but also not be ignored completely.

4.3. Separate removals and emissions

One basic safeguard can help minimise mitigation deterrence, while also striving to provide balance: strictly separate emissions and removals throughout targets, climate policy architectures and specific policies. As a minimum, three different targets should be set: emission reductions (the most important one), land sequestration and permanent removals. This has several distinct benefits beyond avoiding a slow down of emissions reduction efforts.

First, it identifies a specific and sustainable role for removals and land sequestration - and allows them to be undertaken as clear supplements to emission reductions rather than substitutes.

Second, separation between land-based sequestration and CDR provides for better governance of both. As discussed above, these types of activities have different risks and benefits - separation and differentiation helps provide a safer regulatory space to maximise the respective benefits and address the risks while increasing trust and transparency. It creates silos in which each can be developed independently, and more appropriately with targeted policies.

Third, explicit and separate targets better support developers by reducing regulatory risk and providing long-term clarity. Dedicated targets signal demand for high-quality removals, which in turn supports investment. Today, developers of high-quality land-based carbon sequestration activities, such as close-to-nature forestry, and CDR methods experience

uncertainty due to a lack of strategic vision and policy. The lack of regulatory action and support means that voluntary market-based schemes are currently the centre of attention, even if the integrity issues at the basis of voluntary carbon markets are well understood.

Finally, it demonstrates that emissions and removals are different. Once released into the atmosphere, CO2 emissions have a permanent and often irreversible impact on the Earth's climate, ecosystems and human health. Land-based carbon sequestration and CDR can help limit this damage, but they cannot undo them. If done badly (by distracting from emissions, or quantifying removals with narrow system boundaries) removals can actually increase emissions. Emitting carbon and then pulling it out of the atmosphere does not negate the damage done by emitting it in the first place. Keeping targets and policy frameworks separate helps clarify this basic physical principle.

While separation of targets and policies is important, it is only the starting element in any effective CDR policy framework. Further issues that need to be addressed include funding needs, long term vision, defining removals and robust MRV.

Funding: moving beyond short-sighted offsetting to compliance approaches

Permanent removals will remain expensive for the time being, especially if done well. Industry insiders indicated to the authors that Direct Air Capture and Storage is currently in the 500-1000 USD/tonne of CO2 price range, and decreasing that price will take time and investment. On the other hand, land sequestration credits sell for between 0 and 10 USD on the voluntary carbon market (VCM) and many units (removals or avoidance) in the VCM are questionable in terms of additionality and permanence. Land-sequestration units could quickly become more expensive if robust and long term MRV is mandated, coupled with clear liability for reversals such as a requirement for indefinite renewal or repair. This is not the current state-of-play, and could need significant regulatory intervention in the voluntary carbon market. Funding of removals and land sequestration should be separated as well, considering these immense differences in prices and permanence.

Markets are not the right tool for funding removals and land sequestration. Carbon markets follow the economic logic: cheapest option first. By including both land sequestration and permanent removals in one funding mechanism, without differentiation, the market will overwhelmingly support the cheapest, and likely lowest quality removals. Integrating lower quality units (such as forestry units, or forestry-based BECCS with its environmental problems) will mean that only the cheapest ones see any demand, likely leading to a crash in the carbon price and reduced pressure on covered installations to decarbonise.

If only permanent removals are to be integrated there will likely be no to low demand due to price differentials with other compliance units (EU ETS prices are around 80 euros at the time of writing). Some Bio-CCS applications (bioethanol-based BECCS for example) based on existing waste streams or linked to unsustainable biomass (forestry-based BECCS) could already be funded with the current ETS price - but these applications have scale and sustainability issues. DACS on the other hand is currently so expensive that it is unlikely to cause any mitigation deterrence, but would likely also not see significant support mobilised through inclusion in compliance markets.

Inclusion of removals in carbon markets therefore is an inherently flawed approach that does not aid the fight against the climate breakdown. It results in either mitigation deterrence if bargain-priced units (usually low quality with potential major sustainability concerns) are introduced, or there is a lack of demand or support for removal methods with higher environmental integrity. There is no ‘silver bullet’ removal method that promises environmental integrity, affordability, scalability and permanence of storage. This hard truth must lie at the basis of removal policies.

There are alternative funding mechanisms available - a few examples are presented below, but this list should not be considered exhaustive.

Revenues from carbon pricing can be used to invest in CDR - in the EU the Innovation Fund would be a viable mechanism to do so in the short term. Alternatively, an obligation for procuring removals can be placed on polluting companies (Ecologic has proposed this as a

Removal Trading Scheme). The obligation would be additional to the carbon price, not undermining it. This scheme would exist in parallel to the EU ETS, and require covered companies to surrender removal units - either engaging in carbon removals themselves or purchasing them from other entities that generate carbon removals.

California is currently considering a similar approach through the proposed Carbon Dioxide Removal Market Development Act, which would require companies subject to the California cap-and-trade system to purchase negative emissions credits equal to a certain portion of their emissions, namely 1% in 2030, 8% in 2035, 35% in 2040 and 100% in 2045. This requirement would come on top of the current cap-and-trade obligations.

Countries could enact a wide variety of tax benefits, subsidies or public procurement mechanisms. In the EU, removals targets could be set at the EU member state level making national governments responsible for determining how to create demand and fulfil it. Member states directing portions of their EU ETS revenues for public procurement through reverse auctions is a prime example of how such a system could work. The USA's 45Q tax credits for CDR and investments in the DAC hubs take a direct subsidy approach, but do not lead to public ownership of the generated removals, nor does it exclude them being used by companies for other means. That said, in the short term it does invest modest amounts (relative to the US Federal budget) in upscaling a specific removal type and allowing for testing of various technologies at larger scales, without causing problems in other parts of the climate policy framework.

The private sector and the voluntary markets could also provide finance, though not through compensation claim based offsetting (due to mitigation deterrence) but following the contribution claims model. The Frontier fund is an example of such a mechanism - though concerns about participants potentially using procured removals to offset continued emissions remain.

Any funding would, however, need to differentiate between different types of removals and sequestration, and look beyond quantities - especially in the short term. Investments in R&D, start-ups, and underfunded CDR methods will be needed to assess and test a wide

variety of sustainable CDR options. Removal deployment at scale globally will likely need a wide range of CDR methods, rather than relying on one or two approaches to do the heavy lifting. The sustainable potential of any single removal method is likely to be subject to technical, land and sustainability limitations, making a portfolio approach the feasible way to reach scale without trampling on planetary boundaries.

Additionally, MRV, a full and transparent assessment of impacts, as well as promoting sustainable development and other environmental and social goals (such as biodiversity) are a necessary prerequisite for any funding mechanism.

Long term vision of the role of removals

A simple litmus test for climate policy frameworks that are long term, meaningful and sustainable should be: does it reach climate neutrality as soon as possible with residual emissions as low as can be realistically achieved (to limit reliance on CDR, as sustainable removals must be assumed to stay scarce and expensive), and enable deep and sustained net-negative emissions?

To reach climate neutrality entails removals balancing out the last remaining residual greenhouse gas emissions that are deemed too important to society and therefore too difficult to abate. This vision of balancing the last residual emissions and reaching net-negative emissions should be spelled out clearly in any CDR framework. This balancing act should be an imperative at the economy or society level, rather than be considered an easy way out for individual companies or sectors to be given access to removals to balance their particular emissions. Polluters must remain focused on their emissions and be subjected to meaningful carbon pricing mechanisms, rather than look to offsetting mechanisms. From a governance perspective, the three short-term principles also play a crucial role here: the precautionary and 'Do No Significant Harm' principles (to rule out the use of unsustainable and damaging removals), and the primacy of emissions reductions.

Deep and sustained net-negative emissions is the subsequent criteria for success: any policy framework should be geared towards net-negative emissions as deep as possible to deal with any temperature overshoot and to start repairing the damage humans have done

to the atmosphere. Speed and scale of net-negative emissions will become a key scientific and societal concern in the coming decades. While in the shorter term policies might focus on maturing the sector and upscaling, the ability to reach net-negative emissions should be occupying policymakers' thinking. This is mainly important for proposals on funding CDR, where finance from polluters should dry up as fast as possible while emissions are being cut.

For both those goals, reducing emissions still plays the central role, continuing far into the second half of this century, and determining how much removals will be needed.

A longer term vision on removals also means dropping shorter term priorities that some actors and policymakers might choose to focus on: companies demanding access to units to make climate claims (as is being encouraged in the French Label Bas Carbone, and what many are pushing the CRCF towards), and companies and policymakers imagining removals and sequestration as a means to limit the cost of compliance with emission reduction policies (such as the EU ETS).

Defining removals

Not everything that stores carbon is CDR. Clarity on differences between CDR on one side, and CCS and CCU the other side is needed. In addition, vulnerable and perhaps shorter-term land sequestration can play an important role in addressing the climate crisis, biodiversity and other social and environmental objectives are more important for land sequestration. The vulnerability of such sinks means they should be defined separately from permanent removals, and shouldn't be observed through a carbon-centric lens, but rather a holistic environmental approach.

A meaningful CDR policy should ensure that removal processes are well-defined: removals capture CO2 directly from the atmosphere, in a sustainable manner, and store it for at least several centuries. In addition, these processes must have a net-negative emissions balance - the emissions taken out of the air outweighing the direct and indirect emissions involved in the removal process. This latter consideration is not trivial - a direct air capture facility linked to a coal-based grid can lead to more GHGs in the atmosphere, not less.

Robust MRV and accounting

Removal and land sequestration processes can be complex, difficult to quantify and cross borders. This complexity must be met with robust MRV to ensure that any removals used (for whatever purpose) are real and high-quality, coupled with clear and transparent accounting to ensure trust, no double counting and accurate cross-border accounting (including of indirect emissions). Accounting should also take timing of storage into account: vegetation can take months to centuries to grow. Any land sequestration or permanent removal based on biomass (which has to be sustainably sourced, no small hurdle) must incorporate that timing issue in its accounting.

MRV should be based on conservative estimates to limit the potential for overestimation, and take direct and indirect greenhouse gas emissions flows both domestically and abroad into account when quantifying net-removals. Indirect effects can be challenging to address properly, but ignoring them would mean potentially certifying net-emitting activities as net removals. Important indirect effects that should be accounted for are indirect land use change (e.g. agricultural land repurposed or even grabbed for BECCS crops leads to deforestation to maintain agricultural production), market and ecological leakage, and waterbed effects in energy markets (e.g. using existing renewable energy for DACS leaves less clean energy for other sectors and might increase demand for fossil fuels).

Lessons must be learned from failures in voluntary carbon markets where the private sector has significant financial incentives to overestimate the results of projects and/or minimise administrative burdens. Verra methodologies for REDD+ projects, for example, have been shown to be highly problematic with regards to their environmental integrity - and scandals have regularly made headlines the past few years (e.g. here and here). Who develops the methodologies is not a trivial issue: governments must take the lead on this, and ensure methodologies are science- and reality-based, rather than copy-paste exercises from voluntary markets. Designing robust MRV systems will not be simple, many removal practices are extremely complex with regards to lifecycle accounting of energy, land, biomass; indirect and direct impacts on, for example, land use, additionality, baseline setting and simple measurability of climate results.

CONCLUSIONS

The increasing political, scientific and corporate interest in CDR has resulted in various approaches being taken (or theorised) in various jurisdictions or in voluntary schemes to scale up investments and foster innovation in the sector.

The use of offsetting is widespread in both regulatory and voluntary approaches

On the policy side, directly or indirectly including removals in carbon markets is seen by many as a key mechanism. The direct incorporation of removals credits in emission trading schemes could happen either fully, in a way to make them totally fungible with emission reductions allowances, or through a "limited or conditional supply", so as to include in the system a limited amount of removals credits, for example only based on DACS and sustainable waste-based BECCS.

While the second option is preferable to make sure that high-quality and sustainable removals are used, both methods are based on the wrong assumptions that removals and emissions are fully fungible, that removals could in the short term be procured at relatively low price levels, and in the short and longer term be used to substitute decarbonisation efforts. Any inclusion of removals in emission trading systems in the short to medium term will lead to either mitigation deterrence, or no to low demand for said removals.

Similarly, voluntary approaches have significant risks for environmental integrity and climate delivery, and greenwashing through offsetting. At least 14 of the 24 big global corporations assessed in the 2023 Corporate Climate Responsibility Monitor plan to use carbon removals to offset continued greenhouse gas emissions that could likely be abated directly.

The main government-run, yet voluntary, offsetting schemes don't do a better job of distinguishing between decarbonisation efforts and action on CDR. The Australian ACCU Scheme, the French *Label Bas Carbone*, and the proposed Portuguese VCM all allow offsetting continued emissions with land-based carbon sequestration credits. The proposal for a EU Carbon Removal Certification Framework, the UN Clean Development Mechanism and the Article 6 mechanisms do not address mitigation deterrence either.

Good practices are emerging

Good practices to incentivise CDR without slowing down decarbonisation efforts are surfacing and making waves in voluntary carbon markets, such as the SBTi standard and the Frontier Fund Advanced Market Commitment. SBTi requires companies to reduce emissions in their value-chains by 90% before using removals to balance out residual emissions, but does not require detailed CDR plans nor set quality criteria for removals. It is focused on demand-side governance: which conditions must be met before offsets can be purchased by a company. Frontier, on the other hand, builds upon a commitment to buy only removals complying with strict quality criteria, but does not explicitly rule out offsetting-based claims. It is more of a supply mechanism setting standards for the quality of removals to be procured. SBTi and Frontier are in this sense complimentary, but voluntary, mechanisms.

Recommendations for policy frameworks

Carbon removals are necessary to reach climate neutrality and net-negative emissions, but they must play second fiddle to emission reductions, and be implemented sustainably. Currently, all major governance systems for removals do not sufficiently respect those concerns. Three principles should be placed at the heart of any CDR policy system: the precautionary and 'Do No Significant Harm' principles, and the primacy of emissions reductions.

Mitigation deterrence must be taken seriously: there is no time left for (at best zero-sum) offsetting: removals must complement, not substitute emission reductions. A key governance safeguard to address this is separate climate targets and policies for emission reductions, permanent removals and sequestration in the land sector. Among other benefits it can dispel false equivalencies, enable action on all three fronts and provide certainty for project developers - all while minimising mitigation deterrence. The principle of separation should be at the heart of climate targets and net-zero pathways - in the EU during the upcoming 2040 target setting process, but also at the international level via

Nationally Determined Contributions, the Global Stocktake under the Paris Agreement and the implementation of Article 6.

Funding should not come from compensation-based offsetting and linked greenwashing claims, nor from giving polluters a cheaper option for fulfilling compliance obligations. For the private sector the contribution model should be at the core of CDR action, as used by several members of the Frontier fund, but also the Milkywire Climate Transformation Fund and, to some degree, the SBTi Beyond Value Chain Mitigation initiative.

On the public side, the polluter-pays principle should be a primary means of raising funds. Revenues from carbon pricing mechanisms could be used to finance CDR projects - but should look beyond a narrow prism of quantities to include a focus on quality, co-benefits and development. Government procurement can be finalised through a variety of schemes, for example the Swedish reverse auctions for BECCS or a Carbon Central Bank. The EU's Innovation Fund is an instrument that is already operational and could expand relatively easily towards funding a portfolio of CDR projects.

Alternatively, compliance obligations for procuring removals (additional to emission reduction obligations) could be put in place, such as a Removal Trading Scheme, or the proposed Californian Carbon Dioxide Removal Market Development Act. These schemes have significant benefits by mandating demand for removals, providing a steady and predictable development of scale and allowing for government oversight in terms of quality of removals to be supported - all while maintaining pressure for emission reductions.

Fundamentally, both public and private sector support to CDR should be based on a sound definition of CDR, robust MRV and a long term vision that encapsulated the complementary role of removals and the primacy of emission reductions. In the EU, the first opportunity to do so is during the 2040 target setting process and the implementation of that new target across the EU climate policy architecture - this is an opportunity that must not be squandered.