Carbon Gap

WHITE PAPER

A GUIDE TO CERTIFYING CARBON REMOVAL

October 2022

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Executive summary

Alongside emission reductions and adaptation to climate change, carbon dioxide removal (CDR) is a critical third pillar of climate action. CDR includes a wide array of methods, from incorporating carbon into our built environment and long-lived products, to reimagining land management to optimise for carbon absorption, to scaling up entirely new industries that scrub CO_2 directly from the air or ocean through engineered means.

But, without a means to carefully measure, validate and certify carbon removal, we cannot ensure that these potent climate solutions will be effective or positively impactful. Just as urgently as we need to expedite CDR efforts, so too do we need to develop regulatory frameworks that can keep these efforts in check, authenticating removals and promoting ecosystem and societal co-benefits.

Carbon Gap welcomes the European Commission's forthcoming proposal to launch a **Carbon Removal Certification Framework (CRCF) for Europe,** which could help catalyse global scaling of high-quality carbon removals. This White Paper sets out a vision for how such a certification framework should be formed. It is structured in four parts, with sections 1 and 2 covering key principles, inevitable challenges, and an implementation model. Sections 3 and 4 explore appropriate governance systems and use cases for certification.

Like the climate crisis itself, carbon removal knows no national boundaries, and many of the insights here are therefore intended to be universal to all CDR certification frameworks. However, we see a unique opportunity for the European Union to continue its tradition of regulatory leadership, launching an exemplary CDR certification framework. Accordingly, Carbon Gap has designed its recommendations with the EU in mind, but with the conviction that these ideas can be broadly applied. In this spirit, our five key recommendations are summarised below.

Carbon removal certification frameworks should:

1) **Empower an agency to transparently administer the system,** maintaining an open-access database of certified projects and taking a science-led, unconflicted governance approach.

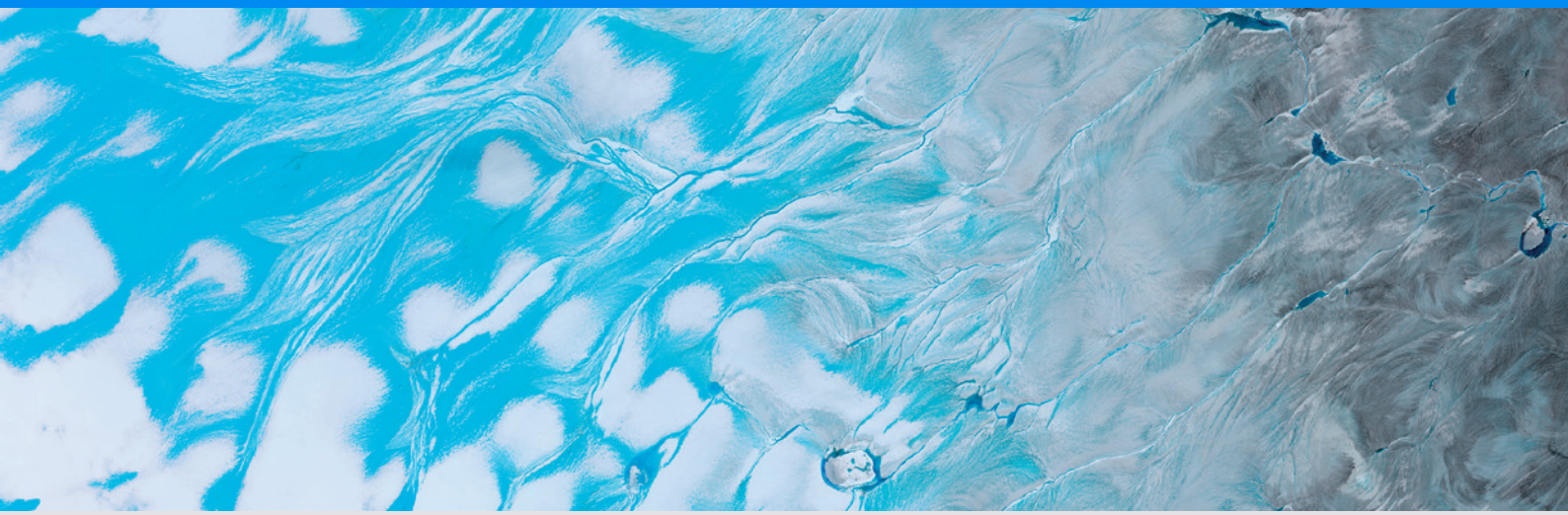
2) **Establish guidelines, principles and baseline standards** that pave the way for the certification of all safe and effective removal methods.

3) **Implement a multi-tier system for "onboarding" methodologies** based on differentiated certainty levels that a carbon benefit has been delivered.

4) **Separate fundamentally different CDR methods** to resolve the "carbon removal equivalence dilemma" (i.e. by distinguishing low-durability from high-durability methods).

5) **Foster the full spectrum of possible use cases of carbon removal certification,** of which compensation-based offsetting is only one.

The EU has a unique opportunity to help the world imagine what credible CDR looks like. If the CRCF is built and governed in a principled, evidence-based way then its impact will ripple through public and private sectors, not only in the EU but further afield. A robust regulatory framework will provide a much-needed backbone for the rapidly growing CDR world, ensuring this industry scales in an integrous way. At a time when escalating global warming is pushing Earth's systems to the limit, high-quality carbon removal methods must get the financial and regulatory support they need. **That starts with the establishment of effective certification.**



Introduction

2020 marked the start of a decisive decade for climate action. There is no silver bullet to solving this crisis. Rather, multiple approaches must be pursued in tandem to reduce and avoid the emission of greenhouse gases (GHGs), and remove them from the atmosphere. Historically, carbon dioxide removal (CDR) methods have received less attention, funding, social support, and governance than reduction and avoidance. Now the zeitgeist is shifting as new evidence emerges. According to the 2022 Working Group 3 report by the Intergovernmental Panel on Climate Change (IPCC), **carbon dioxide removal plays a critical role in curbing the climate crisis.**

But the growing CDR ecosystem can only be as effective as the principles and systems shaping it.

Carbon Gap exists to advocate for the just and responsible deployment of CDR, *not deployment at all costs.* That's why we've devised a set of considerations we think all CDR efforts can adopt, regardless of geography. These are:

1) Reduce GHGs as much as possible, and remove the rest. Carbon Gap supports a strict mitigation hierarchy: priortise emission reductions and remove what cannot be reduced or avoided.

2) Think long-term. Carbon Gap supports a long-term mindset when it comes to CDR. Reaching net zero, and net negative shortly thereafter, is a waypoint on the longer journey to absolute zero emissions.

3) Explore all CDR methods. Carbon Gap supports the exploration and, where appropriate, the safe deployment of all CDR methods. Only by taking a method-neutral approach can we hope to find efficient and effective ways of removing carbon from Earth's atmosphere.

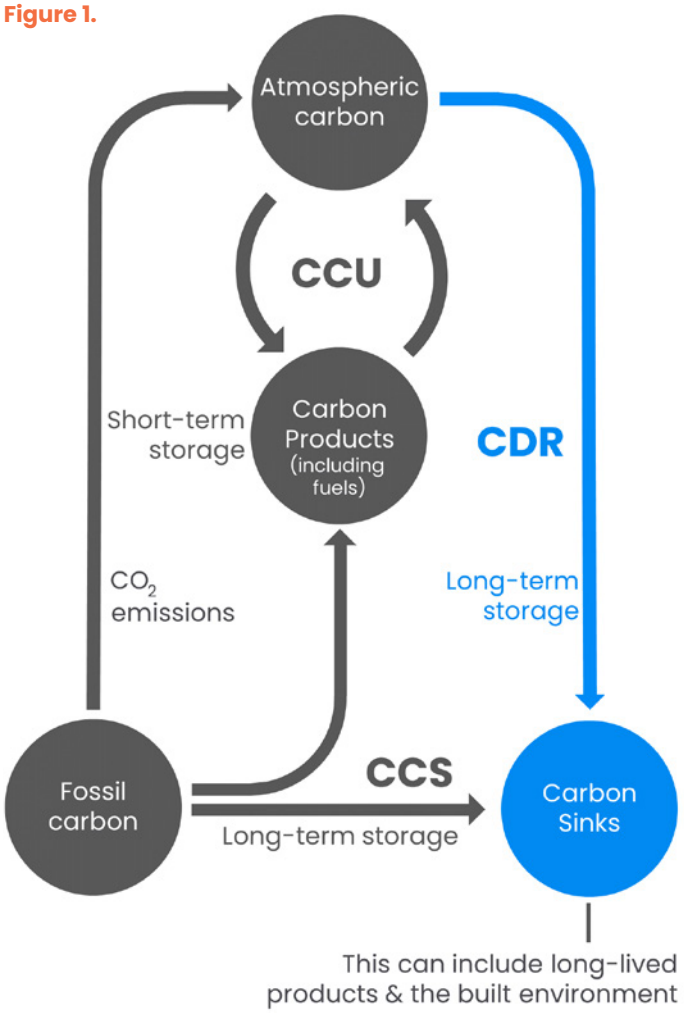
4) Boost non-carbon benefits. Carbon Gap acknowledges the critical need to urgently protect and restore ecosystems, and improve livelihoods (collectively, "non-carbon benefits"). CDR approaches should not only avoid adverse impacts, but moreover deliver progress on these benefits whenever possible.

Zooming into Europe, the European Union's ambitious climate goals necessitate the swift scaling of CDR methods. By 2050, the EU aims to be climate-neutral, and to achieve net negative emissions thereafter. Meeting these goals requires removing carbon on the order of magnitude of several hundreds of millions of tons of CO2 per year, and this, in turn, requires measuring CDR precisely, and diligently monitoring stored carbon to identify and prevent leaks.

To this end, **the European Commission is developing a regulatory framework for the certification of carbon removals (CRCF).** The framework will help ensure authenticity by developing rules on monitoring, reporting and verifying carbon removals, factoring in aspects such as storage duration, risks of reversal, risks of indirect carbon leakage and environmental integrity. In addition as Section 1 will make clear, the framework must distinguish between removals and non-removals, such as some forms of Carbon Capture & Storage (CCS) and Carbon Capture & Utilisation (CCU) (see Figure 1 for an illustration of these distinctions, and Section 1 for further detail).

The difference between CCS, CCU and CDR

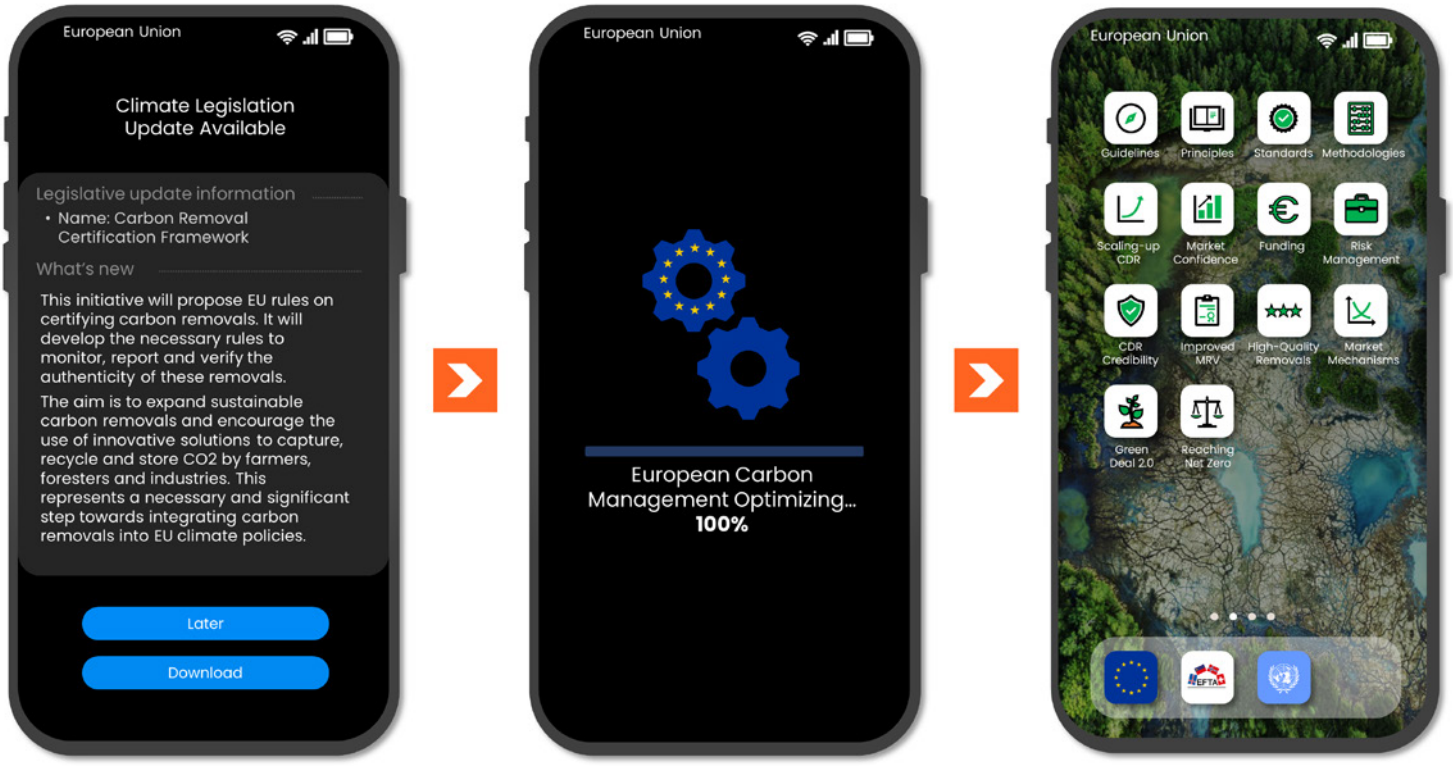
Figure 1.



The initiative was first mentioned in the Commission's communication on Sustainable Carbon Cycles, which was published in December 2021. The legal proposal for the certification framework shall be adopted by the Commission in the fourth quarter of 2022. The framework will be part of a larger Commission agenda on CDR, including objectives on carbon farming and industrial capture, use and storage of carbon.

CRCF is the climate update needed to begin unlocking the full potential of carbon removal

Figure 2.



To date, Europe has rightly focused on ambitious emission reduction targets. With many initiatives adopted; the time is ripe to focus on building the enabling conditions for net-zero...

The CRCF would play a critical role in how we address carbon management by ensuring that there is wide alignment on guidelines, principles, standards, and methodologies...

With the CRCF in place, a robust carbon removal sector could emerge with increased market confidence and credibility, funding, and ultimately higher-quality carbon removals.

The CRCF will act as an " update" for EU climate regulation, unlocking the ability to evaluate carbon removal in the EU and possibly beyond. It will affect policies at the local, national, EU level, and even international level, from the creation of incentives for soil carbon storage for land managers (e.g., via the Common Agricultural Policy), to rewarding procurements of building materials acting as carbon storage (e.g., via building codes), to enabling imports of carbon neutral or carbon negative products (e.g., Carbon Border Adjustment Mechanism).

Beyond policy, the impact of the CRCF will be widely felt. Regulatory leadership by the EU can help build confidence among the public, investors, CDR providers and buyers, that CDR methods can be deployed in a safe, secure, and just way. **Carbon Gap applauds the EU for taking up a leading role in the measurement and certification of carbon removals, pursuing one of the boldest, most comprehensive ambitions of any nation, region, or voluntary non-state actor.**

We recommend ensuring careful coordination with other certification initiatives to encourage interoperability, cohesion, and ideally a transfer of EU CRCF guidelines and principles into other schemes.

This White Paper takes a four-part approach to describing a successful evolution of a carbon removal certification framework in general, using the CRCF as the most pertinent and proximate example. First, we lay out carbon removal certification principles that must be enshrined in the CRCF to ensure that EU-approved carbon removal is effective and delivers real benefits. Second, we propose how carbon removal certification methodologies can be developed and onboarded into the CRCF. Third, we offer guidelines for effective and non-conflicted governance of the CRCF, to ensure environmental integrity and public trust. Fourth and finally, we describe a continuum and timeline of use cases for the CRCF, in light of the EU's plan to offer up a certification scheme on an initially voluntary basis before integration into policy regimes.

1. Principles for Certifying Carbon Removal

Recommendations:

- **Carbon removal certification frameworks must provide a pathway for all safe and effective removal methods,** and exclude non-removals.
- **Dedicated funding,** for practitioners of early-stage carbon removal methods to develop methodologies, unlocks impact for the entire field.
- **The European carbon removal certification framework should establish guidelines, principles, a European standard, and permitted methodologies sequentially.**
- **Set quality principles to establish a minimum quality** bar for all certified carbon removal.
- **Keep lower-durability (predominantly land-sector) removals separated** from higher-durability (predominantly geological storage) removals.

For a carbon removal certification framework to be effective and retain public confidence, it must adhere to a set of clear design principles. First, we must make clear which climate solutions are in-scope and which are not, while ensuring inclusivity of all methods that can safely remove carbon from the air. Second, we must situate the certification framework at the appropriate level of granularity – in this case a European "standard" containing a collection of approved "methodologies". Third, the scheme must adhere to transparent and high-integrity quality principles. Fourth and finally, a carbon removal certification framework must appropriately separate removals according to the character and type of the carbon storage. The question of how specific carbon removal methodologies are sourced, developed, and onboarded is explored in Section 2.

Carbon removal certification frameworks must provide a pathway for ALL safe and effective removal methods, and exclude non-removals.

Designing an effective Carbon Removal Certification Framework starts with clearly defining carbon dioxide removals (CDR). Carbon removal is defined by the IPCC as:

> ***"Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products[A]"*** **(IPCC WGIII AR6)**

Any method which 1) extracts CO_2 from the atmosphere, 2) stores it safely in an identified, well-managed carbon pool, and 3) has been determined to be publicly acceptable and not cause unacceptable negative impacts, is carbon removal and must be in-scope for inclusion in a carbon removal certification framework. Not all CDR methods are ready for immediate inclusion, and we discuss a phased approach to onboarding methodologies in Section 2.

In this context, it is of high importance to continue distinguishing unequivocally between the removal and storage of carbon from the atmosphere, and the avoidance or reduction of emissions to the atmosphere. Clearly distinguishing between the removal and storage of carbon from the atmosphere, and the avoidance or reduction of net emissions (immediate) to the atmosphere, is critical because:

- **Removals play three distinct roles.** As described in the IPCC's most recent report, removals can 1) accelerate the reduction of net emissions (immediately), 2) counterbalance 'hard-to-abate' emissions (near-term), and 3) deliver net negative emissions (long-term).
- **Elimination of emissions must remain the top global climate priority.** If a clear distinction is not maintained, it will be impossible to ensure that removals complement and enhance, rather than substitute for, the elimination of emissions.
- **Ambiguity between removals and reductions could enable greenwashing and undermine public confidence in European climate action.** Countries, companies, and individuals can only claim "net zero" or "climate neutral" when they are fully compensating for all remaining emissions with removals. As a result, attempts to obfuscate which carbon projects create a removal versus a reduction could enable fraudulent and misleading claims.

The EU has already created the basis for maintaining the distinction between removals and reductions by establishing a cap on the degree to which the EU climate goals will be fulfilled by removals before 2030 (225 $MtCO_2$)[2], and reaffirming the goal to reduce the consumption of fossil carbon energy by 95% (an absolute emission reduction) by 2050[3]. It has also committed to climate neutrality by 2050, which implies net zero emissions of CO_2 *before* 2050, and net negative emissions after 2050. These goals can only be achieved by balancing any remaining emissions with the same (net zero) or more (net negative) removals.

In any framework for certifying high-quality carbon removal, two sets of activities must be excluded:

A Definition continues: "It includes existing and potential anthropogenic enhancement of biological or geochemical CO_2 sinks and direct air carbon dioxide capture and storage (DACCS), but excludes natural CO_2 uptake not directly caused by human activities"

1. Rapid recycling of atmospheric carbon is not removal – taking carbon out of the air, incorporating it into a fuel or product, and re-releasing that carbon within a short time horizon is NOT carbon removal. For example, Direct Air Capture (DAC) coupled with manufacture of synthetic sustainable aviation fuel may become an important solution for reducing emissions from air travel, but because the carbon is re-released rather than stored, it constitutes an avoided emission, not removal. **Carbon Capture & Utilisation (CCU),** is a broad category of climate solutions, some of which involve the capture of CO_2 from ambient air or industrial flue gases, and its utilisation in materials, fuels, or other economic uses (e.g., for fuel production, ingredients to food and beverages, fertilising greenhouses, etc.). If the carbon stays in a closed loop over many decades or centuries (such as when incorporated into structural timber or cementitious building materials), the method may be considered removal. In all other cases of CCU in which carbon is rapidly re-released to the atmosphere ("carbon recycling", part of a circular economy for carbon) must be excluded from the CRCF, as this only delays the emissions of CO_2 to the atmosphere. Note that the modular methodology design we propose below (see Section 2) would allow for the use of some methodology modules approved within a carbon removal certification framework, such as the capture step of DAC, in the separate certification of CCU in a circular economy for carbon, provided such certification is unequivocally clear that the action is not carbon removal.

2. Capture and storage of industrial emissions is not removal – The separation of CO_2 from flue gases and other industrial outputs coupled with the permanent geological storage of that carbon (e.g., on cement, steel, power plants, chemicals production, etc.) is widely considered conventional point-source **Carbon Capture & Storage (CCS).** When the origin of the CO2 is exclusively fossil or geological carbon (e.g., fossil fuels, limestone), not biogenic (originally extracted from air by plants) carbon, then this action is emission reduction, not carbon removal. Carbon from fossil sources captured and stored via CCS must not be certified under a carbon removal certification framework, as it does not constitute removal. In Europe, conventional CCS is separately supported by the Innovation Fund, and increasingly by higher European Emission Allowance prices. In some cases, part or all of the carbon from an industrial process may be biogenic (originally extracted from air by plants), such as in waste incineration (often up to 40-50% biogenic, though this may eventually decline as the economy becomes more circular), bioenergy (up to 100% biogenic), often called Bioenergy with Carbon Capture & Storage or "BECCS", or fermentation (up to 100% biogenic). Storing this biogenic CO_2 does in fact constitute carbon removal, therefore some CCS projects will generate a mix of emission reductions and removals.

All safe and effective methods for removing carbon from the air should be eligible for inclusion in a carbon removal certification framework, including the EU's forthcoming CRCF. Because new methods are continually identified and developed, transparent processes and selection criteria for admittance must be maintained by the governing entity of the CRCF.

Numerous early-stage researchers and startup companies are attempting to bring their nascent carbon removal methods to the market. While some receive support through Horizon Europe or Climate KIC (which supports the Swiss-based ClimAccelerator carbon removal incubator, for example), scarce resources must typically be devoted to demonstration projects, hiring new staff, and other operational costs. Rarely do smaller companies have the expertise, human resources, and funds to develop appropriately robust methodologies. To democratise access to the CRCF for such actors, the EU should provide dedicated funding for capacity building and support to cover the costs of methodology preparation for new, high-potential methods.

Removal methods are at significantly different stages of development, not only in terms of Technology Readiness Level (TRL) and maturity, but also in regards to levels of uncertainty when measuring removed carbon, and monitoring the carbon stored. These divergent "Measurement Readiness Levels" mean that certification schemes must keep some carbon removal methods non-fungible, that is, distinct and not considered interchangeable, while ensuring that these levels of measurement uncertainty are disclosed, and efforts to reduce uncertainty undertaken (see the next Section for a discussion of climate benefit uncertainty and a proposed solution to the carbon removal equivalence dilemma).

Guidelines, principles, standards, methodologies – the elements of a removal certification scheme

Carbon Gap welcomes the European Commission's stated intent to develop a carbon removal certification framework. The implicit goal is that this framework acts as a "European standard" to which individual carbon removal projects can be certified, according to methodologies contained within that framework and governed at the EU level.

Assessing the quality of an individual carbon removal project in a vacuum would be impossible. Instead, certification schemes rely on a hierarchical structure of ever-increasing granularity. This also allows certification frameworks to be developed in stepwise fashion, starting with high-level scoping and principle setting, before moving on to the critical details of the certification methodologies themselves.

At the top of the certification funnel are **"Guidelines",** wherein the intent of the certification scheme, the scope of what's included and what's not, and the use cases for certified removals are articulated. The Commission has already commented on all three through the Sustainable Carbon Cycles Communication and forthcoming proposal, and these will be debated and agreed over the course of 2023. Under Guidelines are **"Principles";** these define an overall quality floor for all carbon removal certified by the scheme (e.g., avoidance of unintended negative impacts), and governance principles to ensure the scheme is administered transparently. Next are **"Standards",** which are stamps of quality that can be recognised by specific policies or entities (e.g., on the Voluntary Carbon Market standards include "Verra", the "American Carbon Registry", and "Gold Standard"). There may be multiple standards for different purposes, for example an EU Voluntary Carbon Market standard and an EU Carbon Removal Compliance Standard, all housed within the same certification scheme. Finally, the smallest divisible components of the certification framework are **"Methodologies".** A methodology, sometimes referred to as a "protocol", is a detailed, often technical set of documentation and rules for a given carbon removal method laying out precisely how it is to be measured, monitored, verified, and certified. The same or similar methodologies may exist across multiple standards, for example a biochar methodology might be initially developed within a private company or cross-sector initiative, and later adopted by both a "European Carbon Removal Standard" (based on the CRCF) and a third-party standard such as "Verra", provided it meets the quality principle criteria of each. The table below shows the function of different levels of a certification scheme, predicted timelines for when each will be addressed in the EU, and the stakeholders involved in each.

How can the CRCF's development be phased?

Table 1.

		Actions In Each Phase	Stakeholders Involved
	Guidelines Defining the scope and intention of the certification scheme	• Defining what's in scope (e.g., "carbon removal only, all carbon removal methods") • Clarifying use cases (voluntary for now, eventually EU policy & regulatory regimes)	• Policymakers • Researchers • General Public
Agreed over 2023	**Principles** Defining the quality floor of all carbon removal certified by the scheme	• Quality principles (additionality, avoidance of indirect leakage, durability, do no harm, etc.) • Governance principles (transparency, conflicts, inclusivity of stakeholders from outside Europe where CDR projects are deployed)	• Policymakers • Researchers • General public
Developed or adopted in parallel to CRCF creation	**Standards** Defining a quality stamp with reference to quality criteria principles	• Each standard has a defined use (e.g., to make a net zero claim, to label a product "carbon-negative", to reward green buildings), and a set of methodologies approved under that standard • There will be multiple standards, some used to document & reward voluntary climate action and others used in compliance contexts	• Policymakers • Researchers • CDR providers • Purchaser representatives
Developed over 2023-2025, and updated on an ongoing basis	**Methodologies** Technical set of documentation and rules for a given carbon removal method as to how it is to be measured, monitored, verified, and certified	• Detailed, technical documentation defining a particular CDR method, either in its entirety (end-to-end) or modularly (extraction, conversion, transport & storage), with instructions for certification • Accredited 3rd-party certifiers can certify carbon removal projects against a methodology. Certified carbon removal is tracked on a central, EU database	• Researchers • Carbon Removal Marketplaces • Certifying entities • CDR providers • Verifying entities

Establishing carbon removal quality criteria

After establishing Guidelines (see Table 1), the next step for a carbon removal certification framework is to select the fundamental quality principles that will set the quality floor for all certified removals. For the CRCF, a quality floor for all certified credits can provide confidence to policymakers and other stakeholders that EU-certified CDR can eventually be safely integrated into policies and regulations without undermining the integrity of climate benefits being claimed. Carbon Gap proposes the following quality principles as central to any carbon removal certification effort:

- **Creates a real climate benefit**

  The certified removal must create a real, measurable climate benefit. This climate benefit is precisely measured with rigorous monitoring, reporting and verification methods. Climate benefit includes total greenhouse gas emissions and removals along the entire life cycle of the carbon removal method, as well as other climate-forcing effects such as albedo changes and release of aerosols, which is reported in both raw and CO_2-equivalent terms, and with the uncertainty of that estimate disclosed.

- **Low risk of non-additionality**

  When compensating for emissions, carbon removals need to demonstrate that they would not have occurred in the absence of human action, and relative to the current policy and common practices baselines. Risk of non-additionality is a spectrum, and must be estimated relative to a counterfactual in which the carbon project was not undertaken. This analysis is critical when the use of the certified removal is a compensation claim, but can be relaxed when physical fluxes of carbon are being measured for non-compensation claim based purposes, such as retroactively confirming the amount of carbon removed by an unrelated process.

- **Low risk of indirect carbon leakage**

  Carbon removal projects in one location often lead indirectly to additional emissions elsewhere. Such indirect carbon leakage needs to be precisely estimated and accounted for in the calculation of net climate benefit of the certified carbon removal.

- **Low risk of reversal (permanence / durability)**

  Carbon removed from the atmosphere needs to be stored away from the atmosphere for as long as possible, essentially in perpetuity, in order to continue generating a climate benefit (if a reversal occurs, the carbon once again causes warming). The risk of reversal varies among carbon removal methods and lower durability carbon removal still has substantial value. Critically, these risks must be predicted and monitored, with guarantees that an entity is held responsible for remediating stored carbon in the event of a reversal.

- **Well-accounted for**

  The certified carbon removal must employ a set of prescribed, high-integrity accounting principles. This includes preventing double-counting or double-claiming, and certifying on an ex-post (after delivery of the removal) rather than ex-ante basis. All necessary information on the certified removal, as well as relevant metadata, needs to be transparently accessible.

- **Avoidance of unintended impacts**

  The certified removal has to demonstrate that potential negative impacts on environmental and social well-being have been avoided. Some carbon removal methods, if implemented carelessly, may negatively affect essential public goods such as biodiversity or land availability, underlining the need to consider and limit significant harm to ecosystems and societies. In addition, certified carbon removals should not only avoid harm but bring non-climate benefits, for example bolstering ecosystem resilience and biodiversity.

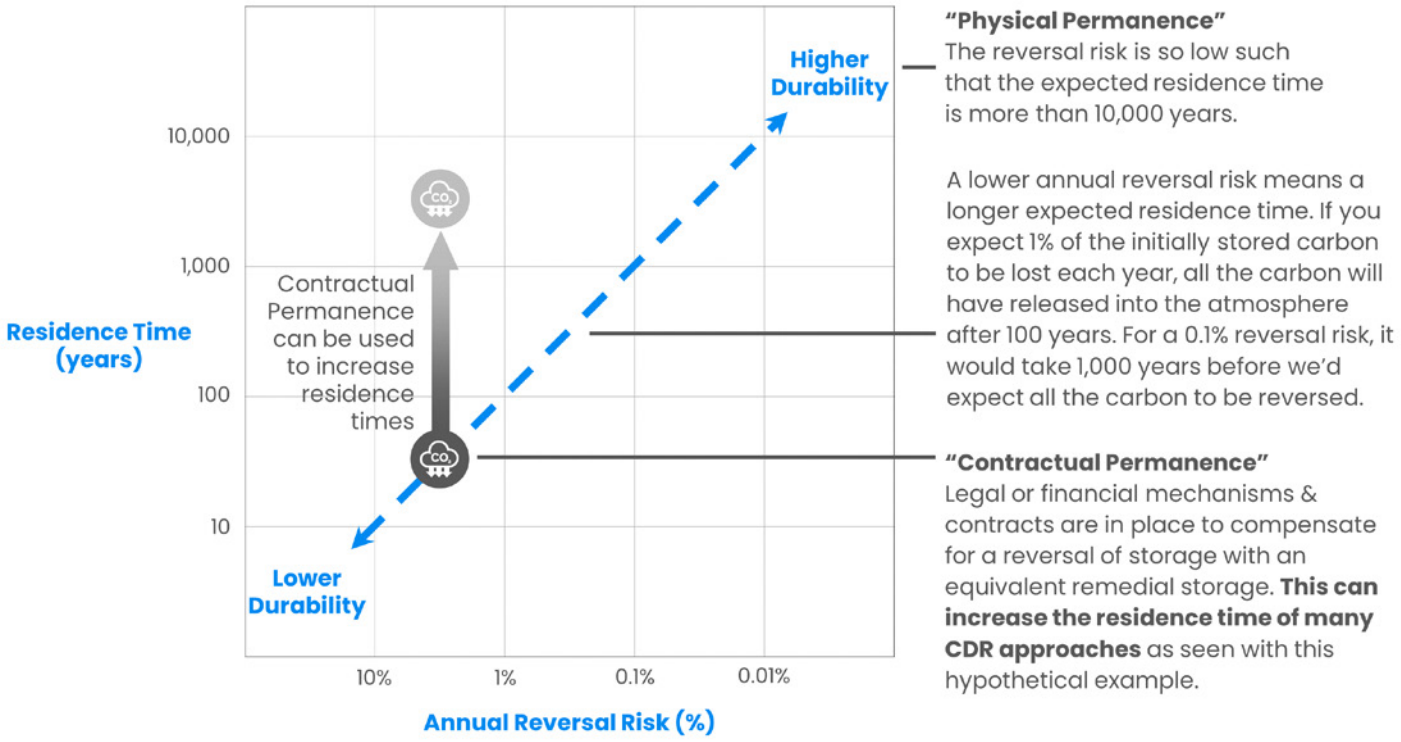
Separating removal methods according to the character of carbon storage

Carbon removal methods vary significantly in their strengths and weaknesses[4,5]. Of particular concern are the longevity and security of the stored carbon, since any reversal back to the atmosphere undoes the climate benefit of the removal. Second, we must also consider the total available "headroom" for carbon storage in a given sink. How much additional carbon can be stored in the land sector, versus in geological reservoirs, for example, and what does this mean for our reliance on future removal and carbon storage in that sink? This subsection will show that based on these two parameters, in practice a carbon removal certification framework must keep land-sector carbon storage (storage in the "biosphere", approximated by the European Commission's term "carbon farming") separate from longer-lived carbon storage such as mineralisation ("geosphere").

Reversal risk – A reversal occurs when stored carbon escapes and is released back into the atmosphere, nullifying the climate benefit that has been delivered by the initial instance of removal. Reversals can be non-anthropogenic ("acts of God", natural disasters such as wildfires, droughts, or disease outbreaks) or anthropogenic (caused by human misconduct or negligence, such as illegal logging). Note that climate change itself is increasing the threat of what were previously considered purely non-anthropogenic reversals, such as those caused by forest fires or extreme weather events. The "reversal risk" is an estimate of the expected magnitude and timing of reversals.

What is the difference between Permanence & Durability?

Figure 3.



The climate impacts of long-lived climate pollutants like CO_2 can span millennia, therefore any attempt to compensate for such emissions should in theory keep removed carbon out of the atmosphere for the same duration or longer. The terms "permanence" and "durability" are both used, sometimes interchangeably, to describe this ideal characteristic of stored carbon. We see a useful distinction between the two terms:

Permanence is an ideal state in which carbon remains stored in perpetuity. We can compare real-world examples of carbon storage against this platinum standard.

Physical permanence is approached when carbon is locked away from any reasonable exposure to reversal risk, such as mineralised carbon in deep geological reservoirs. Physical permanence relies on fundamental chemical and physical characteristics.

Contractual permanence is the use of legal or financial mechanisms to ensure that any reversal is remediated. An insurance product for stored carbon, a legal liability on the part of an assigned steward to restore any reversed carbon, or a guarantee from government that it will take on responsibility for remediating future reversals are all examples of efforts to ensure contractual permanence. Contractual permanence relies on faith in long-lived human institutions.

Durability describes a physical characteristic of stored carbon. It indicates the risk of physical reversal of the stored carbon back into the atmosphere, expressed as an annual risk. Durability is a spectrum from very high (e.g., 0.01% annual reversal risk approximates to 10,000 years expected storage time) to low (e.g., 10% annual reversal risk approximates 100 years of expected storage).

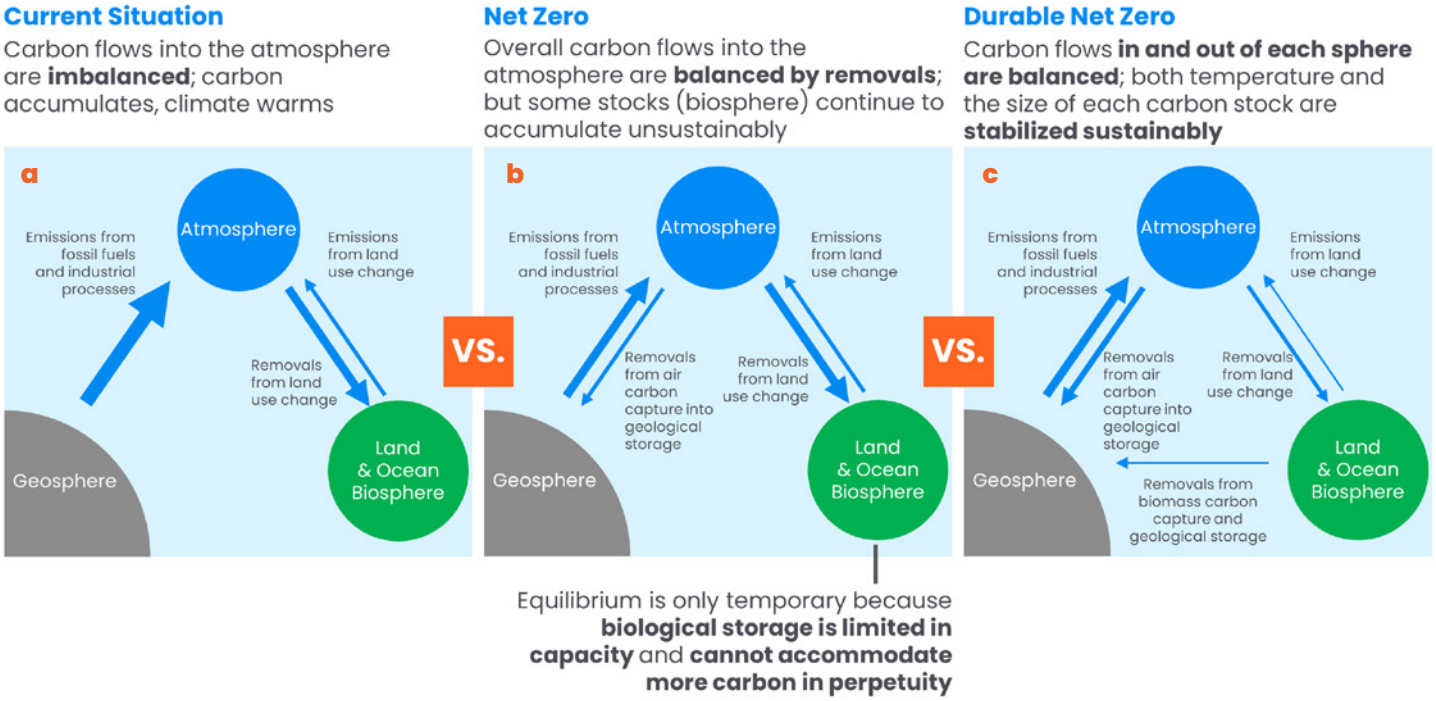
It is difficult to alter the durability of a carbon removal method, but we can improve contractual permanence through ever-improved legal and financial guarantees. The figure above shows this concept in action. A forest might be determined to have a moderate to low durability (an estimated annual reversal risk in the order of 1-10%), but could be confidently considered "contractually permanent" if sufficient safeguards to preserve forest cover in perpetuity are in place and backed by strong, long-lived institutions.

In practice, we must maintain a high-level distinction between carbon storage that is exposed to the constant moderate to high reversal risks of the short-term carbon cycle (forests, soils, peatlands, short-lived wood building materials), approximated by the "biosphere", and carbon storage which is isolated from the short-term carbon cycle, approximated by the "geosphere".

This distinction is also important in setting our net zero goal and creating a framework for legitimate net zero claims. "Net zero" is simply the balancing of emissions with

Not All Net Zeros are the same...

Figure 4.



removals; not all net zero states are the same or equally desirable. The term "net zero" alone does not specify the ongoing volume of emissions, their type (fossil or biogenic), or the destination of removals used to compensate for them (geosphere, biosphere, etc.).

The biosphere has a finite headroom in which additional carbon can be stored. One way of thinking about this is that global soil and forest carbon levels have dropped significantly over thousands of years due to human land conversion and exploitation, and we must at a minimum restore those landscapes to their previous levels. Eventually, ecosystems "saturate" and reach equilibrium, unable to accommodate more carbon. Estimates of total additional carbon storage capacity in the biosphere are difficult, since they require assumptions about future available land area, which is in competition for food & fibre production and habitats for biodiversity, but at estimated maximum rates (on the order of 5-10 $GtCO_2$/yr), saturation could occur within 25 years[6,7]. The geological carbon sink also has finite storage capacity, but the available headroom is orders of magnitude larger than the biosphere[8]. Of further concern is the risk that the **biosphere may flip from a net carbon sink to a net carbon source** as a result of climate change itself. Estimates of increased rates of the **release** of carbon from the biosphere by mid-century, for example through thawing tundra, changes to tropical forest carbon fluxes, or increased wildfires, are similar in size to optimistic estimates of how much carbon the biosphere could **absorb**[9].

It is therefore possible that all available biosphere carbon storage capacity will be required to be filled, simply to prevent the global biosphere from further exacerbating global warming, leaving no additional capacity to compensate for ongoing fossil fuel emissions.

For this reason, Carbon Gap's position is that fossil fuel emissions (which represent the introduction of carbon, that had been securely stored in the geosphere, to the atmosphere) can only be compensated for with return of carbon to the geosphere. The biosphere must be restored and returned to previous levels of carbon storage. Carbon Gap supports the pursuit of "durable net zero", which could be applied at the global, European Union, sectoral, and company levels. Durable net zero is a state in which emissions have been reduced as much as possible (minimising the need for removals), and where the amount of carbon leaving the geosphere and biosphere is balanced by removals that return carbon to the geosphere and biosphere, respectively[5,10]. The figure above illustrates the concept with three states. Panel a) shows our current situation: a massive outflow of carbon from the geosphere released directly into the atmosphere, causing climate change. In Panel b) emissions have been dramatically reduced, removals scaled up, and the excess accumulation of carbon is being temporarily taken up by the biosphere. This is an unsustainable net zero state because the biosphere will rapidly reach saturation; it amounts to

the temporary conversion of fossil fuels into biospheric carbon. Panel C) shows a durable net zero state, in which extraction of carbon from the geosphere and biosphere is matched with removal and storage of carbon back into the geosphere and biosphere respectively, like-for-like.

For the two reasons discussed – 1) dramatically different reversal risks and 2) different degrees of "headroom" for further carbon storage – we recommend **maintaining clear distinctions within carbon removal certification frameworks based on the character of stored carbon.**

Egregious examples of claims to compensate for fossil fuel emissions with less secure storage of carbon in natural ecosystems are increasing in frequency, and when identified have been roundly rejected by the public[11,12].

Such claims amount to storing fossil fuel carbon emissions in at-risk aboveground biomass, and are incompatible with the direction of the EU climate framework on at least two counts: 1) they violate the separate consideration of LULUCF emissions and removals from industrial emissions and removals, and 2) they erode boundaries between "fossil", "biogenic", and "atmospheric" carbon types, which the 2021 Sustainable Carbon Cycles communication proposes be separately labelled, tracked, and accounted for within the EU by 2028 at the latest. Moreover, claiming to compensate for fossil fuel emissions (emissions which exacerbate global warming for decades and centuries) with biogenic carbon storage (where long-lived storage is not guaranteed) risks undermining public confidence in critical carbon management solutions overall.

2. Onboarding Carbon Removal Methods

Recommendations:

- **Create a framework for measuring the level of certainty** associated with a net climate benefit
- **Keep fundamentally different carbon removal methods distinct** to resolve the "carbon removal equivalence dilemma"
- **Use a multi-tier system for onboarding methodologies into a carbon removal certification framework** with progressively higher confidence in the climate benefit delivered as metholodies develop
- **Allow for modularity in carbon removal methodologies,** representing the extraction/capture, conversion, transport, and storage steps
- **Allow the certification framework to both unilaterally develop methodologies, and source existing methodologies from other certification frameworks,** both public and private sector, subject to review and revision

A carbon removal certification framework is a container within which specific approved carbon removal methodologies reside. Each methodology describes in detail how a specific carbon removal method is to be measured and verified. For a methodology to be approved and onboarded into a certification framework, it must adhere to a set of principles defining a high-quality floor (see Section 1). However, each carbon removal method is unique and has different quality characteristics, making one-for-one comparisons difficult. As discussed in the previous Section, the character of the carbon storage is a particularly important differentiator, which necessitates keeping higher-durability removals (loosely analogous to geological and mineralised carbon storage) and lower-durability removals (loosely analogous to removals in the land-sector, labelled as "carbon farming" by the Commission) separate.

In this Section, we first acknowledge the fact that certainty of climate benefit is a spectrum. We next introduce the "carbon removal equivalence dilemma", which confounds our ability to treat all carbon removal methods interchangeably. Third, we propose as a solution to this dilemma a three-tier system for sequentially onboarding and iteratively improving methodologies, each tier representing a higher certainty of climate benefit. Fourth, we argue for a "mix-and-match" modular approach to assembling carbon removal methodologies. Fifth and finally, we discuss how methodologies can be sourced from the market or developed from scratch to be onboarded into a carbon removal certification framework.

Certainty of climate benefit is a spectrum

Carbon removal projects have many different quality attributes (see Section 1), such as impacts on human health and livelihoods (e.g., increased / decreased revenue for farmers) and impacts on nature (e.g., enhanced / reduced ecosystem resilience or biodiversity). These non-climate and climate-adjacent impacts must be measured and disclosed. Negative impacts must be avoided wherever possible, and positive impacts must be celebrated and valued explicitly (through dedicated incentives, such as the Common Agricultural Policy's "greening" incentives for adopting practices that enhance biodiversity and ecosystem integrity) or at the very least disclosed (allowing voluntary buyers or governments to offer differentiated pricing based on their own values and priorities). All certified removals must meet a set of minimum quality criteria, which sets a quality floor.

However, on top of having cleared the quality floor bar, the key determinant of the integrity of certified carbon removal for policymakers, corporate buyers, and the public alike, must be the degree of certainty that a **climate benefit** has been delivered. The climate benefit of a carbon removal project is approximated by the amount of CO_2 that has been removed from the atmosphere and safely stored (other climate impacts, such as changes to albedo and emissions of non-CO_2 gases, must also be included). It must be both estimated upfront as part of the certification process and measured and validated on an ongoing basis over the duration of the project, and ideally in perpetuity. This climate benefit is inherently uncertain, and some carbon removal projects will carry a higher degree of uncertainty than others. Three carbon removal projects, for example direct air capture, reforestation, and soil carbon sequestration, may each be shown to have removed 1 tCO_2, but have different degrees of certainty associated with that claim. The degree of **certainty that a climate benefit has been delivered** rests on:

1) The precision of measurement of the total amount of CO_2 removed by the project.
Example: DACCS – very high, forestation – high, soil carbon sequestration – low at present.

2) The degree of indirect carbon leakage induced by the project.
Example: beef pastureland in an EU Member State is replaced with forest cover for the purposes of a reforestation project. Global beef demand remains constant, and the lost production shifts to another region. The degree of indirect leakage depends on the efficiency of production of the displaced activity. This can be calculated using the Carbon Opportunity Cost framework[13].

3) The estimated risk that some or all of the stored carbon will reverse back into the atmosphere.
Example: For geological storage of removed carbon (e.g., DACCS), dissolved CO_2 mineralises into rock over time and becomes immobilised. Expected reversal risks can be on the order of 0.01% per year[14,15]. For land-based carbon storage, reversal risk varies widely as a function of a range of local risks (drought, fire, disease, pests, illegal land clearing or biomass harvesting).

The required standard of precision for estimating the climate benefit of carbon removal, and how this removal is used, are inextricably linked

When carbon removal is used to claim compensation for emissions elsewhere, the character of the stored carbon must be commensurate with the emission that is being compensated for (see Section 1), and the certainty of climate benefit must be very high. Due to their finality, compensation claims require a much higher level of certainty that a climate benefit has been delivered, since the claimant is being "let off the hook" for the emissions they claim to be compensating for. In a voluntary context, this means they have dealt with compensated emissions once and for all, and they can tout those green credentials. In a compliance context, the regulating entity waives the right (or at least the social licence) to subsequently hold the claimant accountable for those emissions again. Contribution claims, in which the funder simply claims to have financially supported a positive activity without matching those removals against their own emissions, provide much more flexibility.

When carbon removal is not used in compensation claims, and is instead incentivised through other means (see Section 4), the level of certainty required could potentially be relaxed. Examples in which no compensation claim is made by any entity (neither corporates nor governments), and where highly-precise measurement of climate benefit may be less critical, could include: instances where the intended primary outcomes are climate-adjacent benefits (e.g., enhanced soil health, enhanced biodiversity), the piloting of a new carbon removal method, or funding to improve a dataset to upgrade Monitoring, Reporting, & Verification (MRV) capabilities. Particularly for nascent carbon removal methods, building robust MRV capabilities can become a self-fulfilling prophecy: the more we experiment and incentivise the activity, the more data can be collected, allowing for improved monitoring methods.

The carbon removal equivalence dilemma

Some stakeholders, and particularly proponents of a liquid voluntary carbon market for removal credits, are interested in making all certified carbon removal credits equivalent: "a ton is a ton". There are two interpretations of this approach, which generate dramatically opposing results:

"Quality over scale" – In one interpretation of equivalence, for carbon removal to count it must deliver a climate benefit with an extremely high certainty climate benefit, highly precise measurement, and ultra-long-lived storage (e.g., exceeding the long-lived nature of the atmospheric CO_2 that is being eliminated). This level of rigour is currently only achievable by carbon removal methods employing high-durability storage of carbon, such as with Direct Air Capture with Carbon Storage. Requiring land-based carbon removal methods, such as soil carbon sequestration, to adhere to a DACCS-like level of precision would have the effect of dramatically increasing MRV costs, and possibly ruling out such removal methods from consideration entirely. For example, it may simply be impossible with today's level of understanding of soil carbon, and lack of ironclad safeguards ensuring that carbon removed and stored in soils stays there, to generate a soil carbon credit that is one-for-one comparable to a DACCS credit. The market outcome would be the dominance of a small supply of high-quality, but expensive carbon removal. Companies hoping to buy carbon removal to compensate for their emissions but unable to afford the high costs would see the market as "supply-constrained", shocked at the lack of more affordable options. In contrast, carbon removal providers would see it as "demand-constrained" since not enough companies have the requisite willingness or ability to pay multiple hundreds of euros per ton of CO_2. Supporters of this approach include much of the carbon management research community, and environmental NGOs concerned about the inappropriate use of inexpensive, lower-certainty carbon removal credits to compensate for fossil fuel emissions.

"Scale over quality" – In an alternative interpretation, removals are assumed to be equivalent if they can clear a relatively low bar for certainty of climate benefit. For example, DACCS would be held to the level of precision possible with soil carbon measurement rather than the other way around. In this scenario, more expensive removal options have no way of distinguishing themselves from lower-cost options, since all removals are considered equivalent. The market outcome would be the dominance of a large supply of low-cost, relatively low-durability storage carbon removal credits. Nascent carbon removal methods and mature but higher-durability carbon storage options would be unable to compete, deployment would be minimal, and cost reductions from learning-by-doing would not materialise. Funding for land-based carbon management strategies would increase, but at the cost of corporate buyers making potentially dubious claims to have compensated for their fossil fuel emissions using land-based carbon storage. Accusations of greenwashing could lead to public disillusionment with the entire carbon removal certification framework. Supporters of this approach include carbon market participants who want to ensure the market remains liquid and not supply-constrained, corporate buyers who want to make compensation claims as cheaply as possible,

and researchers or NGOs who prioritise the biodiversity crisis and want to increase finance flows toward conservation, even on the back of tenuous compensation claims.

Clearly, full equivalence of either flavour is undesirable. **The solution is to carve out separate categories for different removal types, according to the storage and durability distinctions proposed in Section 1, and ensure they are used differently.**

A tiered approach to methodology onboarding

Carbon Gap's proposed solution to the carbon removal equivalence dilemma is to construct a carbon removal certification framework with a system of three methodology tiers (summarised in Table 2): 1) Recognised methods, 2) Pilot methods, and 3) Established methods.

Recognised method – A status awarded to a carbon removal method that shows promisein terms of its potential, but that is at an early stage in terms of demonstrating high-certainty climate benefit. Such recognised methods should be nascent but ready to absorb dedicated support to answer outstanding questions of effectiveness and public acceptability, or to deploy pilots. Such methods are considered officially "recognised" by the European Union and on a trajectory toward certification and possible transition into an established method recognised in European policy regimes. Funding would be made available for pilots to collect data to feed into methodology development so they can be iteratively improved. The CRCF governing agency would create clear and transparent criteria specifying what is required before moving to the next tier. As soon as a carbon removal provider, researcher, or other stakeholder has a pilot methodology prepared (perhaps with funding or expert support from the CRCF) and ready to submit for review, they are free to do so for consideration in the next tier.

Pilot method – A status for carbon removal methods that are expected to eventually become an approved compliance tool in Europe's climate policy landscape, but for which certainty of climate benefit remains low to medium. Practitioners of "recognised methods" can develop and submit a proposed methodology for review by the CRCF's scientific advisory board, who then determine if it meets the published criteria for a "pilot methodology". If no suitable submissions for a given strategically-important method are forthcoming, the CRCF governing agency should be resourced and empowered to unilaterally develop pilot methodologies itself. Pilot methodologies generate provisional certificates with some restrictions on use, for example exclusion from most compensation claims on the voluntary carbon market or within EU policies (e.g., EU-ETS).

Established method – Once a pilot method has demonstrated a decrease in uncertainty of climate benefit to an agreed level, and MRV techniques have been demonstrated in situ across a variety of deployed pilots and projects, it can apply for approval as an "established method". This status grants the method eligibility for possible incorporation into EU climate compliance regimes (e.g., CBAM, EU-ETS, and perhaps even use in project-level verification of government net emissions accounting, such as in National Inventory Submissions). Critically, only established methods would be intended for use in backing voluntary compensation claims for fossil fuel emissions made in Europe. This could be realised through regulation on permissible green claims (e.g., in Europe, the Sustainable Products Initiative). Some carbon removal methods may be suitable for developing high-certainty methodologies and applying to become established methods from the CRCF's launch. These may include forestation[B], storage of waste biogenic CO_2 (e.g., from wastewater treatment), Direct Air Capture with Carbon Storage, etc.

The tiered approach allows us to avoid the carbon removal equivalence dilemma. It is likely possible to rapidly develop a DACCS methodology with a very high level of certainty that a climate benefit has been delivered. Absolute measurement of the volume of carbon removed, and ongoing monitoring of stored carbon to guard against reversals, are well understood. At the moment, it is likely not possible to develop a soil carbon sequestration methodology with a comparable level of certainty of climate benefit. Doing so would require fundamental scientific advances in monitoring and absolute measurement of soil carbon levels, and lower-cost, more scalable MRV methods. The certification of soil carbon sequestration should nevertheless be urgently enabled so as not to stifle deployment, but aware of the lower threshold of certainty that a carbon benefit has been delivered. This makes soil carbon sequestration a strong candidate for being a "pilot method", for which compensation claims on the basis of the removed carbon would not yet be permitted, but more forms of support (both voluntary and compliance) should be unlocked. Uncertainty can be reduced over time as data is collected and the methodologies are iteratively improved, and users of the CRCF (governments, companies, individuals) can make environmental claims that are appropriate based on the current level of certainty.

Modular carbon removal methodologies

An end-to-end carbon removal methodology consists of several modules: 1) extraction from air (either directly or indirectly, such as in the case of biomass), 2) for some methods, carbon must be converted into a storable form (e.g., combustion of biomass into CO_2), 3) transportation (if necessary), and 4) storage. Each methodology in the CRCF

B We use "forestation" to encompass both "afforestation" (the planting of forests on land that has not been forested since some defined date) and "reforestation" (restoring a forest cover on land that was previously forested since some defined date). From a carbon standpoint, the two can share common methodological elements (setting a baseline and measuring the increase in carbon as trees grow). But note that "afforestation" engenders controversy and can cause unintended consequences related to the use of non-native species, unsustainable monocultures, and potential infringement of land rights. In general, reforestation is more acceptable and sustainable. Forestation methodologies must ensure that these non-climate considerations are addressed and negative impacts prevented.

How can methodologies be developed, onboarded, and improved?

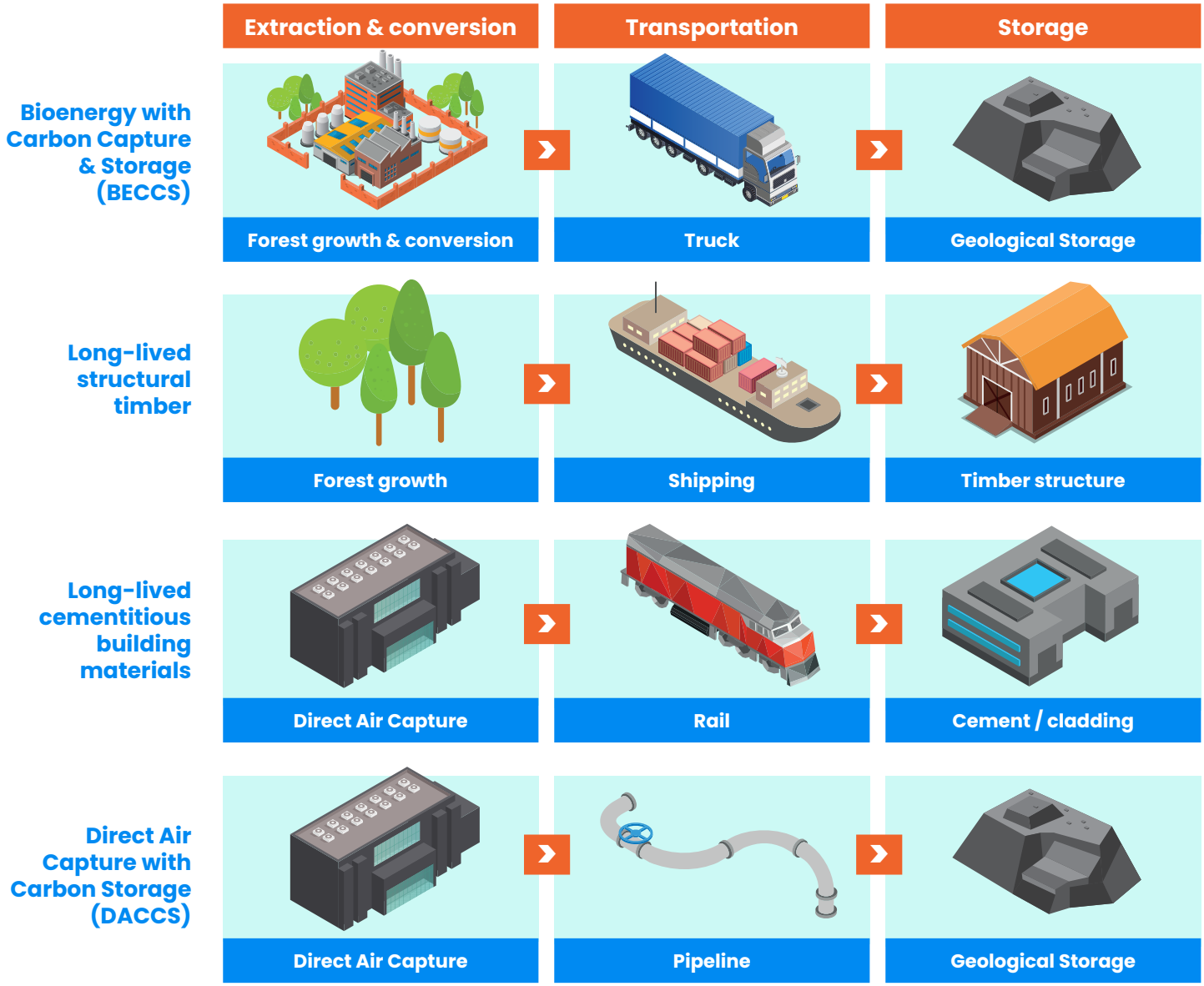
Table 2.

	Unecognised Methods	Recognised Methods	Pilot Methods	Established Methods
Criteria Qualities and stage required for a method to fit into each tier	All carbon removal methods start here. They meet the definition of carbon removal, but are not under active consideration for certification under the CRCF. Outstanding scientific questions or public acceptability may prevent movement to "recognised methods"	• Scientific pathway for removal well-defined, demonstrated at lab-scale • Ready for pilot and demonstration deployment • High-level adherence to quality principles • Preliminary evidence for public acceptability	• Significant successful demonstrations completed • Moderate confidence in potential for scale • Strong evidence for public acceptability	• Certainty of carbon benefit demonstrated to exceed an agreed threshold • Robust and tested methodology available • Public acceptability confirmed
Permitted Uses Ways in which certified removals can be used in voluntary and compliance contexts	Eligible to receive Horizon Europe and other innovation and research funding to explore viability.	• Eligible to receive dedicated funding for research, methodology development, and pilot deployment. • Support via *contribution claims* encouraged for voluntary buyers.	• Eligible for public support for larger-scale demonstrations with data collection to resolve outstanding MRV questions • Support via contribution claims encouraged for voluntary buyers • Limited incorporation into EU policies that are not compensation based (e.g., farm-level process-based certification)	• Compensation claims permitted in a voluntary carbon market • Eligible for direct incorporation into EU policies as a means of compliance
Example Methods of Higher-durability storage		**Offshore kelp sinking** – high potential for scale, still building evidence of efficacy. Some marine mammal and benthic ecosystem concerns.	**Biochar** – diverse variety of production methods & storage pathways (terrestrial spreading, burial, incorporation into products) with varying efficacy	**DACCS** – relatively straightforward pathway to measurement, pending guidance on appropriate life cycle assessment boundaries for carbon removal
Example Methods of Lower-durability storage			**Soil carbon sequestration** - potential for scale at low cost, measurement capability immature, storage security dependent on new legal frameworks	**Reforestation** – relatively robust MRV capability, provided strong legal guardrails are in place to ensure remediation of reversals

should clearly identify its constituent modules, and modules could be reused across methodologies where possible. For example, a common "saline aquifer" **storage module** (e.g., following the EU CCS Directive) could be used across multiple CDR capture methods: i) direct air capture, ii) carbon capture from fermentation processes, iii) bioenergy with carbon capture, iv) many more; any module that yields pure CO_2.

Viewing methodologies in terms of modularity

Figure 5.



A shared "sorbent-based DAC" **capture/extraction module** might be used across several methodologies: i) conventional DACCS, i.e., linked with geological storage, ii) linked instead with a storage module for creating stable polymers from the CO_2, to be used as long-lived building materials. A shared "forest growth" **capture/extraction module** would be relevant across innumerable full-chain carbon removal methods, from the simplest case of forestation to instances of BECCS or biochar production using forest biomass as an input. Figure 5 shows different combinations of modules, each forming a complete full-chain carbon removal method.

Modularity of methodologies is also critical for resolving carbon removal's transborder issue. Many carbon removal methods will span multiple countries. Consider the hypothetical example of biomass harvesting in Sweden (capture/extraction), combustion for energy in Norway (conversion), with transport to Iceland for storage. Only one unit of carbon benefit can be claimed in total across those three countries, which may require that these countries enter into contracts to confirm how corresponding adjustments will be made, giving investors and carbon credit buyers confidence that the climate benefit is unambiguous and not claimed more than once. Having distinct modules for each step will assist in making the chain of custody of CO_2 clear and determining at which stages climate benefit is traded or transferred. Several carbon removal projects and demonstrations already involve this issue: Switzerland's DemoUPCarma demonstration project involves extraction

both inside and outside of Switzerland (biomass from multiple sources), conversion in Switzerland, transportation through the EU by truck and rail, and storage in Iceland. Stockholm Exergi's forthcoming BECCS district heating plant involves extraction inside Sweden (though biomass could be sourced from elsewhere), conversion in Sweden, and storage most likely in Norway.

Note that although a carbon removal certification framework must necessarily omit any non-removal activities (see Section 1), methodology modularity would mean that specific modules originally developed for the capture step of emission reduction project types could be adapted for use in the removal certification scheme, and vice versa.

Sourcing or developing methodologies

With the above Guidelines, Principles, a tiered system for Methodology onboarding, and the governance structure described in Section 3 in place, a carbon removal certification framework will be robust enough to both develop its own methodologies and to solicit, review and incorporate outside methodologies from other certification frameworks or actors. Carbon removal methodologies are being developed at multiple levels, including by various supra-national, national, and sub-national governments, independent research groups, multiple private sector initiatives, and even by carbon removal practitioners and suppliers. The CRCF should take advantage of these early movers, building on the quality work already conducted, and learning from the mistakes identified.

Europe is a clear leader in providing best-in-class regulation and certification frameworks that have substantial extra-territorial impact. Continuing in this tradition, the CRCF can be a leading beacon of high-quality carbon removals, a stamp of approval that is globally recognised. By creating an attractive certification hub, the Commission can use the CRCF as a centre of gravity to attract the best methodologies and initiatives. Critically, the process for submitting a methodology for consideration by the CRCF will need to have a transparent set of requirements and review processes, and be as low-friction as possible, including low administrative costs and fast turnaround.

A non-exhaustive list of promising initiatives and sources to coordinate with on carbon removal certification include:

Governments:

- **Canada** – Has strong geological storage methodologies, and actively working on other methods
- **Norway** – Offshore CO_2 storage already a means of reducing carbon tax liability
- **Sweden** – Developing Bio-CCS methodologies for use in its carbon removal reverse auction scheme
- **Switzerland** – Dedicated resources to methodology development and review, tied to use in a compensation-based low-carbon fuel policy
- **United States** – Both Federal (Section 45Q tax credits) and State (California Low-Carbon Fuel Standard, forthcoming policies in New York) incentives

Private-sector initiatives: C-Capsule, CCS+, Puro, legacy carbon credit standards (Gold Standard, Verra, etc.)

Individual companies or organisations: Several CDR companies have eschewed existing certification initiatives and worked to develop their own methodologies (e.g., Charm Industrial, Project Vesta, etc.)

Research programmes: UK-funded CO_2RE, EC-funded NEGEM, German-funded CDR Terra and CDR Mare, Swiss-funded DemoUpCARMA, etc. are all conducting research or demonstrations that pertain to carbon removal MRV and certification.

3. Effectively Governing Carbon Removal Certification

Recommendations:

- **Empower an agency to transparently maintain and administer the CRCF**
- **Enshrine science-led governance** by separating unconflicted experts from market participants, both of whose expertise is valuable
- **Default to open source.** Data & findings from CDR deployments are a public good
- **Maintain a transparent, open-access database of certified projects** that documents which claims are made on the basis of EU-certified carbon removal

Opportunities:

- **Establish an open registry of scientific gaps** which, if bridged, would improve CDR MRV for the world
- **Seize the opportunity for global leadership** and spearhead multilateral coordination to enshrine interoperability and common global principles

Activities that remove carbon from the air have the potential to permeate society, from forestation and soil carbon sequestration to the incorporation of carbon throughout our built environment. Moreover, how carbon removal is measured and certified, despite being a predominately scientific question, has the potential to become contentious when the implications affect Member States' economic opportunities and their ability to cost-effectively deliver their contribution toward European climate goals. Transparent, fair, and scientifically rooted governance of carbon removal certification frameworks like the CRCF is therefore paramount to ensure legitimacy and separate political considerations from the fundamental question of how much carbon is removed, and for how long.

In this Section we first propose how an agency that administers the CRCF could be governed in order to strengthen public confidence, and propose some of its key functions. Second, we highlight Europe's potential to act as a global leader on carbon removal certification, including seizing two immediate and high-impact opportunities:

1. Establish a shared registry of scientific gaps to improve MRV and guide global research priorities.
2. Kickstart and guide multilateral coordination on CDR MRV and certification.

Empower an agency to transparently maintain and administer the CRCF – The task of evaluating, onboarding, or developing methodologies to enable certification of each CDR method is a daunting task requiring a broad array of expertise, on top of fulfilling the additional functions described below. The CRCF needs a long-term home, perhaps as a part of the European Environment Agency which already administers schemes which share some similarities with the proposed CRCF, such as the EU-ETS. Critically, the CRCF governing agency must be sufficiently resourced over the long-term to provide the below functions to a high standard.

Ensure scientifically-rooted, non-conflicted governance – At every level of the CRCF (see our table on Guidelines, Principles, Standards, and Methodologies in the Section 1), from defining high-level guidelines and quality principles to amending the details of a specific methodology, decision makers must remain vigilant to the risk of compromising environmental integrity to expand market access to more market participants (including both carbon removal *providers* and carbon removal *purchasers*). Given that certainty of climate benefit is a spectrum, and given the "carbon removal equivalence dilemma" (see Section 2), setting the appropriate level of rigour for evaluating carbon removal project quality will remain a complex decision necessitating deep expertise from a variety of scientific and technical fields, including soil science, forestry, agronomy, materials science, geology, life cycle assessment, carbon market design, and many more.

Climate groups and policymakers alike have legitimate concerns about the use of carbon removal in European climate policy, from the potential for mitigation deterrence to the threat of fraudulent green claims and greenwashing based on carbon credit purchases. It is therefore critical that decisions on quality principles, onboarding new methodologies, guiding methods through the tiered system (see Section 2), and guidance on appropriate claims using certified carbon removal be taken by an unconflicted expert board representing a range of disciplines.

We recommend an independent governance board composed of scientific and technical experts without ties to market participating entities – We further recommend a mechanism for utmost transparency and documentation of the input gathered and final decisions made, including the freedom of individual members to disclose instances where final decision-making by the governing agency differs from their recommendations. This independent board must be sufficiently resourced, for example with a high-quality secretariat, support staff, and potential financial support in extraordinary cases to enable the secondment of experts on a full-time basis depending on current needs.

Gather valuable expertise from market & industry participants through a parallel, non-governing group – Many expert individuals and organisations have experience which could be valuable in governing the CRCF, including from having operated voluntary carbon markets and exchanges, certifying carbon projects, to the financial and technical knowledge required to build and operate removal, transport, and storage infrastructure. To avoid the presence or perception of conflicts of interest, the role of these market participants in the governance of the CRCF must remain as a source of recommendations and input only, not as an approval body. Whether such conflicts are real (that is, influencing decision-making) or perceived, they threaten to irreparably damage the credibility of the CRCF and European climate action more generally.

The Commission has begun forming an Expert Group already to facilitate the creation of the CRCF, which draws on both independent expert voices as well as experts with a previous or current participation, or future likelihood of participating in commercial activities that are adjacent to one or more carbon removal methods. When the CRCF is formed and this Expert Group has served its purpose, independent expertise can then be reorganised between: 1) an independent, science-first board with decision-making capabilities, and 2), an independent advisory board inclusive of market participants with the ability to make recommendations.

Open-source data and methodologies – The CRCF should require disclosure of as much non-commercially sensitive data and findings as possible for global benefit. Climate change is a global challenge, and lessons learned by iteratively improving CRCF-approved methodologies through the tiered system will be valuable in non-European countries. All methodologies on the CRCF should be open-source and free-to-use around the world, allowing European regulatory leadership to emerge.

Maintain a transparent and open-access database to track certified removal projects, including how those projects are used – One role of the agency that houses the CRCF will be to maintain a registry of all certified carbon removal projects on an ongoing basis. Some projects will package the certified amount of carbon removed into carbon credits, tradable units each representing a 1 tCO_2 climate benefit with some level of certainty associated with that benefit, as well as a list of characteristics and non-carbon attributes. Other certified instances of carbon removal will remain certified at the project level without allowing for their use in a carbon market (see Section 4 on the importance of expanding the scope of certification to use cases that do not involve carbon credits and compensation claims). In either case, if the certified carbon removal is used to make a compensation claim (e.g., by a voluntary purchaser of a carbon credit) the carbon credit will need to be retired (marked as "used" on the registry so that it cannot be used in a compensation claim a second time). The entry and all associated metadata and transaction history must remain on the registry in perpetuity. Distributed ledger technology and public-private key cryptography could be implemented to preserve pseudonymity of the buyers and sellers of the credit, if such a design feature were required and requested by the Commission. In the event of a physical reversal of the stored carbon back into the atmosphere (e.g., a forest fire) or a substantial revision to the climate benefit calculation methodology (e.g., a dramatically new understanding of the amount of indirect carbon leakage created by the carbon removal project), the credit would become void and need to be remediated or replaced by a new credit.

We now turn to two key opportunities for the European Union to provide global leadership as a frontrunner on CDR MRV and certification.

Establish an open registry of scientific gaps – As the first high-profile, government-led, and comprehensive carbon removal certification scheme, the CRCF can play a critical role as a definitive clearing house for unresolved scientific questions that, if resolved, would enable more precise climate benefit calculations in carbon removal methodologies. As discussed in Section 2, certainty of climate benefit is a spectrum, not a binary determination. Some carbon removal methods cannot currently be quantified as precisely as others, due to technological limitations or fundamental gaps in knowledge. We propose the creation of a "carbon removal accounting hit list" of outstanding scientific questions with particular relevance to improving the precision of carbon removal measurement.

This registry would be open to submissions from the scientific community, other governments, and carbon removal providers who are closest to these challenges. The entries on the registry would be prioritised by the independent scientific governance board described above, according to the estimated improvement in precision that their resolution would allow, and the estimated potential for carbon removal among the CDR methods that rely on these findings.

Carbon Gap recognises that climate action across a wide array of removal methods is too urgent to await a uniformly high-confidence ability to establish certainty of climate benefit before attempting to pilot a CDR method (the carbon removal equivalence dilemma). A degree of flexibility is required to allow lower-certainty methods the opportunity to be deployed, initially on a pilot basis but with an eye toward scale once safety and public acceptability are ensured in Europe. We believe this is possible through the methodology tier system proposed in Section 2, which requires Established Methods for making compensation

claims, while Pilot Methods and Recognised Methods place a greater emphasis on improving the precision of their methodologies. The goal should be perpetual improvement of methodologies by resolving lingering sources of uncertainty. Research funding and attention can be directed toward those methods with the highest total removal potential and a high number of unresolved scientific questions, and should be designed to yield rapid outcomes.

Other important features and considerations for the open registry include:

- The CRCF-administered "hit list" would form a valuable set of input for Horizon Europe and other European funding programmes and agencies to allocate research resources accordingly for highest impact.
- Creative funding models could be used to promote urgency and outcome-oriented research, for example by involving carbon removal providers (who have a shared interest in accurately measuring their carbon removal) and philanthropic and corporate funding partners (provided non-conflicted governance is retained).
- Feedback mechanisms are required to ensure that findings from rapid research sprints are used to update CRCF methodologies on an "as discovered" basis. For example, grants could be awarded on the basis.

Foster coordination among governments

Carbon removal is uniquely global; robustly-certified carbon removal and storage can in theory be located anywhere, and be potentially funded by distant governments or entities either through direct compensation of emissions or through contribution claims. Quality principles should be universally shared, even if local deployment conditions differ. Multiple parallel policy efforts in Europe and beyond will require the ability to certify carbon removals[18]. As of October 2022, a non-exhaustive list includes:

United States – In response to the recent appropriations from the Inflation Reduction Act, the Infrastructure Investment and Jobs Act, the CHIPS and Science Act, including $3.5 billion allocated to establish four "DAC Hubs", the US Department of Energy is working internally to develop guidance on CDR MRV and methodologies that will allow projects to benefit from incentives.

United Kingdom – The UK is in the midst of deciding how it will incentivise "greenhouse gas removal" through a "business model" (a public incentive scheme), most likely in the form of contracts for difference awarded to high-durability carbon removal (lower-durability carbon removal methods involving biological storage of carbon are already

Examples of Knowledge Gaps

Example #1: What is the warming or cooling impact of volatile organic compound (VOC) aerosols released by trees? The climate impacts of these natural aerosol emissions have confounded scientists and courted controversy as to whether they have a net warming effect or net cooling effect on the atmosphere[16]. Imagine this uncertainty is determined to have a ±X% effect on the climate benefit estimate for CRCF forestation methodologies, representing a Y $MtCO_2$ total carbon removal potential gap (compared by the global warming potential metric), which makes this gap among the top Z knowledge gaps in terms of addressable potential. A targeted, rapid research call could assess the degree of uncertainty this knowledge gap creates in measuring forest-based carbon removal, prioritise the fundamental atmospheric chemistry, physics and climate research needed to resolve it, and establish a mechanism for iteratively improving forest-based methodologies as this new knowledge is generated.

Example #2: Bridging the data quality gap in Life Cycle Assessment. Some carbon removal methods with otherwise precisely measurable features (e.g., DACCS, where the mass of CO_2 extracted and ultimately stored can be measured directly with high precision) rely on Life Cycle Assessment to estimate upstream Scope 1, 2, and 3 emissions from materials and energy input. In evaluating submitted DACCS methodologies, the CRCF governing agency may find that fundamental data availability and data quality are undermining LCA upstream emission estimates with a ±X% effect on climate benefit, high enough to merit exploration. In this instance, improving product-level climate data quality is highly aligned with parallel EU regulatory proposals including the Initiative on Substantiating Green Claims or the Strategy for a Sustainable Built Environment[17].

separately incentivised). The UK Government has awarded £100 million in a combination of pilot and demonstration project support, and research and development funding, some of which is targeted at establishing a framework for certifying various carbon removal methods.

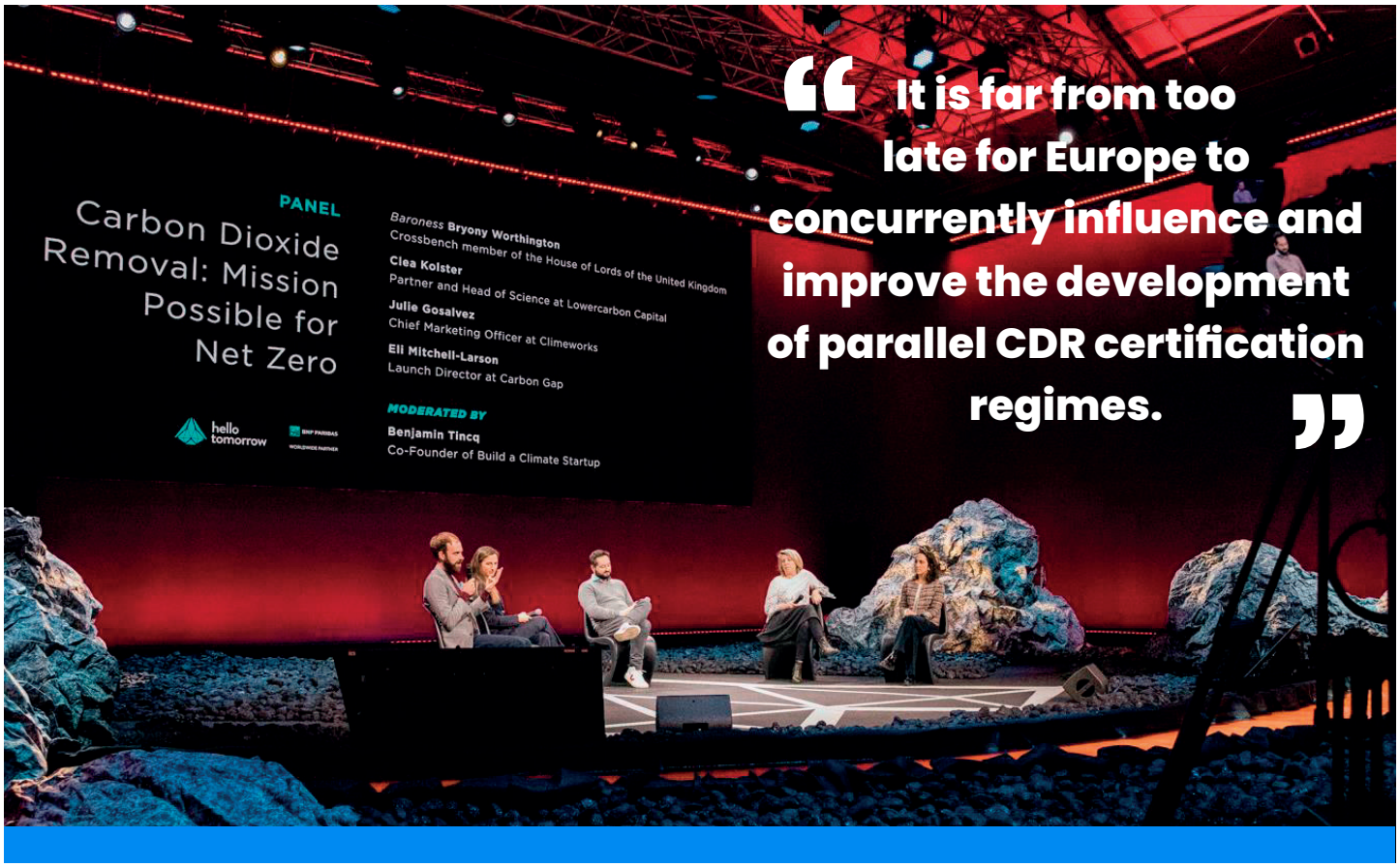
Sweden – With an express focus on "Bio-CCS" (carbon removal relying on capturing streams of biogenic carbon for subsequent high-durability geological storage), Sweden is running a reverse auction policy incentive. Storage will likely be governed by the CCS Directive, but the extraction and conversion steps require rapid development of government-approved methodologies.

Switzerland – The Swiss low-carbon fuel standard requires fuel importers to compensate for an escalating portion of the carbon contained in these fuels, with the option of using carbon removal to do so. The Swiss Federal Office for the Environment (FOEN) is overseeing methodology review and development and could form the nucleus of a high-quality Swiss CDR standard, with potential complementarity with the EU. Switzerland is also an early mover in forming bilateral agreements with other countries to confirm how corresponding adjustments are to be made, providing a blueprint for others to take advantage of the flexibility offered by Article 6 of the Paris Agreement.

All of these efforts have unique strengths and capabilities. However, based on conversations with the relevant government officials, Carbon Gap has determined that no single effort among those listed share the comprehensive scope (potentially open to all CDR methods), the tie-in with a very large compliance-based climate policy regime, and the desire for global leadership provided by Europe's proposed Carbon Removal Certification Framework. **It is far from too late for Europe to concurrently influence and improve the development of parallel CDR certification regimes.**

On a practical level, the Commission could propose and lead this coordination through a multilateral platform it is a member of, such as the **Clean Energy Ministerial** or **Mission Innovation** (which has a carbon removal workstream). Areas of focus for cooperation could include:

- Agreeing on common quality principles for carbon removal certification frameworks
- Committing to cooperation on fundamental research to improve MRV
- Piloting corresponding adjustments for transborder carbon removal projects



4. Use Cases for Certified Carbon Removals

Recommendations:

- **Do not conflate certification with offsetting.** Many promising use cases of a carbon removal certification framework can deliver positive climate and economic impacts without the tradeoff of allowing compensation claims.
- **Proactively make use of carbon removal certification within existing or forthcoming policies at supra-national, national, and local levels** where it is appropriate to do so.
- **Some lower-certainty carbon removal methods (e.g., soil carbon sequestration) can and should be certified and incentivised through means other than generating carbon credits,** sidestepping the risks of flooding the market with carbon credits with low-certainty climate benefits, while still advancing important goals.

Alongside emission reduction and adaptation, carbon removal is a critical third pillar of climate action. Carbon removal includes a wide array of activities, from incorporating carbon into our built environment and long-lived products, to reimagining land management to optimise for carbon absorption, to scaling up entirely new industries that scrub CO_2 directly from the air or seawater through engineered means. Often stakeholders are already removing carbon without being explicitly aware or rewarded on that basis, such as when farmers adopt "greening" techniques to receive extra support under the Common Agricultural Policy, or foresters who strategically manage their forest to optimise a forest's rate of carbon absorption for commercial purposes.

Despite the involvement of disparate industries and actors, measuring and certifying the amount of carbon removed can be done consistently across the board. Carbon Gap agrees with the European Commission's proposed approach of creating a **Carbon Removal Certification Framework** to underpin the measurement and validation of any activity which meets the definition of carbon removal. How will this scheme be used, and how quickly can it be integrated across the European policy landscape?

The Commission's proposed sequence is to create the certification framework first (e.g., 2024-2025), allowing it to be piloted on a voluntary basis (from 2024 and on), and gradually incorporated into policy and compliance mechanisms over time (see Sustainable Carbon Cycles Communication). Carbon Gap sees a strong case for rapid and creative piloting of the CRCF across a wide range of uses, many of which do not involve carbon credits, and cautions against overreliance on the Voluntary Carbon Market as the sole proving ground for the framework.

In this Section we first make the case for why certification is distinct from offsetting, and review the benefits of looking beyond compensation claim offsetting toward other powerful uses of certification. Second, we propose a non-exhaustive list of such policies and mechanisms where the CRCF could be piloted and incorporated before 2030.

Certification ≠ "offsetting" – Carbon offsetting is the act of claiming to compensate for emissions by retiring carbon credits. Carbon credits can be either emission avoidance or reduction credits, or removal credits. Only removal credits make a "net zero" or "climate neutral" claim possible. **Offsetting is usually enabled by a market (voluntary or compliance) in which carbon credits are bought and sold until they are retired.** Voluntary purchases are motivated by companies' desire to make environmental claims at either a firm level (e.g., "net zero" Scope 1-3 emissions) or product level (e.g., "carbon free", "net zero product", etc.).

Certification ≠ Offsetting

Table 3.

	Certification	VS.	Offsetting
What it Entails	Carbon removal certification is the act of reporting and authenticating carbon removals		Carbon offsetting is the act of claiming to compensate for emissions by retiring carbon credits
Examples of use cases	In addition to certifying carbon credits that could be used in offsetting, certification can be used to validate contributions towards climate positive actions or attest to the adherence of other standards or regulations		Carbon credits used in offsetting typically stems from project involving forestry and conservation, renewable energy, and energy-efficiency related community projects

While a potentially potent financing tool in theory, offsetting can in practice prove problematic:

1. The use of low-quality carbon credits can create a doubly negative impact: the claimed climate benefit isn't generated, *and* the purchaser has a smaller disincentive to emit, potentially leading to even more emissions in the long run.

2. When offsetting is conducted voluntarily, this can reduce governments' motivation to step in and appropriately regulate the market to make such compensatory actions compulsory.

3. Consumers may be confronted with numerous disingenuous claims (some of which may be considered fraudulent) about companies' environmental bona fides. If the claims are believed, they falsely assuage climate anxiety and undermine climate action by the public. If the claims are not believed, they sap the public's overall confidence in carbon credits, including otherwise very high-quality CRCF-certified carbon removal credits.

Provided the carbon credits are of very high quality, used only to compensate for emissions of comparable character (fossil emissions with geological storage, biogenic emissions with biological storage), and used to compensate for emissions which are considered very expensive and difficult to abate, offsetting is an appropriate voluntary use for CRCF-certified carbon removals.

Offsetting is not certification; **it is one specific use case of certification.** There are two broad categories of use cases for certified carbon removal that are entirely distinct from offsetting:

1) Uses that do not involve compensation claims – Certified carbon removal could be used to make contribution claims, rather than compensation claims. A Member State may wish to support the piloting of a variety of carbon removal methods through grants and other direct incentives on the basis of fostering innovation, creating jobs, and demonstrating climate leadership. That government program would still want to know how much carbon each recipient was able to remove, in order to assess impact, and could certify those removals under the CRCF, but that government could stop short of counting them as compensation against other emissions. In a voluntary context, corporations may wish to demonstrate climate leadership by supporting early-stage CDR methods and simply claim to have "contributed" to the scale-up of those solutions, rather than "compensating" for any specific emissions (see Stripe, Milkywire, Shopify, etc.).

2) Uses that are not quantised into carbon credits – The amount of carbon a project removes can still be measured and reported without being divided up into severable and tradeable 1 tCO_2 carbon credit units. Especially with land-based carbon removal, the unit of certification for a given methodology could be an *acre of land* that is being certified against a set of prescribed practices. Other examples could involve certification to demonstrate adherence to mandated practices. For example a municipality or region could pass a rule that a minimum percentage of all publicly procured concrete for municipal works contain a fraction of removed carbon. The CRCF would be used to validate only.

Examples of use cases for a carbon removal certification framework

The use of certified carbon removal in a voluntary carbon market is the first thing many policymakers, investors, and market participants think of when they hear "carbon removal certification framework". Thankfully, there are a host of other uses for such a framework, many of which do not involve one entity claiming to compensate for emissions using removals conducted elsewhere. Carbon Gap is keen to support the EU in capitalising on the regulatory leadership it is demonstrating by building the CRCF. We are convinced that numerous short-term opportunities to make use of the CRCF in compliance, voluntary, and hybrid contexts and at multiple levels of government are available. One of the key impacts of the CRCF will be iterative improvement of carbon removal methodologies and MRV techniques. This process can be accelerated by ensuring that the framework is experimented with in a variety of contexts. A non-exhaustive list of ideas follows, roughly sorted from most proximate to most distant likely timeline for implementation:

Immediate:

- **Advertising regulation** – Companies are already making bold environmental claims to consumers in Europe, either at the company ("net zero") or product ("carbon neutral petrol", "net zero flight") level. Many of these claims are scientifically inaccurate, misleading, or fraudulent. The EU could invest in education and capacity building of European advertising regulators to help them identify and police scientifically faulty claims, and also publish guidance on what is required to make an accurate claim to the public. For example, claiming a flight is "net zero" would require the purchase of the requisite volume of high-durability carbon removal employing geological storage, certified under the CRCF. To claim a loaf of bread is "carbon neutral" could require the purchase of the requisite number of agriculture-based removals, again certified under the CRCF. This policy lever has the triple-benefit of stamping out greenwashing, creating an incentive for more actors to voluntarily purchase high-quality carbon removal, and

immediately pilot the CRCF in a context that is a blend of voluntary (the nature of the claims) and compliance (EU and Member State governments having final say on permissible advertising language).

Short-term:

- **Building codes** – National or subnational building codes could require or incentivise builders to measure, certify, and disclose the amount of removed carbon incorporated into buildings (e.g., through long-lived structural timber, or cementitious building materials with mineralised carbon).

- **Procurement** – All levels of government engage in large scale procurement of products and services, many of which contain long-lived carbon. Examples include building materials (e.g., timber and carbon removal-based concrete replacements for infrastructure) and food (provide rebates to school districts that buy a percentage of food from "carbon farming"-certified farms). Governments can also engage in direct procurement of carbon removals, or allow the carbon content of other procured products to be compensated for with removals.

- **Results-based financing for nature** – The vast majority of global funding for nature-based solutions ($133B in 2021) comes from public sources[19], with less than 0.5% from Voluntary Carbon Market sales[20]. Although usually not the primary intended outcome, many of the projects funded presumably result in the removal and storage of carbon in ecosystems. CRCF methodologies could be adopted by EU and non-EU conservation funders alike as a means of accurately representing and rewarding carbon removal amounts.

- **Certifying volumes of removal on land** – Many landowners, public and private, may find benefits in using CRCF methodologies to measure levels of carbon removal. National incentive schemes for "carbon farming" practices could reward such behaviour.

- **Working forests regulation** – Many national forestry policies require owners of working forests to obtain harvest plans in advance of removing timber. These policies could be amended to provide incentives (e.g., discounts to fees, reduced tax burden, direct payments) to landowners who have used the CRCF to measure removal volumes and demonstrate that they are harvesting within sustainable yield constraints.

Farm-level carbon removal certification

In Europe, the "organic" label is a process-based certification at the farm level that allows products from that farm to carry that attribute through the supply chain all the way from farm to fork. We recommend a similar approach to soil carbon certification, through the creation of a "carbon farm" label. A set of desired practices (e.g., regenerative agriculture techniques, multi-cropping, agroforestry, set-asides for habitat value, etc.) would be defined.

Farms that adhere to a certain number of incentivised practices, and that can demonstrate an X% increase in soil carbon content through a CRCF pilot methodology, can be certified as a "carbon farm". Food and other products carrying the "carbon farm" certificate could command differentiated premium prices relative to conventional products in multiple ways:

1. consumers voluntarily choose to pay more, as is the case with most organic certification

2. governments mandate that a prescribed percentage of agricultural product flowing through public procurement channels, or perhaps even on grocery shelves, must be "carbon farm" certified

3. governments provide direct incentives to "carbon farm" certified farms.

In all three cases, policy is being used to guide a mix of public and private funds directly to farmers to incentivise desired practices, all without the generation of a single carbon credit. Critically, this avoids all the dangers that a flood of soil-based carbon credits could bring to the Voluntary Carbon Market. Moreover, it would immediately shift agricultural practices toward soil carbon sequestration and soil health improvement, and provide a broad base of activity to pilot farm-level certification using the CRCF, the learnings from which can be used to further refine the precision of the soil carbon pilot methodology.

Medium-to-long-term:

- **Fuel standards** – Low-carbon fuel standards could require that an escalating percentage of the carbon contained in imported fuels be compensated for with specific types of removals.

- **Carbon Border Adjustment Mechanism** – Starting in 2028, the EU CBAM will be a pioneering policy harmonising the carbon pricing regime experienced by producers within the EU with that experienced by companies importing products into the EU. The carbon footprint of imported products will be required to be reported at the border, and align with internal conditions created by the EU-ETS and other policies. The net carbon footprint of imported products could be calculated as Scope 1, 2, and 3 emissions less CRCF-certified removals of the appropriate type.

- **Member State funding allocation decisions** – Some Member States may set a minimum percentage of R&D funding they wish to allocate to CDR. The CRCF would be used to validate the removals associated with these funded projects.

- **National Inventory Reports (NIRs)** – Member States and other countries may choose to adopt CRCF approved methodologies for project-based verification of removal estimates in their NIRs.

- **Effort Sharing Regulation** – Member States are permitted to use up to 262 million land use sector credits through 2030 to assist in meeting the ESR goal. Removal credits used in this scheme should be certified under the CRCF. If further flexibility for Member States to trade emissions and removals during a pre-2030 reconciliation period is permitted, CRCF-certified removals should be the only removals allowed.

Conclusion

Given the need for ambitious and extensive CDR efforts, many governance, environmental, social, technological, and economic factors will need to be considered when scaling up CDR in Europe and beyond. The Commission's proposed CRCF will set the general framework for CDR in the EU, allowing for a safe and well-examined scale-up of CDR activities in Europe. The challenges associated with the needed expansion of CDR efforts are numerous and complex, yet solvable or manageable under adequate legislation, which the CRCF is to provide.

The recommendations and overarching principles explored in this white paper serve to address many of the important questions around building an effective and high-integrity certification framework for carbon removal in Europe. If done properly, the CRCF has the potential to nurture the emerging Carbon Removal ecosystem, addressing concerns around certainty, enabling greater funding for research and MRV, and improving carbon removal methods. Additionally, with a robust set of standards, the CRCF can support the scaling up of carbon removal in Europe with higher market confidence and credibility, and ultimately lead to the deployment of high-quality carbon removal. Lastly, as a first of its kind, the CRCF will influence the ambition of other carbon removal certification mechanisms around the world by setting the bar high for those who follow.

Carbon Gap welcomes the European Commission's initiative on the CRCF and looks forward to constructive and nuanced discussions with a range of diverse stakeholders in this field, including policymakers from the EU and its Member States, the scientific community, CDR providers, voluntary market platforms, purchasing parties, MRV specialists, CDR verifiers, NGOs and advocates, and the public at large. It is Carbon Gap's hope that the CRCF, if built properly, will not only serve the Carbon Removal ecosystem in the near-term, but will moreover set the foundations for further ambition under a possible "Green Deal 2.0".

Carbon Removal Certification Lexicon

- **Additionality** - Characteristic of a change which would not have occurred without the linked policy intervention or activity (IPCC AR6 WGIII). Since additionality is impossible to demonstrate with 100% certainty, it is more accurate to refer to and estimate the "risk of non-additionality". International efforts such as the Integrity Council for the Voluntary Carbon Market (ICVCM) are adopting this approach. Note that additionality is a strict requirement of compensation claims (e.g., use of carbon removal for offsetting), but can potentially be relaxed or even ignored when there is no compensation claim being made (e.g., direct government payments to farmers to incentivise a shift to regenerative practices). Three primary tests for assessing the risk of non-additionality are typically used:
  - **Financial additionality** – Are the revenues from the carbon project the decisive factor in allowing the project to proceed?
  - **Regulatory surplus** – To what degree is the activity already incentivised or required under the existing policy regime?
  - **Common practice** – Is the activity that is being financed commonly conducted? E.g., as more farmers in a region adopt regenerative agricultural methods, the risk of non-additionality increases as the activity becomes more widely understood and accepted.

- **Carbon credit** – A unit representing a one ton of CO_2 climate benefit. Carbon credits can either be an avoided emission / emission reduction carbon credit, or a removal carbon credit. If "offsetting" is the verb (the act of compensating for emissions), "carbon credit" is the noun (the unit of account). Carbon credits can be used in other contexts that are not offsetting.

- **Carbon offsetting** – The act of compensating for a unit of carbon emissions with the purchase and retirement of a carbon credit.

- **Carbon pool / sink** – A reservoir in the Earth System allowing for carbon to remain over various periods of time, depending on the specific pool. (IPCC AR6 WGIII)

- **Carbon removal** – "Anthropogenic activities removing CO_2 from the atmosphere and durably storing it in geological, terrestrial, or ocean reservoirs, or in products" (IPCC AR6 WGIII). Carbon removal involves several modules: extraction from the air or upper ocean, conversion into a storable format, transportation, and storage. Carbon dioxide removal is often abbreviated "CDR". Note that some policy environments (e.g., UK) use "greenhouse gas removal" as a broader category which contemplates the removal of GHGs other than CO_2. "Carbon removal" could be interpreted to mean the removal of any GHG containing carbon (i.e., both CO_2 and CH_4 (methane)), but would not include the removal of other GHGs such as N_2O.

- **Climate benefit / climate outcome** – An impact on climate and warming, for example the change in radiative forcing due to the removal of 1 ton of CO_2 from the atmosphere coupled with very long-lived storage of that carbon. Some climate benefits carry a higher degree of uncertainty than others.

- **Climate claims** – An assertion by an entity (government, non-state actor such as a corporation, individual, etc.) that they have generated a positive climate outcome.
  - **Compensation claim** – An entity claims to have "compensated" for a negative impact by funding an equal and opposite positive impact. Carbon offsetting is the most common form of compensation claim, in which emissions are claimed to have been neutralised by the purchase and retirement of a carbon credit.
  - **Contribution claim** – An entity claims to have "contributed" to a positive climate outcome, perhaps through voluntary commitment of funds, without also taking credit for the climate outcome they are delivering. Examples could include: 1) direct government subsidy of a carbon removal project in which the climate benefit stays with and can be monetised by the project developer, 2) direct results-based funding of ecosystem restoration by a company, without that company receiving a carbon credit in return.

- **Climate neutrality** – State in which all climate impacts are fully balanced with corresponding compensatory actions, such as removal of carbon or other remediation. Climate neutrality includes all greenhouse gases (e.g., CO_2, CH_4, N_2O, etc.) and other climate impacts (e.g., albedo from land-use change, desertification, etc.).

- **Durability** – A physical characteristic of stored carbon reflecting its risk of reversal back into the atmosphere. Durability is a spectrum (lower vs. higher durability) rather than a binary distinction.

- **Indirect Carbon Leakage** – The displacement of GHG emissions to another location due to actions in one location, thereby counteracting some or all of the desired mitigation effects (IPCC AR6 WGIII). For example, reforesting sheep pasture land in one country may lead to additional land clearing to make room for additional sheep pasture in another country to meet constant demand. Frameworks like the Carbon Opportunity Cost allow for analysis to estimate the magnitude of this displacement, which is a function of the efficiency of production at the location to which the activity is displaced.

- **Method** – A carbon removal method is a technique for removing, converting & transporting (if necessary), and storing carbon. Examples include "forestation" and "direct air capture with carbon storage".

- **Methodology** – The corresponding process description for each carbon removal method, with associated documentation allowing for the evaluation, measurement, and potential certification of an instance of carbon removal. Methodologies could describe a discrete module of a carbon removal method, such as a particular technique for extraction (sorbent-based direct air capture), or a particular type of storage (injection into a saline aquifer), rather than a full-chain method.

- **Net negative (GHG emissions)** – A state in which anthropogenic GHG removals exceed anthropogenic GHG emissions for a defined region or entity and over a set time period (IPCC AR6 WGIII)

- **Net zero (GHG emissions)** – State in which emissions of GHGs are in balance with removals of that same GHG for a defined region or entity and over a set time period. (IPCC AR6 WGIII)

- **Permanence** – A hypothetical ideal state in which stored carbon persists in perpetuity. Absolute permanence is not attainable, but real-world residence times of carbon in soils, forests, geology, and products can be compared against the ideal of permanence. A distinction can be drawn between *physical permanence* (as defined above) and *contractual permanence*, which is the use of legal and financial contracts to simulate permanence by holding someone responsible for remediation in the event of a reversal. Permanence is sometimes used to mean "residence time", or the actual duration in years that a GHG is expected to remain out of the atmosphere.

- **Reversal** – A reversal occurs when stored carbon escapes and is released back into the atmosphere, reducing or nullifying the climate benefit that has been delivered by the initial instance of removal. Reversals can be non-anthropogenic ("acts of God", natural disasters such as wildfires) or anthropogenic (caused by human misconduct or negligence, such as illegal logging). The "reversal risk" is an estimate of the expected magnitude and timing of reversals. Note that climate change itself is changing the risk of non-anthropogenic reversals in some cases, e.g., elevated frequency or severity of forest fires or extreme weather events may *increase* reversal risk in some regions. See also "durability" and "permanence".

- **Stewardship principle** – An underlying principle of carbon removal in which stored carbon is at all times the responsibility of an assigned steward. The steward might initially be the entity responsible for storing the removed carbon (e.g., a North Sea geological storage operator under the CCS Directive), with stewardship being reassigned at a later date subject to some statute of limitations (e.g., stewardship automatically transferred to a government body after X years). In the event of a reversal, the current steward is responsible for remediating the environmental impact, perhaps by paying for the removal and storage of an equivalent amount of carbon.

- **Overview of acronyms**
  - **BECCS** - Bioenergy with carbon capture and storage
  - **BiCRS** - Biomass carbon removal and storage
  - **CBAM** - Carbon border adjustment mechanism
  - **CCS** - Carbon capture and storage
  - **CCU** -Carbon capture and utilisation
  - **CDR** - Carbon dioxide removal
  - **CRCF** - Carbon Removal Certification Framework. A proposed EU regulatory framework for the certification of carbon removals
  - **DACCS** - Direct air capture with carbon storage
  - **EU-ETS** - European Union emissions trading system
  - **GHG** - Greenhouse gas
  - **IPCC** - Intergovernmental Panel on Climate Change
  - **LCA** - Life cycle assessment
  - **LULUCF** - Land use, land use change and forestry
  - **MRV** - Measurement, reporting and verification
  - **NIR** - National inventory reporting
  - **TRL** - Technology readiness level
  - **VOC** - Volatile organic compound

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Carbon Gap is a climate not-for-profit focused on eliminating the carbon dioxide that's already heating up the planet. We exist to drive essential climate action by helping Europe become a leader in carbon removal, working with scientists, NGOs, governments, and businesses to unlock the support for a full spectrum of safe and scalable carbon removal techniques, storing carbon safely in trees, soils, oceans, rocks, and the built environment.

We are **independent** - funded exclusively by climate philanthropy, **inclusive** - open to all safe methods for taking carbon from the air and storing it responsibly, and **planet-first** - advancing the carbon removal that the planet needs to restore our atmosphere.

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