Making Carbon Removals a Real Climate Solution

How to integrate carbon removals into EU Climate Policies

Nils Meyer-Ohlendorf

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Contact

Dr. Nils Meyer-Ohlendorf
Head, International and European Governance
Ecologic Institute
Pfalzburger Straße 43/44
10717 Berlin

E-Mail: nils.meyer-ohlendorf@ecologic.eu

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Contents

Abbreviations

BECCS	Bioenergy with Carbon Capture and Storage
CARE	Climate Action Regulation for Europe
CCB	Carbon Central Bank
CCU	Carbon Capture and Utilisation
CDM	Clean Development Mechanism
CO2eq	Carbon dioxide equivalent
CRCF	Carbon Removals Certification Framework
DACCS	Direct Air Carbon Capture and Storage
ECL	European Climate Law
EJ	Exajoule
ESR	Effort Sharing Regulation
ETR	Emissions Trading Register
ETS	Emissions Trading Scheme
EW	Enhanced Weathering
GHG	Greenhouse gas
Gt	Gigatonne
HFC	Hydrofluorocarbon
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
JI	Joint Implementation
LPG	Liquefied Petroleum Gas
LRF	Linear Reduction Factor
LULUCF	Land use, land-use change and forestry
MSR	Market Stability Reserve
Mt	Million tonne
NDC	Nationally Determined Contribution
NZE	Net-Zero Emissions by 2050 scenario
NZU	New Zealand Unit

PFC	Perfluorocarbon
RMU	Removal Unit
RTS	Removal Trading Scheme
UNFCCC	United Nations Framework Convention on Climate Change

Executive summary

Carbon removals should not substitute reductions of fossil fuel emissions. Removals are an **inherently weaker form of climate action than emission reductions**. This has been a core principle of EU climate law, but **now it is under threat**. The Commission's proposal on the Carbon Removals Certification Framework (CRCF) puts the EU on a dangerous track that facilitates replacing emission reductions with removals. Integrating carbon removals into the EU Emissions Trading Scheme (ETS) carries similar risks. Announcements that the EU's new LULUCF target effectively scales up the EU's 2030 climate target to -57% also point towards the wrong direction of supplanting reductions with removals. It is very likely that these ideas will gain momentum as the EU is moving closer to its climate neutrality target, and hence much more stringent reduction requirements and the need for more clarity on carbon removals.

Effectively, the debate on the role of carbon removals puts **EU climate policies at a crossroads**. Should voluntary carbon markets that are largely based on emission offsets serve as a model for EU climate policies, or should EU climate policies maintain the principle of non-interchangeability of removals and reductions of fossil fuel emissions? How can EU carbon removal policies fully take account of the fact that the climate crisis will severely undermine the carbon storage capacities of natural sinks, possibly turning an ally in the fight against the climate crisis into an enemy? To what extent can removal options with permanent storage play a meaningful role when their removal capacities are minute, their costs are high, and their consumption of clean energy is significant?

At this critical juncture, the EU should not take the wrong turn. The EU **should not build its climate policies on sand** where carbon removals with unsafe storage of carbon become a central part of climate action. To make removals a real climate solution, the EU should treat them as what they are: currently a small tool that complements emission reductions but that cannot become the EU's climate backstop. To this end, the EU's carbon removal framework should be built on (1) a robust definition of carbon removals, (2) a focus on removals with truly permanent storage, (3) targets and instruments that separate removals from reductions, (4) a cautious approach to the integration of removals with permanent storage into the ETS and (5) the development of a Removal Trading Scheme (RTS) in the medium term:

- **A robust definition of carbon removal – the backbone of a strong carbon removal system:** It is the fundamental purpose of carbon removals to counteract the warming effects of emissions and to reverse the trend of ever-increasing greenhouse gas (GHG) concentration in the atmosphere. As carbon dioxide remains partly in the atmosphere for more than 1000 years, carbon removals can only serve this purpose if they keep the CO_2 out of the atmosphere for the same period. For this reason, carbon removals should be defined as removing CO_2 from the atmosphere and storing it for the time that corresponds with the lifetime of CO_2 in the atmosphere. Apart from this fundamental consideration, this definition offers several other benefits:
  - First, it ensures that all removal credits have the same climate benefits and are not conflated with removals of significantly lower climate value.
  - Second, in a changing climate with ecosystems in disarray, temporary storage in biomass adds to the world's carbon debt in a disguised manner. Defining carbon removals as removals with permanent storage helps address this problem.
  - Third, a definition that includes all types of removals automatically leads to complex policies that are required to balance out the significant differences among removal options.

- Fourth, monitoring, verifying, and accounting for nature-based removals is challenging, making it difficult to safeguard against fraud. Issues of additionality and baselines, for example, have often led to over-crediting and fraudulent certification. The proposed definition would only include removal options that have reliable verification, monitoring, and accounting rules.
- Fifth, carbon removal efforts in land sectors often result in the intensification of agricultural land use and the planting of forest monocultures. The proposed definition would exclude these activities, hence avoiding incentives that can be harmful to the environment.

- **Focus on Direct Air Carbon Capture and Storage (DACCS) and enhanced weathering (EW):** The proposed definition of carbon removal has significant implications. It includes technology-based removal options with permanent storage – such as DACCS and EW – and excludes carbon farming and carbon capture and utilisation (CCU). As the removal and storage capacity of DACCS and EW is still minimal and marred by high consumption of clean energy – in a new context where nearly all economic sectors will depend on the availability of clean energy – it is pivotal that innovation overcomes these bottlenecks. Innovation must also make these options cheaper. Bioenergy with carbon capture and storage (BECCS) would also qualify as a form of carbon removal but should not play a role in the EU's removal efforts due to its many negative effects on biodiversity, water, and soils.
- **Keeping emission reductions and carbon removals separate:** The proposed definition of carbon removal is an important step to ensure the integrity of climate policies. However, this definition does not address problems that even removals with permanent storage have, such as leakage risks, demand of clean energy, or land use. Emission reductions do not face these challenges. For these reasons, separate removal targets remain an important pillar of climate action.
- **Integration of carbon removals into the EU ETS:** Integration of carbon removals into the ETS should be considered with caution. It is an option for further discussion if several safeguards are in place. First, it should only include removals that store carbon permanently - in line with the proposed definition. Second, similar to California's ETS, the maximum amount of eligible removals should be limited by a ceiling. The ceiling should be set conservatively, only including removals that are likely to materialise. The ceiling would define the amount of residual emissions, strengthening the transparency and integrity of the ETS.
- **EU Removal Trading Scheme?** An EU Removal Trading Scheme (RTS) would create a market for removals, incentivising the generation of negative emissions. The RTS would use some of the design elements of the ETS, but instead of capping and trading emissions, the RTS would obligate ETS installations to remove and store carbon. The removal obligation would be allocated primarily based on historical emissions or the carbon debt of the covered entities.

  The RTS offers various benefits. Based on historical emission, it would implement the polluter-pays-principle. It would also support generating negative emissions. It could help pave the path towards climate neutrality and net negative emissions. It would also lead to higher demand for removal options that require innovation. The RTS would not require public subsidies. However, the RTS also has shortcomings. At its outset, it would not create a liquid market, and it would put additional costs on industries that are already under stress to reduce their emissions to near zero. Therefore, it is an instrument that could be introduced only in the medium term. California's Legislature is discussing to establish a so-called Carbon Dioxide Removal Market by the end of 2027.

In the face of accelerating climate change, drastically more stringent reduction requirements in the run-up to climate neutrality and a rapidly accelerating transformation of all economic sectors, it is important that the political debate in the **EU explores all options**. An unlimited integration of carbon removals into the ETS, the establishment of a Carbon Central Bank (CCB), discount factors to produce equivalence between removals and reductions and an obligation to constantly renew expired removals are other ideas under discussion. Depending on their designs, they have the following advantages and disadvantages:

- **Unlimited inclusion of removals into the ETS:** An unlimited inclusion of any type of removals into the ETS could cushion price spikes, but it has significant shortcomings and should not be pursued. First, it would make all removals and reductions of emissions from fossil fuels interchangeable. Second, the unconditional and unlimited inclusion would effectively abolish the ETS emission cap, obscuring the amount of residual emissions. Third, this option would incentivise prioritising currently cheap removals over emission reductions and the development of costly technical sinks with permanent storage.
- **Discount factors:** In theory, discount factors offer a solution for reconciling the differences between reductions and removals but in practice they have problems. It is challenging to establish a reliable discount factor. There is no guarantee that removal credits can be renewed after they have expired – an issue that is difficult to factor into discount factors. Discount factors can also create incentives to pursue removals that are cheap today, while discouraging investment in more expensive but effective approaches.
- **A CCB - a bad bank?** A CCB or another intermediary agency could be mandated to procure physical carbon removals. The CCB would convert carbon removal into credits that ETS installations could purchase for compliance purposes. The proposal could stabilise carbon prices while maintaining the net-emissions path. It could create a new market for removal options that store carbon permanently but that have yet to achieve cost-competitiveness.
  However, the proposal also raises concerns. First, it treats different removal options alike. Discount factors are supposed to address these problems, but they are unlikely to provide the solution. Second, temporary removal options are cheap today, but they can effectively become very expensive over time. This defeats one of the CCB's regulatory purposes, i.e., to cushion price increases and spikes. Third, it is not clear whether the CCB's mandate can be sufficiently funded and governed to guarantee the procurement and renewal of non-permanent removals for centuries or even millennia (see below). Fourth, it is also unclear whether carbon removals required for renewal of expired removal credits are physically available in the real world.
- **A public obligation to constantly renew expired non-permanent removal credits?** In theory, an obligation on Member States, the CCB or any other public entity to constantly renew expired credits could solve the permanence problem. However, as carbon partly stays in the atmosphere for more than 1000 years, this is a questionable regulatory approach. Unlike the storage of nuclear waste – another example of regulations spanning millennia – the renewal of non-permanent carbon removal credits requires the active and constant management of a complex and dynamic subject matter. It is very uncertain how natural or technical sinks will develop over the next 1000 years. The regulatory context of such a time span is equally uncertain. Moreover, such renewal obligation would externalise economic costs, disburdening polluters, while placing a significant burden on many future generations. A public obligation of constant renewal of removals is incompatible with the polluter-pays-principle.

1 Introduction

Carbon removal is an **important element of EU climate policies and laws**. The EU's commitment to becoming climate neutral by 2050 requires a balance between greenhouse gas (GHG) emissions and removals. The European Climate Law (ECL) also permits the contribution of removals to meet the EU's 2030 climate target and obliges the EU to aim for more GHG removals than emissions after 2050. Additionally, the land use, land-use change and forestry (LULUCF) regulation and most long-term climate strategies of the Member States require carbon removals.

However, the EU's current carbon removal framework has **several deficiencies**. The EU framework lacks a strong definition of carbon removals and robust safeguards against conflating reductions and removals. Moreover, EU climate policies do not provide clarity on the roles of carbon removals in the EU's efforts to achieve climate neutrality by 2050 and net-negative emissions afterwards. Furthermore, there is a lack of incentives for companies, individuals, and other stakeholders to permanently remove carbon in a sustainable manner.

These **deficiencies are a problem**. Without a clear definition of carbon removals and with no agreed understanding of their roles, there is the risk that removals could substitute emission reductions – even though they are a weaker form of climate action. This risk is real. With the Emission Trading Scheme (ETS) running out of allowances around 2040, pressure is mounting to make removals a compliance unit for the ETS. The Commission’s proposal for a Carbon Removals Certification Framework (CRCF) helps pave the way to use carbon removal units for any possible purpose – including for offsetting emissions. **There is the relatively clear intention that any removal certified under the CRCF is automatically deemed higher quality and therefore automatically fungible with emissions.**[1] Without the right incentives, carbon removals with permanent storage might not materialise on the required scale on time.

This **paper explores how to make carbon removals a real climate solution**. In chapter 2, the paper introduces the guiding principle of robust climate policies, i.e., that removals and reductions are not interchangeable. Chapter 3 defines what qualifies as carbon removal and what does not. Chapter 4 discusses the roles of carbon removals in EU climate policies, while chapter 5 examines instruments for incentivising removals, such as the integration of removals into the EU ETS or a Removal Trading Scheme (RTS). The paper does not discuss technical issues surrounding the quantification of removals or quality requirements.

2 One guiding principle: Reductions and removals are inherently different and not interchangeable

Carbon removals are a tool of climate protection. Hence, it is their **primary objective** to contribute to achieving the temperature goals of the Paris Agreement. They must help reverse the trend of ever-increasing atmospheric concentrations of GHG in the coming decades and help keep these concentrations at safe levels indefinitely. In the EU, they play a crucial role in supporting the achievement of the climate targets set out in the ECL.

[1] Carbon Pulse, 2023

Because of this fundamental purpose, carbon removals can only be considered a real climate solution if climate policies fully acknowledge the **inherent differences** between emission reductions and removals[2]:

- **Permanent storage:** Unlike carbon stored in coal, gas or oil in the ground, storage of carbon in biomass or soils is only temporary. After certain periods, carbon stored in plants or soils is released back into the atmosphere. Similarly, carbon stored in products will only be kept out of the atmosphere during a product's lifetime. This can be several centuries in exceptional cases, but remains shorter than the time CO_2 partly stays in the atmosphere. The different temporal characteristics of fossil and biotic carbon make them inherently different and represent a fundamental barrier to equivalence.[3]
  Technology-based removal options can solve the problems of permanent carbon storage (see below). However, their long-term impacts are unclear, and they face challenges related to biodiversity, land use, energy consumption, high costs, and low removal potentials (see below).
- **Locking in too high emission levels and risk of earth feedback:** Relying strongly on removals, rather than reducing emissions, could lock in emission pathways that make achieving 1.5°C more difficult. Extensive use of removals today can result in greenhouse gas concentrations in the atmosphere that are more likely to set in motion tipping points of the climate systems, which – in turn – can lead to additional emissions and accelerating climate change.[4] Carbon removals cannot simply repair delayed or foregone emission reductions.[5]
- **Challenges with ensuring high quality removal units:** Compared to emission reductions from fossil fuels or abatement of non-CO_2 gases, the accounting of nature-based carbon removals is challenging. First, data quality of removal activities and their wider environmental impacts and global implications with regard to leakage and food security is often poor. Second, the establishment of baselines for some removal activities struggles with significant uncertainties.
- **Expected removals could not materialise:** Partly linked to issues of data quality, it is challenging to project the EU's removal potentials. Significant uncertainties persist, in particular because of expected and unexpected impacts of climate change or natural disturbances in the removal capacities of natural sinks. In light of these uncertainties, there is the danger that emissions continue, while projected removals do not materialise.
- **Inventory visibility:** Ensuring visibility of carbon removals in national GHG inventories poses significant challenges. First, for carbon removal activities such as Direct Air Carbon Capture and Storage (DACCS), storage in long-lasting products, rock carbonisation/enhanced weathering (EW) or marine geo-engineering, no quantification methodologies have been agreed upon by the Intergovernmental Panel on Climate Change (IPCC) or under the United Nations Framework Convention on Climate Change (UNFCCC). Second, the allocation of some potential removal activities to different inventory categories has not been clarified. Third, for some land-use activities such as soil carbon enhancement, the granularity of national GHG inventories may not be sufficient to ensure visibility.[6] However, visibility of removal activities in inventories and allocation to inventory categories is crucial for the EU to account for

[2] Meyer-Ohlendorf et al., 2023
[3] Carton et al., 2021
[4] IPCC, 2021
[5] Zickfeld et al., 2021
[6] Schneider et al., 2022

these removals towards achieving its Nationally Determined Contributions (NDCs). While most emission reductions are easily visible in national GHG inventories, some removals may not be.

These differences make **carbon removals an inherently weaker form of climate action than emission reductions**. For climate protection, it is risky to swap carbon safely stored in coal, gas, or oil in geological reservoirs – which are not subject to natural reversal risks – with carbon unsafely and temporarily parked in terrestrial reservoirs, such as in biomass or products which are subject to significant anthropogenic and natural reversal risks.[7]

The ECL recognises these differences. It is one of its **guiding principles that emission reductions are the priority**. Article 4.1 of the ECL stipulates that the EU and Member States must "prioritise swift and predictable emission reduction". As the exception to this principle, Article 7 of the Effort Sharing Regulation (ESR) allows the use of a limited amount of surplus LULUCF removals to meet emission reduction obligations. Climate policies that are committed to the temperature targets of the Paris Agreement must maintain this principle.

Underlining this principle, the **EU states in its submission to Article 6.4** that "*enhanced removals cannot be used to defer the necessary deep cuts in emissions in the short term. This would lock into higher emissions pathways which would accelerate climate change, including through dangerous feedback loops, and could reduce our ability to achieve removals in the future*".[8]

3 The scope of the removal framework: What is a carbon removal – and what is not?

Defining the term "carbon removal" is crucial. The definition determines which activities qualify as carbon removal and which do not, including or excluding removal activities with uncertain benefits for climate action from a carbon removal framework. Despite its practical significance, the term "carbon removal" lacks a clear definition.

Different stakeholders use **varying definitions**:

- **IPCC:** The IPCC defines carbon removals as human activities "removing CO_2 from the atmosphere and *durably* storing it in geological, terrestrial, or ocean reservoirs, or in products" (emphasis added). Accordingly, this definition includes "existing and potential anthropogenic enhancement of biological or geochemical sinks and direct air capture and storage and excludes natural CO_2 uptake not directly caused by human activities".[9] Importantly, the IPCC does not define the crucial adjective "durable". In its information note on carbon removal mechanisms, the IPCC states that 100 years are commonly used duration.[10]
- **US Federal Carbon Dioxide Removal Leadership Act of 2022**: This Act defines the term "remove" as (A) "to capture carbon dioxide using an eligible technology and" (B) "to permanently store that captured carbon dioxide" (Section 2, (a), (3), (A) and (B)). Unlike the IPCC, the provision uses the term "permanently" stored, not durable

[7] Meyer-Ohlendorf et al., 2023
[8] EU submission Article 6.4
[9] IPCC, 2018
[10] IPCC, 2022

storage. Like the IPCC, it does not define "permanent". It provides for no exact timeframe that would constitute "permanent".

- **ISO standard 14064-1:2018**: This standard defines GHG removal as "withdrawal of a greenhouse gas from the atmosphere by greenhouse gas sinks" in 3.1.6. According to 3.1.3, a GHG sink is "a process that removes a greenhouse gas from the atmosphere". The standard does not address the duration of storage.
- **EU definitions:** Depending on the context, the EU uses different definitions of carbon removal. These definitions contradict each other.
  In its **submission to Article 6.4**, the Swedish Council Presidency and Commission state "the enhancement of removals only contributes to achieving the long-term goals of the Paris Agreement if the increase in carbon storage due to mitigation activities is maintained over *very long timespans*. Therefore, only activities that are designed to achieve long-term storage should be eligible under the mechanism. For example, long-term storage of carbon in geological reservoirs or in long-lived products should be eligible, whereas storage in short-lived products should not. Activities with very high reversal risks (e.g., certain practices to enhance soil carbon) or activities where reversal risks are very uncertain (e.g., storage in oceans) should not be eligible" (emphasis added).[11]
  In contrast to this definition, the **Commission's CRCF proposal put forward a definition that does not exclude removals with short-term storage**, such as soil carbon sequestration. In addition, the CRCF definition includes items that are not removals, e.g., reductions of "carbon release from a biogenic carbon pool to the atmosphere".[12] In her report on the CRCF, the Parliament's rapporteur Perreira put forward yet another definition that resembles the IPCC definition.[13]
- **Definition in climate strategies of EU Member States:** Deviating from these definitions, some national long-term climate strategies consider carbon capture and storage (CCS) as removal of carbon, although CCS does not remove carbon from the atmosphere but only avoids the release of emissions into the atmosphere.

There is a compelling argument to define carbon removals as deliberate **human activities that remove CO_2 from the atmosphere**. The term "removal" suggests that carbon is withdrawn or subtracted. It does not imply that emissions are reduced. Emission reductions only slow down the pace at which carbon is added to the atmosphere. This definition is in line with the established definitions offered by the IPCC, ISO standard and the US Federal Carbon Dioxide Removal Leadership Act. In contrast, the definitions of the CRCF and some national climate strategies are outliers that conflict with the standard definitions.

In addition, it is crucial that the definition of carbon removals includes the **criterion of permanent storage**. While the IPCC, US Federal Carbon Dioxide Removal Leadership Act, and the EU's submission to Article 6.4 recognise this criterion, they lack clarity in defining it. They do not specify the minimum duration of storage, allowing for permissible storage lengths ranging from a few years to eternity.

To address this ambiguity, **permanent storage should be defined as the time that carbon is set to stay in the atmosphere**, which is up to 1000 years or more. This definition is already used by the Frontier Initiative.[14] It offers several benefits, such as:

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[11] EU submission Article 6.4.
[12] Carbon removal as "either the storage of either the storage of atmospheric or biogenic carbon within geological carbon pools, biogenic carbon pools, long-lasting products and materials, and the marine environment or the reduction of carbon release from a biogenic carbon pool to the atmosphere" (Art. 2.1(b)).
[13] European Parliament, 2023.
[14] Frontier, n.d.

- **Serving its purpose to counteract the warming effect of accumulating emissions:** It is the fundamental purpose of carbon removals to counteract the warming effects of emissions. As CO_2 partly remains in the atmosphere for more than 1000 years, carbon removal can only serve this purpose effectively if it keeps CO_2 out of the atmosphere for the same period. Carbon removals only make a dependable contribution to climate action if they store the removed carbon for such timespans. Temporary removals, in contrast, only have temporary effects and cannot offer a reliable contribution to climate action.[15] For these reasons, "*the enhancement of removals should last indefinitely to keep global emissions within a carbon budget compatible with limiting global warming to 1.5°C*".[16]
- **Avoid growing the carbon bubble:** The capacity of ecosystems to store carbon declines drastically[17] as temperatures increase and as droughts and other extreme weather events occur more often and more severely. The transformation of the Amazon from a carbon-rich rainforest to a savannah that only allows for low carbon storage is one example that illustrates the impact of climate change on the carbon storage capacity of ecosystems (see text box 1).
  For this reason, relying on "removals with high reversal risks could seriously undermine efforts to keep the 1.5°C goal within reach".[18] Put differently, carbon stored unsafely in biomass can become a carbon bubble that bursts when the climate gets hotter and tipping points are set into motion. In a changing climate with ecosystems in disarray, temporary storage in biomass adds to the world's carbon debt in a disguised and ambiguous manner. Defining carbon removals as removals with permanent storage helps address this problem.
- **Ensure carbon removals have the same climate value:** A definition of carbon removal that encompasses all types of removals is very likely to pave the way to a system where any removal constitutes one removal unit – regardless of whether this unit offers permanent or only temporary storage. The CRCF is a case in point. It would allow temporary and permanent storage removals to be turned into one removal unit if they meet certification requirements. Once these units are certified and issued, removals with permanent and temporary storage will have the same value for the time of their validity - despite the fact that their climate benefits are different. A definition of carbon removal that requires permanent storage ensures that all removal units have the same climate benefits and are not conflated with credits of significantly lower climate value.
- **Clarity – avoiding complexity:** Clarity and simplicity are essential factors for a well-functioning carbon removal system. A definition that includes all types of removals makes the system significantly more complex than one that focuses only on carbon removals with permanent storage. The broad definition automatically leads to complex regulations and policies that will be needed to balance out the significant differences among various removal options. All users of the scheme will struggle to understand the system, but it will be a particular challenge for smaller operators (e.g. individual farmers and foresters) to comprehend it.
- **Safeguard against fraud:** Monitoring, verifying, and accounting for nature-based removals is challenging, making it difficult to safeguard against fraud. Issues of additionality and baselines, for example, have often led to over-crediting and fraudulent certification in the past.

[15] Cullenward & Hamman & Freeman, 2020
[16] EU submission Article 6.4.
[17] IPCC, 2018
[18] EU submission Article 6.4

A narrow definition of carbon removals can be effective in addressing these issues. This definition would focus on removal options that have well-established and rigorous verification, monitoring, and accounting rules. By doing so, it would help mitigate the problematic use of any type of removal as a currency for offsetting emissions, which has been at the root of over-crediting and fraud. Scandals of systematic over-crediting in voluntary markets show that LULUCF removals are more susceptible to fraud than permanent removals, suggesting that these markets cannot be fixed unless they are exclusively based on the removals with permanent storage.

- **Achieving climate neutrality in a robust manner:** Climate neutrality can be achieved in different ways, with high shares of reductions and low contributions of removals or vice versa, as described below. It can also be achieved through removal shares that include a high number of permanent removals and a low number of temporary removals. Each scenario is compatible with the target of climate neutrality but has important differences in terms of climate protection. Only the scenario with high reduction shares, low removal contributions, and removals primarily encompassing permanent storage represents a high level of climate integrity. The narrow definition of carbon removals facilitates such a scenario.
- **Avoiding perverse incentives that harm ecosystems and climate protection:** Nature-based carbon removals can offer several benefits, such as restoring ecosystems, improving climate resilience, and storing carbon. However, they can also have adverse effects. Carbon removal efforts in land sectors often result in the intensification of agricultural land use and the planting of monocultures in forests.[19] Land-intensive carbon removals may also lead to carbon emissions in other locations, if, for instance, an afforestation project reduces agricultural land, leading to deforestation elsewhere. Additionally, subsidising carbon removal without taxing carbon emissions at the same rate may make it lucrative to cut down a forest just to plant a new one.[20] The proposed definition would avoid these perverse incentives. It would help to ensure that nature-based removals stay focused on their primary purpose – the protection and restoration of ecosystems.[21]

[19] EU submission to Article 6.4
[20] Edenhofer et al., 2023
[21] Scherger & Sharma, 2023

The impacts of climate change on carbon storage capacities of ecosystems (Text Box 1)

Climate change is projected to increasingly affect the carbon storage capacities of ecosystems. With high confidence, the IPCC projects that the land and ocean carbon sinks will be less effective at slowing the accumulation of CO_2 in the atmosphere in scenarios with increasing CO_2 emissions.[22] Higher temperatures, droughts, wildfires, mass mortality of trees, and insect infestations are making forests very vulnerable to carbon loss. It is possible, for example, that the Amazon rainforest[23] and boreal forests[24] – two of the world's largest carbon sinks – become sources of emissions as climate change sets into motion a vicious circle of self-reinforcing ecosystem decline with ever increasing loss of stored carbon. Climate change also has negative effects on the ocean's carbon uptake capacity, possibly reducing it by up to 50% by the end of the century.[25] Climate change is very likely to cause the world's soils to release large amounts of CO_2.[26] For instance, permafrost could thaw although to an uncertain extent. Permafrost stores around 1.5 trillion metric tons of organic carbon or twice as much as Earth's atmosphere currently holds.[27]

The **proposed definition of permanence for carbon removal options has significant implications**. According to this definition, technology-based removal options with storage in geological formations would qualify, as they can store carbon for centuries or even longer. The IPCC's 2005 Special Report on CCS concluded that appropriately selected and managed geological reservoirs are 'very likely' to retain over 99% of the sequestered CO_2 for longer than 100 years and are 'likely' to retain 99% of it for longer than 1000 years.[28] However, it should be noted that long-term evidence on leakage from CCS pilot sites is not yet available. Some studies assume that CCS stores only 65-80% of captured CO_2 permanently, and storage of CO_2 in geological formations can pollute groundwater.[29] Other studies have assessed the risks associated with storage in the seabed of the North Sea and have concluded that the likelihood and severity of risks such as leakage, earthquakes, and pollution largely depend on the specific site conditions.[30]

Another removal option that would be included in the proposed definition is **EW**. This process removes carbon through the weathering of silicate, carbonate rocks, construction waste, or mining waste, and can store it for millennia. Biochar would also qualify if it persisted in soils for thousands of years under the right conditions. However, evidence of long-term impacts remains scarce, the mitigation potential and environmental impacts of biochar are contested,[31] and the availability of excess biomass to produce biochar at scale is uncertain.[32] BECCS is another option that meets the proposed definition but should not play a role in the EU's removal portfolio due its many negative effects on ecosystems (see Text Box 4).

Conversely, the proposed definition would **exclude various activities that are at the core of the discussion on carbon removal**. Carbon removal with "storage" of carbon in e-fuels, plastic, and methanol would not constitute removals, as these activities only lead to short-term storage or immediate use and combustion. These CCU activities are better described as delayed emissions, not as carbon removals. Due to its short-term storage, carbon farming as well as

[22] IPCC, 2023
[23] WMO, 2021
[24] Box, 2021
[25] IPCC, 2019
[26] Todd-Brown, 2020
[27] MIT, 2022
[28] European Commission, n.d.
[29] Umweltbundesamt, 2022
[30] Wallmann et al, 2022
[31] Ding et al. 2016
[32] Paustian et al. 2016; Minasny et al. 2017

ocean alkalinisation and fertilisation would not be considered a carbon removal activity. Removal with storage in products would also be excluded, as their storage duration can only be up to several centuries (e.g., wooden buildings) but not for more than 1000 years.

4 The firewall: Keeping emission reductions and carbon removals separate

The proposed definition of carbon removal with permanent storage is an important step towards ensuring the integrity of climate policies and addressing the problem of permanent storage. However, it is important to note that **this definition does not address several challenges that removals with permanent storage face but reductions do not**.

Technical options with permanent storage depend on the availability of significant additional amounts of clean energy (see Text Box 2). This raises questions about their feasibility as the world transitions to clean energy sources and the electrification of nearly all economic sectors. In addition, technical removals may have negative impacts on ecosystems, water and land, and some uncertainties remain concerning leakage risks. If life-cycle emissions and energy inputs are considered, the actual carbon removal potential of technical options may be very small. Moreover, technical options for removing carbon emissions can encounter **political opposition**, particularly from communities directly impacted by storage sites and infrastructure. This opposition has hindered the implementation of CCS projects in several Member States.

Therefore, there are **strong arguments for keeping reductions and removals separate**. Climate targets that separate between reductions and removals and instruments that do not conflate reductions and removals are the tools that keep reductions and removals separate. These mechanisms are often called a "firewall" between reductions and removals.

Estimated energy consumption from DACCS (Text Box 2)

DACCS could demand considerable amounts of clean energy.[33] According to the Rocky Mountain Institute[34], for example, DACCS's demand for low-carbon electricity (excluding any that is used for regeneration heat, addressed below) would reach 0.9 exajoules (EJ) in 2040 and 4.4 EJ (range of 2.2–6.2 EJ) by 2050, an amount greater than Japan's 2020 total final electricity demand of 3.5 EJ. This is equivalent to about 5% of total global electricity consumption in 2020 (81.8 EJ). In scenarios of even greater DACCS, the 2050 electricity demand for DACCS reaches 7.9 EJ (3.9–11 EJ). Heat demand for DACCS could grow to around 2.3 EJ by 2040 and 11.3 EJ (6.8–15.8 EJ) by 2050 or even up to an additional 20 EJ (12–28 EJ). [35] By comparison, the global cement industry's 2019 total final energy consumption was approximately 12 EJ.

4.1 Separate removal targets

The **EU's climate target for 2030 differentiates between reductions and carbon removals**. Article 4.1 of the ECL requires a reduction of net GHG emissions by at least 55% compared to 1990 levels by 2030. The second part of Article 4.1 places a cap on the contribution of net

[33] IPCC, 2018
[34] Kahsar, et al, 2022
[35] Kahsar, et al, 2022

removals towards achieving the target at 225 million tonnes of CO_2 equivalent (MtCO2eq), establishing a separate target for carbon removals. However, beyond 2030, the EU has not set a separate target for removals. The EU's 2050 climate neutrality target combines reduction and removal commitments into one consolidated target and is silent on the amount of carbon to be removed.

The EU's **2030 climate target could serve as a model** for the EU's future climate targets that places a limit on the amount of removals permitted for target achievement:

- **Targets matter:** Targets have played a crucial role in shaping EU climate and energy policies, providing a clear reference point for political debates and heavily influencing the selection and design of measures. As an established and accepted method of policy making, targets have proven to be an effective tool for driving progress towards decarbonisation.
- **Avoid delaying emission reduction:** The ECL requires the EU and Member States to prioritise swift and predictable emission reduction and, at the same time, enhance removals by natural sinks. This obligation alone is vague and largely meaningless. A quantified, separate removal target would provide specificity and strengthen this obligation. It would also address concerns that removals are merely a pretext for slowing down mitigation efforts.
- **Clarity on residual emissions:** Separate targets offer greater transparency compared to combined targets. They provide a clear understanding of one of the key issues in the EU's journey towards climate neutrality – the amount of residual emissions available until 2050 and beyond, and the required share of removals.
  In contrast, combined targets lack this clarity. The EU's 2050 climate neutrality target is a good example of this. In theory, the target can be achieved through 100% reductions and no removals, or with significantly lower reductions (e.g., 80%) and correspondingly higher removal shares. This ambiguity obscures the remaining amount of residual emissions and the level of investment required to deliver negative emissions.
- **Investments:** Separate removal targets are essential for encouraging necessary investment and innovation in the land sectors and technologies – as in the case in the energy sector where targets for renewable energies have been an important driver for investment, innovation and drastic cost decreases.

In principle, there are **various ways to design separate removal targets** in terms of timeframes and scope, and level of legal commitment. However, the EU's 2030 climate target provides a good model. It includes a quantified and legally binding removal target – the highest possible commitment. Clear quantification of targets – combined with strong accounting rules – provides a robust verification basis, which in turn supports accountability.[36] The EU target could feature as a percentage share of the EU's overall climate target – y% of overall climate efforts (similar to the climate law of Portugal) – or it could be a quantified amount in tonnes – x Mt (similar to Germany's climate law).

4.2 Separate targets for technical and nature-based removals?

As part of its consultation for an EU 2040 climate target, the **Commission is seeking input from stakeholders** on the relative contributions of nature-based removals in the LULUCF sector and industrial removals (DAC or CCS associated with bioenergy). Possible responses include (1) a stronger reliance on the LULUCF sink, since the large-scale deployment of industrial

[36] Meyer-Ohlendorf, 2020

removals is uncertain (2) a balance between the LULUCF sink and industrial removals and (3) a stronger reliance on industrial removals, since the evolution of the LULUCF sink is uncertain.

Against this backdrop, it seems very likely that the political discussion will also address the issue of **separate targets for these different groups of removals**. Separate targets are necessary to accommodate the significant differences between these groups of removals. Distinct targets for nature-based removals and industrial removals also provide more clarity on how climate neutrality is being achieved, whether through large shares of carbon stored in unsafe terrestrial storage or safer geological formations. It should be noted, however, that separate targets are obsolete in a system that is based on the definition of carbon removals as proposed above.

4.3 Equivalence through discount factors?

Discount factors offer a **potential solution for addressing the differences between reductions and removals**. By applying a discount factor, removal credits can be valued relative to emission reductions, with a specific number of physical removal credits equal to one physical emission unit. For example, x removal credits (where x > 1) may be required to offset the emissions from one tonne CO_2eq. The IPCC information note on carbon removal mechanism contains an overview of tonnes of CO_2 needed to produce mitigation equivalent to one tonne CO_2 permanent removal stored over different periods of time. [37]

So far, discount factors **have not yet been incorporated into law**. Under the Kyoto Protocol, Removal Units (RMUs) were a tradable carbon credit but were not calculated using a discount factor. Rather, RMUs represented an allowance to emit <u>one</u> tonne and were traded on a 1:1 basis.

Other methods aim to **balance the economic costs of renewed temporary and permanent removals**. For instance, CarbonPlan has developed a calculator to compare the costs of sequentially renewed temporary removals and permanent removals over the time that CO_2 stays in the atmosphere. While such cost models are useful for calculating the economic costs over time, they do not establish regulatory equivalence between reductions and removals. They are distinct from discount factors, which would help to transform removals into a compliance unit for meeting reduction obligations.

Discount factors can **increase the uniformity of removal credits**, which can, in turn, enhance market liquidity and supply. Removal credits of certain types may be too scarce to facilitate trading and generate reliable daily price signals. Discount factors can help mitigate this issue.

Despite the potential advantages of discount factors, they have **significant shortcomings** that prevent them from delivering true equivalence between reductions and removals. These shortcomings include:

- **Challenging to determine the discount factor**: To create equivalence between reductions and removals with temporary storage, discount factors usually take account of storage duration. The IPCC information note on removal activities, for instance, states that 5.48 tCO_2 and 2.14 tCO_2 respectively should be required to earn one credit if a discount rate of 1.75% applies and removals are stored for 10 years and 30 years respectively.[38]
  However, it is equally important that discount factors fully take into account whether specific types of removals are more or less likely to rerelease carbon to the

[37] IPCC, 2022
[38] IPCC, 2022

atmosphere. This is part of risk tools, applied to different extents in voluntary markets.[39] However, as climate change intensifies, the uncertainties increase, making it challenging to determine why a particular discount factor is preferred over another. Exacerbating these uncertainties, it is important to note that even minor inaccuracies in assessing storage times, future discount rates, or future removal costs can have significant financial implications for society.[40]

- **Impeding renewal of temporary removals:** In principle, an obligation to renew temporary removals after expiry is an option to make a removal framework more robust - but it is not part of any removal framework. Discount factors are often argued to address non-permanence risk, thereby impeding the establishment of renewal obligations.
- **Uncertain future availability of replacement removals (or emissions reductions):** Even if discount factors were established in a reliable manner, there is no guarantee that removal credits can be renewed after they have expired. It is possible that technical or nature-based removals will not be physically available once the credit has expired, rendering even high discount factors ineffective in addressing this problem.
- **Misleading incentives:** Discount factors reduce the incentives for the discounted removals, relative to non-discounted removals. However, if they are still cheaper after discounting, discount factors may create incentives to pursue cheap and temporary carbon removals today while discouraging investment in more expensive and effective approaches in the future.[41]

5 Emission trading and carbon removals

The **EU is just starting to explore the instruments** for supporting carbon removals at scale (beyond the LULUCF Regulation). The debate is expected to gain momentum quickly in the coming years, as the EU is moving closer to the climate neutrality target and more stringent reduction requirements. Proposals to integrate carbon removals into the EU ETS are already gaining traction, especially in policy and expert circles. The revised ETS Directive, for instance, has requested the Commission to report on the integration of carbon removals in the EU ETS.[42] A legislative proposal could accompany this report. Additionally, options such as establishing a separate RTS are emerging.

5.1 Integration of carbon removals into the EU Emission Trading Scheme?

The reformed ETS 1, with its new linear reduction factor (LRF) of 4.3% and 4.4% respectively, is expected to stop generating emission allowances by around 2040, leaving only banked allowances for use. This increase in the LRF implies that the total emission budget will be reduced

[39] Verra, 2029
[40] Edenhofer et al., 2023
[41] Cullenward & Hamman & Freeman, 2020
[42] Art 30a, paragraph 4a: "By 31 July 2026, the Commission shall report to the European Parliament and to the Council on the following, accompanied, where appropriate, by a legislative proposal and impact assessment: (a) how negative emissions resulting from greenhouse gases that are removed from the atmosphere and safely and permanently stored could be accounted for and how these negative emissions could be covered by emissions trading, if appropriate, including a clear scope and strict criteria and safeguards to ensure that such removals are not offsetting necessary emissions reductions in accordance with Union climate targets as laid down in Regulation (EU) 2021/1119;"...

from 29.5 $GtCO_2eq$ to 15.8 $GtCO_2eq$.[43] As residual emissions are likely to continue after 2039, emission **allowances are expected to become scarce and potentially very expensive**.[44] The political acceptance of the ETS could be at risk.

As a response to this challenge, proposals to **integrate removals into the EU ETS are gaining traction**. Some players see this as a central option to address the scarcity of allowances and the resulting price spikes. Carbon removal credits could potentially constitute a new source of supply that could be surrendered for compliance in the ETS.[45] However, the ETS Directive currently does not allow the use of removal credits for compliance.[46]

Although proposals for integrating removals into the ETS are not yet fully developed, **several design options are conceivable**. These include (1) full integration of removals in the ETS with no limits on the types of removals allowed to offset emissions, (2) partial integration with only certain types of removals being eligible, (3) partial integration for specific emissions, (4) limited integration up to a maximum amount of removals, (5) inclusion of biomass incineration into the ETS, and (6) the use of an intermediary agency such as a CCB to distribute removals.

It is important to note that these **design options can be combined**.

5.1.1 Full and unconditional integration: any removal can be used to meet reduction commitments (Option 1)

Under this option, carbon removals can substitute emission reductions. Any type of removal in any quantity could be used to meet the obligations under the ETS. This proposal **promises** to be particularly effective in **cushioning ETS price spikes** and in maintaining political support for the ETS.[47]

However, it is **uncertain whether this option can deliver on its promise**, as some nature-based removals may become scarce and expensive with accelerating climate change, and it is unclear whether technical sinks will become significantly cheaper.

Additionally, this option has **several shortcomings**. First, removals and reductions are fundamentally different and should not be interchangeable. Second, the unconditional and unlimited inclusion would effectively abolish the ETS emission cap. The amount of residual emissions would be unclear. Third, there is a risk of double-counting, as many nature-based removals are already accounted for under the LULUCF Regulation. Fourth, this option would incentivise prioritising currently cheap removals (such as afforestation and soil carbon enhancement) over emission reductions and the development of technical sinks with permanent storage, which have higher investment costs.[48] It is important to set "*incentives for a long-term storage, as this ensures that the cost of preserving carbon stocks is adequately reflected in the prices of carbon credits and that the costs is not externalized to society*".[49]

5.1.2 Partial integration - only specific types of removals can be used to offset emissions (Option 2)

Unlike option 1, option 2 proposes that only removal credits generated by specific types of removal activities would be eligible as a compliance unit. This could be achieved using **positive lists**, where only listed activities would be eligible. For example, eligible removals could be

[43] Rickels, et al 2022
[44] Pahle, et al, 2023
[45] Pahle, et al, 2023, Rickels, et al, 2021
[46] The revised ETS will include an exception, allowing removals to offset aviation emissions if certain requirements are met.
[47] Rickels et al, 2022
[48] Rickels et al, 2022
[49] EU submission Article 6.4

limited to those with permanent storage in geological formations – similar to a legislative proposal discussed in California's Legislature (Text Box 6). As in the same legislative proposal, it is also conceivable that temporary removals are eligible provided they are replaced by permanent removals after expiry (Text Box 6).

Alternatively, this approach could be based on **negative lists**, whereby all removal activities would be eligible unless they are prohibited. Similar to the EU ETS phase 3 (2013-2020), credits from afforestation or reforestation activities could be prohibited. Additionally, removals from BECCS could be excluded due to their many negative side effects on ecosystems.[50]

Option 2 **addresses some of the shortcomings** of option 1. For instance, if only removals with permanent storage in geological formations are eligible, concerns of leakage could be solved. Additionally, by excluding temporary removals, the system would not create incentives to primarily use cheap unsustainable temporary removals. Depending on its scope, it could incentivise the use of permanent removal options. This option would limit the supply of removal credits, which could undermine the liquidity of the market.[51]

5.1.3 Removals only eligible to offset specific emissions (Option 3)

Another alternative is to allow removals only to offset **specific emissions** covered by the ETS, such as aviation emissions, as established in the revised ETS Directive under Article 11a.

However, this option raises **concerns** as it does not address the equivalence problem and makes accounting more complex. It also creates questions about why only certain emissions should be eligible for offsetting through removals, while others are not. Ultimately, this option may further complicate an already intricate system.

5.1.4 Integration up to a maximum amount for removals (Option 4)

Another design option is to limit the integration of all removals to a maximum amount eligible for fulfilling obligations under this directive. The ETS Directive would set a ceiling for removals eligible for compliance purposes, either in a maximum amount in tonnes or a percentage share of the reduction obligations.

The EU ETS phase 3 could serve as a model for this option. During its third phase, the ETS featured maximum limits on eligible international credits. Member States determined these maximum amounts, which became valid after approval by the Commission. For instance, in the 2008-2012 period, operators in Germany could use Joint Implementation (JI) and Clean Development Mechanism (CDM) credits equalling 22% of their individual allocation amount.[52] If they had not used up this maximum by 2012, they could use it in the third trading period.[53] California's ETS is another example that limits the contribution of removals (see text box).

A maximum ceiling of eligible removals could **partly address the problem of environmental** integrity, provided that the ceiling only includes removals that (1) qualify as such and (2) are likely to be available in the real world. The ceiling may not include removals that are unlikely to materialise. As BECCS should be excluded, DACCS and EW are the only eligible removal options. As their removal potential is still minimal and future removal rates are uncertain, the ceiling for removals is bound to be very small at the start, but it could increase as technologies mature and increase removal capacities (see above). In its communication on carbon cycles, the Commission proposed that technical options remove at least 5 Mt of removals by 2030.[54]

[50] Umweltbundesamt, 2019, see below.
[51] World Bank, n.d.
[52] German Emissions Trading Authority, 2018
[53] Participants to the EU ETS used 1.058 billion tonnes of international credits in phase 2 (2008-2012) to account for their emissions. Unused entitlements were transferred to phase 3 (2013-2020).
[54] European Commission, 2021

This would only have a small impact on climate policies. However, the Commission's 2018 Long-Term Strategy projects that DAC could remove between 123 Mt (Scenario 1.5 Life) and 210 Mt (Scenario 1.5 Tech) by 2050. [55]

In a way, this **option attempts to square the circle**. On the one hand, a low ceiling would likely defeat its regulatory purpose of softening high allowances prices and fostering innovation. On the other hand, only a high ceiling could mitigate allowance prices, but it would bet on risky removals that might leak and never materialise.

California's ETS – a case study of how forest offsets and buffer pools can undermine the integrity of climate policies (Text Box 3)

California's ETS allows companies to comply with their emissions obligations by purchasing offset credits. Offsets come primarily from forest projects. To prevent overreliance on offsets, the scheme sets quantitative limits on their use. For 2013-2020 emissions, entities could meet up to 8% of their obligations using offset credits. This share decreases to 4% per year for 2021-2025 emissions and increases to 6% for 2026-2030 emissions. Moreover, the scheme imposes restrictions on the types of offset credits eligible for compliance obligations. Entities cannot use more than 50% of their offset credits from projects that do not provide direct environmental benefits in California.

To address concerns about the permanence of carbon storage in forests, the scheme establishes a "buffer pool" mechanism. Under this mechanism, forest offset projects must contribute 15% to 20% of their total credits to the buffer pool to compensate for unintentional carbon loss or "reversal" across all forest projects in the offset programme over the projects' 100-year commitments. If there is an unintentional reversal of forest carbon storage, an equal number of credits from the buffer pool is retired.[56]

California's scheme exposes structural weaknesses that the inclusion of forest offsets in emission trading schemes is bound to have.

Undercapitalised buffer pools: The buffer pool mechanism provides insurance coverage only as long as it is not depleted. However, with California experiencing increasingly intense forest fires, the buffer pool is failing to provide the intended insurance. In less than a decade, wildfires have depleted nearly one-fifth of the total buffer pool, which is equivalent to at least 95% of the programme-wide contribution intended to manage all fire risks for 100 years. Additionally, the potential carbon losses from a single forest disease, such as sudden oak death, could fully exhaust all credits set aside for disease and insect risks. As a result, California's buffer pool is severely undercapitalised and unlikely to guarantee the environmental integrity of California's forest offsets programme for the intended period of 100 years.[57]

Over-crediting: California's system has resulted in significant net over-crediting. According to CarbonPlan, over-crediting amounts to around 30 $MtCO_2eq$ in total, or 29.4% of the analysed credits. The excess credits are valued at $410 million.[58]

No monitoring after project end: To ensure the environmental integrity of buffer pools, it is crucial to monitor buffer pool projects well beyond the end of the project's crediting period to account for reversals that may occur on a larger scale than the amount of cancelled buffer credits. However, such ongoing monitoring is currently not required.

5.1.5 Inclusion of biomass incineration in ETS (Option 5)

Under current rules, installations exclusively using biomass are not within the scope of the ETS Directive (No. 1 of Annex I). This rule would exclude most BECCS installations from the ETS,

[55] European Commission, 2018
[56] Herbert et al., 2020
[57] Badgley et al, 2022
[58] Badgley, et al, 2021

provided these installations burn exclusively biomass.[59] In turn, allowing the use of biomass would open BECCS removals to the ETS.

There are **several problems associated with the use of BECCS**. First, BECCS typically relies on monocultures, which have many negative impacts on nature, biodiversity, climate resilience of ecosystems, soils, and water. Second, at a large scale, BECCS requires a significant amount of land that is needed for food production and conservation efforts. Third, while BECCS installations that use only waste biomass offer some solutions to these issues, it is a challenge to ensure that only such waste biomass (e.g., food processing waste, municipal waste) is utilised and not additional biomass from forests or other sources. As the demand for biomass grows in the bioeconomy, it will become more challenging to ensure that only waste biomass is used.

Bioenergy with Carbon Capture and Storage: A false climate promise (Text Box 4)

Many climate scenarios assume that BECCS can effectively remove significant amounts of CO2 from the atmosphere. Usually, these scenarios recognise BECCS´s environmental implications in broad terms but do not specify them, hiding BECCS's problems. BECCS´s systematic problems include in particular:

First, BECCS itself causes significant amounts of emissions during the process. Emissions from the use of CCS, transportation and processing can account for 64% of all carbon stored. [60] Additionally, the expansion of biomass production in dedicated crops can lead to a significant increase in fertiliser use, resulting in additional emissions.

Second, growing dedicated crops for BECCS would require large areas of land, possibly an area 1-2 times the size of India (depending on the climate scenario). [61] This is an unrealistic proposition as the world's population grows, food demand increases and solving the biodiversity crisis requires turning more land into protected areas.

Third, increasing demand for land for BECCS would be an additional threat to biodiversity. The areas considered to have good potential for bioenergy crops often compete with protected areas.

Fourth, it is estimated that to produce enough biomass for BECCS to meet the two degrees aim would require more than doubling the amount of water currently used to irrigate food production.[62] These levels of water consumption can harm ecosystems and their capacities to adapt to climate change.

Because of these problems, BECCS should not be part of responsible climate policies unless it only uses excess biomass from residual waste.

5.1.6 Carbon Central Bank or another intermediary agency

According to this proposal, a **Carbon Central Bank (CCB) or another intermediary agency would be mandated for procuring physical carbon removals and converting them into carbon removal credits**.[63] This conversion process could involve discount factors to account for the risk of leakage or buffer pools to address non-permanence. The CCB would use these removal credits to establish a removal reserve or add them to the Market Stability Reserve (MSR). Procurement of removals could be organised through technology-specific tenders or forward transactions, with financing possibly provided by the Modernization Fund or Innovation

[59] If these installations burn fossil fuel and biomass, biogenic CO2 emissions are accounted for as carbon neutral.
[60] Fern, 2022
[61] Fern, 2022
[62] Fern, 2022
[63] Rickels et al, 2022 and Edenhofer et al, 2023 presented this idea with many similarities but also some important differences in detail.

Fund. Carbon removal options with above-market prices, such as BECCS or DACCS, would particularly benefit from these advance purchase programmes.

After the procurement and certification of removals, the **CCB or another intermediary agency would auction the carbon removal credits**. Auctioning would occur if ETS prices surpassed a maximum price ceiling or if other conditions were met. The CCB could also commence auctioning at its own discretion, which could be either conditional or unconditional. Companies obliged by the EU ETS would surrender these removal credits to meet their obligations. Under this system, there would be no direct exchange between emitting companies and carbon removal companies. The CCB or another agency would act as a clearing house.

Although many details need clarification, the **proposal promises several benefits**. The proposed system could stabilise carbon prices while maintaining the net-emissions path. It could create a new market for removal options that store carbon permanently but that have yet to achieve cost-competitiveness. The CCB's broad mandate would allow for flexibility in response to future developments. The CCB could also invalidate credits to ensure the permanence of removals. With no direct exchange between emitting and removal companies, accounting issues would be less acute. Designed as an independent institution, possibly similar to central banks, the CCB promises to function shielded from political influence.

The proposal, however, also **raises concerns**. These include, in particular:

- **Only legislators should take far-reaching decisions:** Depending on the exact design of the mandate, the CCB would determine the amount of the EU’s residual emissions as well as the amount of permanent and temporary carbon removals. De facto, it would be the CCB´s prerogative to set the emission budget of the EU. These far-reaching decisions have significant implications for the EU, its Member States and its citizens. They should be assigned to the democratically elected legislators only, not to a CCB or an agency with limited democratic legitimacy. They should be part of an open political process that facilitates political debate and negotiations.
- **Different carbon removal options should not be treated alike:** In principle, any type of removal credit will be a full ETS compliance unit, regardless of whether it stores carbon permanently or only short-term, or whether it has a negative or positive impact on ecosystems. It is equally problematic that removals with robust monitoring and accounting systems, such as most technical removals, and removals with weak monitoring and accounting systems, such as most nature-based removals, are treated alike. Discount factors are supposed to address these problems, but they are unlikely to provide the solution (see above).
- **Constant renewal of non-permanent removals may be impossible:** In theory, obliging the CCB to constantly renew expired or invalid credits could solve the permanence problem, but – as carbon partly stays in the atmosphere for more than 1000 years – this is an implausible regulatory approach. Unlike other examples of regulation spanning millennia, such as the storage of nuclear waste and liability regimes for exploited mines, the renewal of carbon removal credits requires an unprecedented active and constant management of a complex and dynamic system for millennia. A rule that only allows permanent removals to renew removals could solve this problem, but the CCB proposal has not put forward such a requirement.

  The constant renewal of non-permanent carbon removals has been dubbed a Sisyphean challenge or “a chain of perpetual removal activities” to offset emissions from past non-permanent removals.[64] However, unlike Sisyphus' rock, the carbon removal

[64] Edenhofer et al, 2023

challenge becomes more difficult over time, as climate change impacts the storage capacity of ecosystems. In other words, the rock constantly grows with every tonne of emitted carbon. As tipping points are reached, it can even grow exponentially, making it unmanageable and dangerous.

- **Is it cheap and capable of decreasing costs?** While many temporary removal options are cheap today, particularly afforestation and reforestation, they can actually be very expensive in the long run. Their costs are likely to rise over time. This is not only due to climate change impacts on ecosystems, but also due to increases in land prices and the anticipated tightening of regulations on carbon certification requirements. Regulators will probably tighten rules on carbon certification in response to concerns over additionality and baselines. Crucially, a centuries-long obligation to constant renewal increases the costs of these renewals drastically.
- **Is ensuring sufficient supply impossible?** The CCB must ensure that the removal credits in the MSR or a specific CRC reserve actually exist in the real world. If the credits are only on paper, the system would undermine climate action. However, ensuring a constant supply of removals in the real world is a significant challenge when climate change is impacting the carbon storage capacities of ecosystems and the necessary level of clean energy has not yet been achieved to make DAC a viable climate action instrument (as discussed above).
- **The CCB - a bad bank?** The management of credit, operational, market, and liquidity risks is central to bank operation. Banks typically manage such risks by reducing their exposure through diversification or by holding sufficient liquid assets. The CCB could use similar risk management approaches to manage the reversal risks.

  However, ecosystems and the biosphere cannot be treated like the financial system. While a collapse of the financial system can cause an economic crisis, it can be remedied. In contrast, a collapse of the climate system cannot be fixed – it is truly too big to fail. Therefore, the main concern is not merely to ensure that the CCB's mandate is sufficiently supported by public funds to guarantee the procurement and renewal of non-permanent removals, but rather to ensure that carbon removals are physically available in the real world. This is a risky proposition since it assumes that the carbon debt can be repaid in a world where carbon storage capacity is likely to be severely depleted as the climate crisis intensifies.

Removals in New Zealand's ETS (Text Box 5)

New Zealand's ETS is the world's only trading scheme that obliges forest owners to report GHG emissions and surrender units. Owners of forests that meet specific requirements – such as a certain size, height, and crown cover – can earn New Zealand Units (NZUs). To earn units, forest owners carry out activities that are recognised as a "Removal Activity". Eligible removal activities include, among others, embedding GHG in a product (i.e, production of methanol), storing CO_2 after capture, exporting Liquefied Petroleum Gas (LPG) or exporting or destroying bulk synthetic GHG such as hydrofluorocarbon (HFC) and perfluorocarbon (PFC) gases.

Forest owners participating in the NZ ETS hold an account in the NZ Emissions Trading Register (ETR) to receive, trade, or pay units. Each unit represents one tonne of CO_2 (or equivalent GHG). Removal units for forestry and industrial activities are not bound by the overall limit and add to overall market supply.

In the past, the NZ ETS has proven to be ineffective in reducing emissions. This is partly because many key features, such as the cap, free allocations industry and price moderation measures, caused oversupply. Moreover, biogenic methane emissions (a source of approximately 50% of NZ's emissions) are not subject to a price signal from the NZ ETS. The agricultural sector is part of the NZ ETS, but only has reporting obligations, though policy changes are being discussed to price agricultural emissions in NZ.

5.2 EU Removal Trading Scheme?

An EU Removal Trading Scheme (RTS) is another option to incentivise the removal of carbon. It would create a market for removals, driving the generation of negative emissions. The RTS would use some of the core design elements of the ETS, but instead of capping and trading emissions, the RTS would put an **obligation on covered entities to remove and store specific minimum amounts of carbon**. Covered entities would either be obliged to remove carbon themselves or to buy removals from companies or other entities that had removed carbon or had surplus removal in their portfolio. This obligation would be an addition to existing ETS obligations, if applicable. The RTS would be established after 2030, possibly running in parallel to the ETS during its initial phase and merging with it as the EU approaches climate neutrality.

To address the problem of non-equivalence between reductions and removals, the RTS would allow for the trading of carbon removal credits, but only within the RTS. The RTS would be a **separate system** with no interchangeability with the ETS or any other mitigation obligation. The Legislature of California is discussing a Carbon Dioxide Removal Market Development Act, which would also establish a dedicated market for carbon removals (Text Box 6).[65]

As **broad overview**, the EU RTS would incorporate the **following elements**:

- **Obligation to remove a specific amount of carbon:** Covered entities would be obligated to remove a minimum quantity of carbon, measured in tonnes, from the atmosphere within a set time frame, either annually or at the end of the commitment period. This mandatory removal quantity would be referred to as the entity's removal obligation.
- **Calculating the removal obligation - determining how much carbon needs to be removed:** The removal obligation would be allocated primarily based on historical emissions or the carbon debt of the covered entities. Therefore, the removal allocation would be equal to the full or a partial amount of historical emissions emitted over

[65] Senate Bill, California, 2023

a specific period, such as the past x years, which could be ≤100% of emissions. At the outset of the RTS, the amount of removals would be minimal and would gradually increase over time. Like the legislative proposal discussed in the Legislature of California, the RTS would have an escalating removal path as the need for carbon removals grows with accelerating climate change.

- **Scope of the RTS – which entities are covered:** The RTS primarily serves two purposes: (1) to incentivise larger-scale permanent carbon removals, and (2) to partially repay the carbon debt of covered entities, upholding the polluter-pays principle. For these reasons, larger installations covered by the ETS 1 and 2 could fall under the RTS. This scope also helps to ensure the proper functioning of the RTS as ETS installations have the capacity and expertise to operate trading schemes. The scope of the RTS needs to establish robust rules on legal succession to accommodate, for example, cases of bankruptcy, renaming, or purchase. It will also include rules governing emissions emitted outside the EU.
- **Overall obligation on the EU to remove carbon:** The removal obligations on covered entities would derive from an overall EU removal target. This overall removal obligation of the EU includes all types of eligible removals, going beyond the LULUCF obligations.
- **Eligibility of removals – in principle only removals with permanent storage are eligible:** Eligible removals must be certified. Carbon removals are only certified if (1) they exclude removals with temporary storage, (2) they only include permanent storage in geological formations (see above), and (3) they meet sustainability criteria, particularly regarding biodiversity, energy consumption, and life-cycle emissions. Applying these criteria, removals from DACCS and EW might be the only eligible removal solutions at this point. The non-waste based BECCS would not be eligible because of its many negative implications for ecosystems and the need to use sustainable biomass for the many other purposes of the bioeconomy, while BECCS could be included if it only uses waste biomass that is narrowly defined. Like the legislative proposal discussed in the Legislature of California, it is conceivable that temporary removals become eligible provided they are replaced by permanent removals after expiry.
- **How to meet the removal obligation:** Covered entities would have two options to meet their removal obligations: either remove carbon themselves or purchase removal credits from the RTS market. At the end of each year, covered entities must surrender sufficient removal credits to fulfil their removal obligation, or else face fines. The fines should be higher than the prices of removal credits to ensure compliance.
Alternatively, a CCB or another intermediary agency could act as a central purchasing house that companies can use as a marketplace or to pay a fixed price. This system could reduce administrative burdens, especially for smaller companies.
- **Trading:** Initially, carbon removals from DACCS, EW, and other eligible sources would be very scarce in the RTS market. The market would mainly consist of bilateral transactions between a few eligible providers and buyers. However, as the supply of removals increases, the market will become more liquid and shift from bilateral purchase agreements to trading. Marginal removal costs decrease as technologies mature, while marginal abatement costs increase as carbon prices for residual emissions in hard-to-abate sectors grow.[66]

[66] Edenhofer et al, 2023

Carbon Dioxide Removal Market Development Act: Legislative Proposal discussed in the Legislature of California (Text Box 6)

According to this proposal[67], the state board adopts – by the end of 2027 – a regulation requiring "emitting entities" to purchase negative emissions credits. These credits are equivalent to an increasing portion of the entity's GHG emissions: 1 % in 2030, 8 % in 2035, 35 % in 2040 and 100% in 2045. Emitting entities are installations that are subject to the California ETS, which is triggered by emissions ≥ 25ktCO2e/year.

To fulfill their negative emissions obligation, emitting entities are only permitted to utilize negative emissions credits obtained through "durable carbon sequestration methods". Durable carbon sequestration method are methods "that can reasonably be projected to retain a large majority of the carbon atoms out of the atmosphere for 1,000 years and for which the responsible entity provides a guarantee period of at least 100 years" (section 39742.1).

Alternatively, emitting entities can use so-called two-phase negative emissions credits – provided the state board has adopted pertinent rules. Two-phase credits consist of (1) a negative emissions credit utilizing a temporary carbon sequestration method and (2) a legally binding commitment to purchase an additional negative emissions credit utilizing a durable carbon sequestration method upon the expiration of the guarantee period associated with the original temporary negative emissions credit. If an emitting entity uses two-phased credits, no more than 50 % of the negative emissions credits used by an emitting entity to meet its obligation may be two-phase emissions credits.

On 29 May 2023, the Senate of California approved the proposal on a 24-9 vote. The proposal is now headed to the California Assembly. It must pass several other legislative steps before becoming State law.

Overview: Removal Trading Scheme – advantages and disadvantages

Advantages	Disadvantages
The RTS helps generate negative emissions. It could help establish a net-negative ETS, a critical tool supporting the achievement of climate neutrality and net-negative emissions.	At its outset, carbon removals would only be available at a very limited scale. The RTS would not create a liquid market, possibly entailing significant market power of just a few removers.
The allocation of removals based on historical emissions helps implement the polluter-pays-principle.	The RTS would create an additional layer of EU climate policies, making a complex system even more complicated.
The RTS clarifies that zero emissions are not the "endgame" of EU climate policies but removing carbon for the centuries to come.	The RTS puts additional costs on entities covered, at a time when these entities are already under stress to reduce their emissions to near zero. It can only be introduced in the medium term after 2030.
The RTS supports the EU in moving beyond offsetting and in refocusing its climate efforts to support decreasing atmospheric concentrations of GHG through net-	Historic emissions may be detached from current revenues, profits, and ability to cover costs, possibly leading to higher chances of bankruptcy. This is an important difference to

[67] Senate Bill, California, 2023

negative emissions - the ultimate objectives of climate action.	the ETS where additional costs are aligned with their current production.
After the spending sprees of the last years, it becomes more difficult to hand out subsidies for climate action, including incentivsing carbon removals. The RTS does not require subsidies.	In principle, prices and incentives should be placed as far as possible on those who can effect change. Most of the actors in an RTS will not have the ability to remove themselves.
The RTS will lead to higher demand for removals from DACCS and EW, the only technical removals with permanent storage. This demand is likely to lead to innovation.	

6 Integration of Removals into the Climate Action Regulation for Europe

The Climate Action Regulation (CARE) alias Effort Sharing Regulation (ESR) allows Member States to use up to 280 Mt of LULUCF removals to meet their reduction obligations under the ESR (Article 7, ESR). This flexibility is an exception to the principles of the ECL that removals cannot substitute reductions.

Although limited to 280 Mt, this flexibility is problematic. First, it makes removals and reductions equivalent. Second, this flexibility makes temporary removals a compliance unit for reduction obligations. Third, it is an incentive to prioritise low-cost removals (e.g., afforestation and soil carbon enhancement), thereby deterring emission reductions and the development of more mature technical sinks with higher investment costs.

For these reasons, this flexibility should discontinue. If this flexibility were to be continued, it should be built on the definition of carbon removals and a ceiling, as discussed above.

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