

DISCUSSION PAPER

HOW TO AVOID CARBON REMOVAL DELAYING EMISSIONS REDUCTIONS

October 2023

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In some cases, using, or planning to use carbon removal may risk delaying or stopping emissions reductions. Such cases are commonly referred to as 'mitigation deterrence' or 'moral hazard'. Much of the literature on this topic tends to remain theoretical, seeking to understand if and when this happens. This discussion paper is an effort to take the conversation to a practical level, giving clear suggestions for how countries and companies can manage such risks depending on why carbon removal is used and by whom. We suggest 12 solutions that governments and the private sector can start implementing today.



	before net zero	net zero	after net zero
	USE CASE A	USE CASE B	USE CASE C
1	 Remove obstacles for emissions reductions		
2	 Support CDR today		
3	 Require like-for-like compensation		
4	 Regulate climate related claims		
5	 Set separate fixed targets for emissions reductions and CDR in the short-medium term		
6	 Set short-term emissions reductions targets based on remaining carbon budgets on top of long-term net zero targets		
7	 Only plan for a limited amount of removals to be available for net zero targets		
8	 Establish principles for using carbon removal instead of emissions reductions		
9	 Set and implement targets that avoid or minimise overshoot		
10		 Demand transparent and accessible CDR plans	
11		 Allocate future responsibility for CDR to address overshoot	
12		 Set targets that include a country's upstream & downstream emissions	

Figure 1: Summary of the solutions to each use case

Executive summary

With global carbon budgets shrinking rapidly, carbon removal strategies have become an essential component of reaching net zero emissions and stabilising rising temperatures. However, concerns persist within the climate policy community that reliance on future carbon removal deployment could deter or delay urgent efforts to cut emissions in the near term. This phenomenon, known as ‘mitigation deterrence’ or ‘moral hazard,’ poses risks of overshooting carbon budgets if efforts on emissions reductions are lowered today based on assumptions about large-scale availability of carbon removal technologies in the future.

This report aims to enable policy-makers and practitioners to responsibly accelerate carbon removal deployment while avoiding mitigation deterrence risks. It provides a comprehensive framework for understanding and proactively addressing potential mitigation deterrence across three key use cases of carbon removal as defined by the IPCC. Based on this analysis, tailored solutions are proposed to **remove the factors encouraging mitigation deterrence and establish the guardrails needed to limit its impact.**

Accelerating progress towards net zero

The first use case examines deploying carbon removal to complement aggressive emissions reductions in accelerating progress towards reaching net zero targets. With current climate action lagging, carbon removal deployment must begin immediately in order to have time to scale up to the massive gigatonne levels needed by mid-century. Starting deployment now also **reduces risks of carbon removal solutions failing to materialise at scale or underperforming expectations.**

Removing obstacles to emissions reductions

through incentives, infrastructure, and regulations is a key starting point to avoiding mitigation deterrence. However, safeguards are also essential in the near-term to avoid mitigation deterrence, given the remaining uncertainty about carbon removal technologies. The report highlights the **like-for-like principle** where only permanent carbon storage can be used to neutralise fossil fuel emissions. Doing so avoids the risk of deterring fossil fuel phase-outs by relying on low-permanence biogenic storage.

In addition, the report advises instituting **separate, fixed interim targets for emissions reductions and carbon removal ramp-up.** These targets would prevent carbon removal deployment from displacing ambitious reductions.

Reaching net zero

The second use case for carbon removal covers deploying carbon removal to neutralise residual emissions and sustain a durable net zero state with the minimum level of overshoot.

The report highlights the importance of **planning for net zero using conservative assumptions on the availability of carbon dioxide removal** and advises setting **short-term emissions reductions targets aligned with remaining carbon budgets** to complement long-term net zero goals to avoid backloading mitigation.

The report also proposes developing clear principles to determine when carbon removal may be deployed instead of further emissions reductions efforts. This optimisation should weigh the costs, negative impacts and feasibility constraints of both options.

Enabling net negative emissions

The third use case involves planning to use future carbon removal technologies to achieve net negative emissions and lowering temperatures after overshooting 1.5°C or 2°C climate goals. The theoretical availability of negative emissions to compensate for overshoot could deter the radical near-term emissions reductions required to avoid overshooting carbon budgets in the first place.

Several factors determine whether mitigation deterrence is occurring in relation to overshoot for a given country. These include the feasibility of further emissions reductions under current conditions, a country's interpretation of their fair share of global effort, and their overall commitment to climate goals.

Although few countries explicitly plan to overshoot their fair share of the carbon budget, many could be said to implicitly do so. Countries without plans for near-term emissions cuts could be said to be particularly exposed to mitigation deterrence, and they provide particular cause for concern. Countries that already have 1.5°C-compliant emissions reductions targets that are not overly reliant on CDR could be said to not be mitigation deterred.

The report puts forward solutions to avoid mitigation deterrence related to overshoot. Firstly, urging countries to set binding near-term **targets consistent with 1.5°C carbon budgets and rapid mitigation is paramount.** Any references to negative emissions solutions should also prompt **demands for detailed roadmaps demonstrating feasibility and alignment with the like-for-like principle.**

Quantitatively allocating future negative emissions responsibilities across countries would also sharpen incentives for ambitious targets today. The last proposed solution is to make countries set targets for all of the emissions for which they are responsible, including their consumption-based emissions and the emissions from the export of fossil fuels, for example.

Other types of mitigation deterrence

In addition to the policy-driven mitigation deterrence forms covered in the three use cases, the report acknowledges a more indirect discourse driven form of deterrence. Portraying removal as a 'silver bullet' solution risks creating complacency and a justification for climate inaction. While this indirect deterrence risk is difficult to quantify, the solutions proposed in the report would significantly limit its impacts.

In summary, this report's proposed solutions enable decision-makers to responsibly scale up removal while maintaining urgency on emissions reductions and avoiding a harmful tradeoff (see Figure 1 on page 2 for a full summary of the paper).



1. Introduction

What is mitigation deterrence?

There is broad agreement that carbon dioxide removal (CDR) at scale is needed to stabilise climate change well below 2°C (Paris Agreement) by reaching net zero greenhouse gas emissions and then enabling a net negative phase to compensate for any overshoot and bring atmospheric CO₂ concentration back to a safer level. There is, however, disagreement around the size of CDR's contribution and how and when different actors should engage with it. Mitigation deterrence, or moral hazard, is a key theme in these disagreements and refers to **the risk of delaying or stopping emissions reductions due to the availability of alternative mitigation options, among them carbon removal.**

Mitigation deterrence is not a new concept and it applies equally to other mitigation options such as carbon capture and storage (CCS) and offsetting, along with broader climate interventions such as solar radiation management (Merck 2019; Austin and Converse 2021). The appearance of new technological alternatives mostly deployed in the future creates the fear that they might interfere negatively with ongoing efforts and **divert resources or political will away from existing/preferred near term options.**

Such fears are particularly justified by a series of deeply-embedded societal drivers that favour mitigation deterrence. First, the fossil fuel industry and its associated infrastructure is still at the heart of how our society works. The transition away from fossil fuels requires huge changes that may create significant amounts of stranded assets. Therefore, any alternative that would allow reducing emissions while continuing to use the fossil fuel system is naturally attractive.

Second, as pointed out by Carton et al. (2023), a significant driver dates back to 1992 and Nordhaus's early conceptualisation of what today is called the marginal abatement cost. Since then, collective thinking on mitigation is dominated by an economic approach where mitigation options compete mostly on cost efficiency. Policy-makers often favour economic considerations over other such important dimensions as impacts on ecosystems and communities, long-term sustainability and climate justice, thereby enabling mitigation deterrence.

A third important driver is the nature and temporalities of the challenge we are facing. Actors are supposed to make rational decisions if they are well informed and exposed to the consequences of these decisions. Climate change deviates from this ideal situation; **individual decisions made today generate shared consequences in the future.**

Therefore, today's decision-makers are largely protected from the consequences of a failure in the substitution of one mitigation approach by another. This situation reduces their aversion to the risk they take, creating further room for mitigation deterrence.

Some authors argue that in the case of CDR, the fear of mitigation deterrence is further justified by the fact that current existing mitigation options are compared with future theoretical techniques that are unproven, adding the risk that they may actually turn out to be impossible. This argument is increasingly becoming less true as CDR methods are deployed and acquire more data that supports them as a proven approach.

When does mitigation deterrence happen?

The question of whether mitigation deterrence happens and how to evidence it is addressed by Carton et al. (2023) in their paper *Is carbon removal delaying emission reductions?* They found that there is significant disagreement among researchers regarding whether or not mitigation deterrence is a serious problem, and that different groups have different standards for what would constitute evidence for mitigation deterrence.

McLaren (2020) reviews three scenarios that are helpful for understanding where mitigation deterrence can come from:

- **Substitution and failure:** refers to situations where CDR pathways fail to deliver the expected removed tonnes required to replace emissions reductions. There could be many reasons for such failure: lower technical performances, higher reversal, higher cost than expected, or even a more systemic failed scaleup due to policy shortcomings.
- **Rebounds:** refers to 'indirect and typically unintended effects in which GGR [Greenhouse Gas Removal] might trigger additional emissions', for example by maintaining fossil value chains with all the associated emissions beyond those directly compensated for by CDR.
- **Mitigation foregone:** or 'imaginary offsets' refers to the indirect reassurance effect that CDR may create, resulting in actors lowering their engagement on emissions reductions, even unconsciously.

¹ Although carbon removal is a form of mitigation, the term mitigation deterrence is still used to refer to emissions reductions being stopped or slowed down. As Carton et al. (2023) notes, 'the mitigation deterrence concept is therefore more correctly described as concerned with deterrence not of "mitigation" in its entirety but of "emission reductions".'

In determining where mitigation deterrence happens, Carton et al. (2023) suggest that mitigation deterrence occurs mechanically in Integrated Assessment Modelling (IAMs) used by the IPCC, since any CDR option introduced in the model mathematically displaces emissions reductions. Their conclusions are more nuanced at an individual level; where diverging conclusions are reported, they are largely linked to the design of the studies and have potentially low applicability to the more complex and subjective nature of real-world decision making.

In discussing if and where mitigation deterrence happens, a frequently overlooked point is the definition of **the baseline with which to compare CDR scenarios**, and whether there even was something to be deterred in the first place. Specifically, since we are collectively failing to reduce emissions at the required speed, and the climate crisis continues, authors like Rogelj (2023) or Van der Ven (2023) warn that currently-planned pathways to net zero already lack credibility, mostly due to a lack of clear implementation roadmaps. This setback further reveals the issue with unspecified counterfactual baselines, since nothing guarantees that they are actually feasible. Indeed, with or without CDR, current emissions reductions efforts have failed to meet set targets. These failures may result in what could be called 'removal deterrence,' a situation in which CDR development is blocked by mitigation deterrence fears, yet emissions reductions keep failing to meet the targets.

Can mitigation deterrence be controlled?

The potential drawbacks of carbon removal are highlighted by Carton et al. (2023). These include continued air pollution from fossil fuel use and resource constraints such as land use, among others. They argue that CDR 'is far from functionally equivalent to emission reductions.' However, activities that reduce emissions can also have drawbacks, such as land use, mining, and waste. No activities are absolutely substitutable due to different secondary effects. An analysis of which methods to choose needs to take all the effects into account, not just cost.

Whether perceived or real, mitigation deterrence is currently a twofold issue. On the one hand, it is not well understood and not taken seriously enough by decision-makers, leaving significant room for vested interests to push for a poorly regulated deployment of CDR (allowing mitigation deterrence). On the other hand, mitigation deterrence fears hinder the deployment and the conversation on CDR, which creates delays in the development of much needed CDR capacity.

This discussion paper aims to explore the conditions under which mitigation deterrence can be prevented so that emissions reductions and CDR can both progress at maximum speed without interference. In a series of real-world carbon removal use-cases, we examine when CDR is used, or planned to be used, why and by whom. In doing so, we evaluate how to (i) **remove the factors that encourage mitigation deterrence** and (ii) **create the guardrails to limit its impact**. Our analysis is based on the three primary use cases of carbon removal identified in the IPCC Synthesis Report and identifies the possible risks for mitigation deterrence along with corresponding solutions.

Using the three use cases for CDR provides a framework for understanding the different ways in which carbon removal can be used, how these use cases might interact with efforts to reduce emissions, and how mitigation deterrence might arise as a result. It also enables us to provide specific, tailored solutions for each scenario. The ambition is to make our recommendations more actionable and relevant for different actors, from governments to companies. Although this approach covers many of the risks of mitigation deterrence, it is not exhaustive, as we discuss at the end of the paper.

Key definitions

Net zero CO₂ means counterbalancing anthropogenic (human-caused) CO₂ emissions with anthropogenic carbon removal, meaning on net, no more carbon dioxide is being added to the atmosphere by humans than what is taken out. This state of net zero does not contribute to more warming due to human caused emissions without increases in other greenhouse gasses (IPCC SR15, 2018)².

Contrarily, net zero greenhouse gas emissions (GHG) is defined as zero emissions of other greenhouse gasses, mainly methane and nitrous oxide. Neutralising these gasses would lead to reduced temperatures.

One can talk about net zero CO₂ on a global level, leading to temperature stabilisation, or on a country or corporate level, meaning that entity is not contributing to further warming.

² See for example Chapter 1.2.4 and Figure 1.5 in the [IPCC SR15 report](#)

2. Carbon removal use cases

The IPCC AR6 synthesis report (IPCC 2023) lists three roles for carbon removal (in this paper referred to as ‘use cases’), namely:

- 1) Accelerating our progress toward net zero alongside rapid emission cuts;
- 2) Enabling net zero and halting temperature increases by offsetting residual emissions;
- 3) Supporting net negative emissions after net zero to reduce temperatures, dealing with overshoot and stabilising our climate at safer levels.

These use cases refer to the different functions carbon removal plays on our journey to a safer climate. Each use case presents its own set of challenges and potential risks in relation to mitigation deterrence, as well as solutions.

While the use cases are helpful to explore different mitigation deterrence situations, drivers and solutions, they should not be seen as mutually exclusive. Indeed, they may overlap and the solutions proposed in the following sections can be useful in several use cases (See figure 2).

2.1 Use case A: Accelerating net zero achievement alongside rapid emissions cuts

In this use case, carbon removal is used to accelerate the reduction of greenhouse gasses in the atmosphere, working in tandem with efforts to cut emissions. This use case focuses on using carbon removal technologies and strategies to expedite the process of achieving a net zero state.

For some, deploying carbon removal before net zero is a distraction and creates room for increased mitigation deterrence. Yet, if CDR is deployed today in addition to emissions reductions, it can contribute to minimising the CO₂ increase in the atmosphere. However, **the main reason to deploy carbon removal today is to increase its deployment toward the scale needed to reach and maintain net zero.** As CDR is scaled up there is some possibility it becomes ‘too attractive’ an option and replaces emissions reductions.

An example of mitigation deterrence under this use case for CDR could be offsetting the use of fossil fuel powered internal combustion engine (ICE) cars. If permanent removal credits would cost 200 USD per tonne, the cost of offsetting a litre of petrol would be around 50 cents. This amount would be a significant increase in petrol prices, but still just around 25% of the price at the pump

	before net zero	net zero	after net zero
	USE CASE A	USE CASE B	USE CASE C
	CDR accelerates net zero alongside emissions reductions	CDR enables net zero by neutralising residual emissions	CDR used to deal with carbon budget overshoot
Level	Individual Corporate National	Corporate National	National
Role of CDR	Early deployment of CDR to reduce uncertainty and prepare scale up to Gt scale	Enables durable net zero by compensating residual emissions by following the like-for-like principle	Allows some countries to go net negative, addressing their historical emissions to restore some carbon budget and/or address an overshoot
Drawbacks	Uncertainty remains on the feasibility of large-scale CDR Costlier and more resource-intensive than most current emissions reductions Possible distraction from funding emissions reductions in lagging actors	Demands high-quality, sustainable CDR Risk of insufficient CDR availability to reach net zero Risk of unsustainable net zero with high flows (remaining emissions and CDR) if CDR costs go down	Relies on future CDR funding, which may be unrealistic The assumption that large amounts of CDR is possible may reduce the aversion to the risk of an overshoot
Mitigation deterrence risks	Risk of overreliance on CDR due to lack of data Risk of lock-in and using CDR to compensate for practices that should be temporary Low risk if permanent CDR is used due to its high cost	If carbon budgets are not used, the concept of net zero itself may lead to insufficient emissions reductions before the target date, resulting in overshooting carbon budgets Risk of inflated residual emissions to use cheap CDR instead of assuming costly changes	Potentially deters radical emissions reductions needed to minimise overshoot, particularly since future responsibility to deploy CDR is not allocated

Figure 2: A summary of the use cases and the role of CDR

in many European countries. Many consumers might see this asymmetry as an acceptable tradeoff to be able to continue to use their ICE cars. The problem is that such neutralisation would create a risk of lock-in and slow the adoption of far more resource-efficient electric vehicles. This risk in turn would lead to the world being unnecessarily dependent on carbon removal.

Key definitions

Neutralising emissions is the act of counterbalancing residual emissions with carbon removals, thereby reaching net zero. The remaining emissions at net zero are also often called residual emissions. Emissions reduction credits cannot be used for neutralisation.

Solution 1: Remove obstacles to emissions reductions and make decarbonised alternatives economically viable

In the short term, one of the main drivers for mitigation deterrence is arguably the lack of accessible mitigation options to decarbonise existing activities. **Removing obstacles to emissions reductions** should be the starting point of all efforts to address mitigation deterrence. If companies and consumers cannot make choices that reduce their emissions due to various barriers, carbon removal might end up being the only actionable option, even if sub-optimal. For instance, consumers or businesses may not opt for electric vehicles due to a lack of charging infrastructure or higher upfront costs. Similarly, companies may continue to rely on fossil fuels if clean energy is not accessible due to a slow build out of the electric grid. Therefore, policy efforts must increase the accessibility and affordability of sustainable alternatives, improve infrastructure, provide incentives and subsidies for green choices and implement regulations that discourage high-emission activities.

Solution 2: Set separate fixed targets for CDR and emissions reductions in the short to medium term

One of the most efficient solutions for avoiding mitigation deterrence in this use case for CDR is to set **separate fixed targets** for CDR and emissions reductions in the short to medium term. Doing so forces companies and countries not to offset any specific emissions, but instead scale up CDR according to a set target and reduce their emissions in line with science. This solution restricts the substitution of emissions reductions with carbon removal, so that if a company or country increases their CDR deployment, they avoid the risk of displacing other emissions reductions efforts. One example could be the EU setting a target of 55% emissions reductions and, in addition, a (hypothetical) target for permanent carbon removal of 50 million tonnes for 2030. For long-term targets however, it would be sub-optimal to set fixed proportions between CDR and reductions today, since we do not know how different removal and mitigation options will be developed. On the other hand, as is discussed later under use case B, decision-makers today should assume that the amount of CDR available by mid-century will be limited.

Solution 3: Carefully regulate climate related claims and increase the requirement for transparency

Poorly or unregulated net zero or climate claims are also a major incentive for mitigation deterrence since companies can claim additional recognition or value on weak mitigation strategies. There are legions of companies buying large amounts of cheap CDR credits instead of reducing emissions and claiming to be carbon neutral. Eventually, such mechanisms divert significant amounts of money and create the false impression of climate action (see our position paper on Green Claims [here](#)).

The solution to this issue is to **carefully regulate climate related claims and increase the requirement for transparency**. Examples already exist where such claims must be supported by a genuine decarbonisation strategy that imposes yearly updates to inform the public about the company's progress.

Solution 4: Strictly implement the like-for-like removal principle to regulate any permitted compensation

Mitigation deterrence may also occur when a company seeks to avoid expensive emissions reductions measures by categorising most of its fossil emissions as 'residual' or 'hard-to-abate' and compensates for them with cheap, low durability carbon removal. Such an approach contributes to creating both unsustainable (fossil carbon stored in biogenic pools) and high flows of carbon at net zero.

Implementing the like-for-like principle (see Figure 3 on the next page) as defined above is a crucial part of avoiding low integrity strategies and mitigation deterrence. Fossil CO₂ from the long carbon cycle cannot be allowed to be compensated with CO₂ restored to the short carbon cycle.

For now, high permanence CDR remains very costly and is available in limited amounts. Playing on the economic approach to mitigation described above, these high costs can serve as a natural disincentive for mitigation deterrence if countries are able to carefully regulate compensation following the principles of like-for-like removal, maintaining durable net zero. Indeed, any fossil emission would have to be compensated by high permanence removals, making their high price tag a natural disincentive for mitigation deterrence.

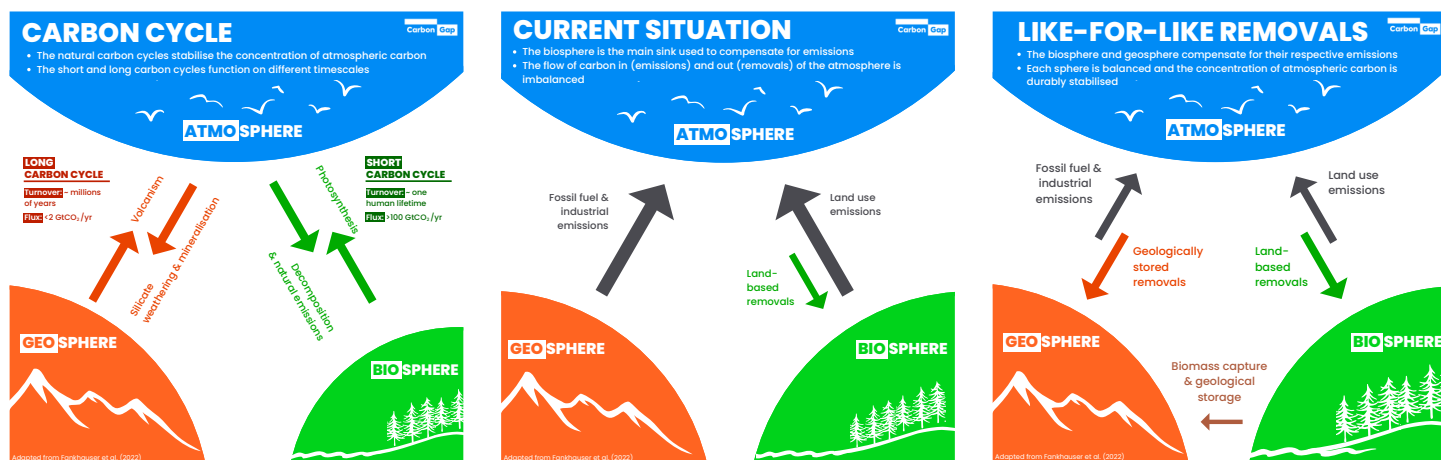


Figure 3: Comparison of carbon flows in the natural carbon cycle, under current pledges and in a durable net zero state (adapted from Allen et al. (2022))

Key definitions

Like-for-like removals are defined by the UNFCCC's [Race to Zero campaign](#) as 'when a source of emissions and an emissions sink correspond in terms of their warming impact, and in terms of the timescale and durability of carbon storage'. This definition indicates that CO_2 that came from permanent storage, such as fossil fuels, must be returned to permanent storage. At the same time, CO_2 released from insecure storage such as forests or soils can be returned to the same type of storage (i.e. offset land use change with forestation). It also means that short-lived greenhouse gases such as methane could potentially be neutralised by CO_2 storage with the same lifetime as methane (adjusting volumes for global warming potential). The like-for-like principle stems from the structure of the natural carbon cycle and safeguards against, for example, an oil company continuing to produce fossil fuels and releasing CO_2 from the long carbon cycle, while offsetting their emissions by planting trees and restoring carbon into the short carbon cycle. The like-for-like principle should always be used when neutralising emissions with [removals to contribute to reaching a durable net zero state](#).

Solution 5: Support carbon removal today to reduce the risk of it failing to materialise to fulfil its planned role

Another risk is CDR not growing at the pace required to fulfil its role. CDR at scale requires innovation, talent, permitting, new policies, land, engagement with local populations and a lot of electricity. To grow durable CDR from the [tens of thousands of tonnes removed today](#) to the gigatonnes needed at net zero, rapid deployment needs to start today (for example reaching a removal capacity of just $1.5 \text{ GtCO}_2/\text{yr}$ would require building one 1 Mt/yr removal facility every week for 28 years.) If we wait until all cheap and actionable emissions reductions have been made, we will be decades too late deploying CDR, resulting in a large overshoot.

Moreover, at this stage (near term), CDR still lacks credibility, and uncertainty on the feasibility of the different CDR pathways remains large, increasing the risk of 'substitution and failure' with actors betting too much on it. Instead, policy-makers must invest in the emerging CDR industry to accelerate its deployment, build test facilities and acquire the data and knowledge required to reduce uncertainty on what CDR may or may not deliver and reduce the risk of 'failure'.

2.2 Use case B: Enabling net zero and halting temperature increase by compensating for residual emissions

The first use case describes CDR's role leading up to net zero, while the second defines how CDR enables net zero by offsetting residual emissions to halt further increases in global temperatures.

CDR is essential in reaching net zero and stabilising temperatures. There is virtually no disagreement on this point. The question to answer is how much carbon removal will be needed to achieve this goal.

We can, in theory, reach different net zero states depending on the **magnitude of the flows** (residual emissions vs removals) required to sustain net zero and on the extent to which these flows **balance the carbon cycle in the long term**. This theory is what has led to the definition of durable net zero (Allen, 2022): a net zero state in which flows are balanced between the long and short carbon cycle. The question of what happens before we reach net zero also matters since the accumulated emissions will set the **level of overshoot**. This overshoot may in turn trigger more adverse climate change effects or even trigger negative feedback loops threatening the feasibility of stabilising our climate. The magnitude of the flows, the balance of carbon cycle, and the level of overshoot are all affected by unchecked mitigation deterrence and can lead to unsustainable net zero states.

How much carbon removal is it possible to deploy?

There is a huge difference between the theoretical limit for CDR and how much of it is likely to be available at a certain point in time.

There are many different CDR methods, all of them theoretically limited, for example either by land use, CO₂ storage or resource availability. However, the theoretical capacity for CDR is large, particularly if we decided to use all the available CDR pathways (portfolio approach) and spend dedicated budgets to create the extra decarbonised energy we need to increase the scale of CDR.

The first step in carbon removal – extracting CO₂ from the air – is bounded only by the amount of low-carbon energy that is available and allocated by society to this use. The final step in carbon removal – storing that CO₂ in a highly durable form – is bounded by the amount of high-durability storage capacity that can be developed. Estimates of geological storage potential, for example, vary widely but are in the range of *thousands of gigatons* of CO₂³ (De Coninck and Benson, 2014; Kelemen et al., 2019; National Academies of Sciences Engineering and Medicine, 2019; Snæbjörnsdóttir et al., 2020).

For illustration purposes, it is possible to imagine dedicated zero carbon power plants that run direct air capture plants 24/7 in places with very large CO₂ storage capacity, as suggested by Goldberg et al. (2013). The upper theoretical removal capacity of such

efforts could be much larger than our needs. But that is, of course, unlikely to materialise any time soon and should not be relied upon as a likely scenario.

Even if the CDR sector got a blank check and money was not an issue, the *speed* of the deployment would be limited by factors like talent, permitting, supply-chain issues and access to energy and other resources.

It is often argued that since CDR is limited in the foreseeable future, it should only be used for certain limited purposes and not to compensate for air travel for vacations, for example. This critique is valid when CDR supply is constrained but not necessarily when its demand is constrained. Supply and demand interact, of course, making the issue complex. CDR is not something that spontaneously occurs. Barring a certain sector from using CDR, for example, would also mean less demand for CDR, leading to less supply in the long run.

Currently, the CDR market for durable tonnes is constrained by a lack of demand⁴, and the pre-sale of carbon removal credits is what enables the building of removal capacity. At the same time, physical deliveries of purchased high-durability CDR credits are still very limited and not anywhere near what is needed. This situation may shift to a lack of supply as companies start using CDR to reach net zero targets and CDR is included in compliance markets.

³ For more information see [The world has vast capacity to store CO₂: Net zero means we'll need it](#)

⁴ For tonnes with future deliveries, see for example [CDR.fyi 2023 mid-year report](#). For the small amount tonnes that are already removed, supply is smaller than demand.

Solution 6: Set short-term emissions reductions targets based on remaining carbon budgets in addition to long-term net zero targets

A company or country that sets a net zero target but does not plan to substantially reduce its emissions and instead relies on future removals is engaging in mitigation deterrence. Here, it is the belief that carbon removal will be available and affordable in the future that potentially keeps the company from making near-term emission cuts, while they still get good publicity from what might look like an ambitious target.

To prevent such situations, **short-term emissions reductions targets that consider carbon budgets** should be required to accompany any long-term targets. A target that is only concerned with reaching net zero irrespective of the path taken contributes to leading to an overshoot and a 'high flows' net zero state. Moreover, such an approach also endangers the net zero target, since very large quantities of CDR are not likely to be available.

Key definitions

Carbon budgets refer to the estimated total amount of carbon dioxide (CO₂) that can still be emitted while keeping global temperature rise below a specific level, such as 1.5°C or 2°C above pre-industrial levels. To have a 50% chance of staying below 1.5°C warming, the remaining carbon budget from the beginning of 2023 is estimated at approximately 250 gigatons of CO₂ (Forster et al 2023). Carbon budgets provide a finite limit on total emissions over time, informing required rates of decarbonisation. As emissions continue, the remaining carbon budget shrinks, implying emissions must fall faster to avoid overshooting budgets and temperature guardrails. Tracking carbon budgets guides policy-makers in ratcheting climate targets and strategies consistent with global carbon constraints.

Solution 7: Only plan for a limited amount of removal to be available for net zero targets

While CDR must be scaled as fast as possible, countries and companies should also purposely **plan for a limited amount of removal to be available** in reaching their long-term net zero targets. This restraint is to account for the high uncertainty that remains on the feasibility of large scale deployment of CDR, and is in line with the precautionary principle enshrined in various international treaties, including the Treaty on the Functioning of the European Union⁵.

The Science-Based Target initiative's (SBTi) [Net Zero Standard](#) is an example of such an approach where companies need to reduce emissions by at least 90% and only use carbon removal to neutralise up to the last 10%. However, for corporate and national long-term targets, a range rather than a fixed percentage is likely best since it leaves room for technological development both in emissions reductions and carbon removal.

Solution 8: Develop clear principles for when it is preferable to deploy carbon removal instead of emissions reductions

In considering hard to decarbonise sectors, a clear principle of when to deploy carbon removal instead of emissions reductions becomes essential. The remaining emissions to be compensated with removal are referred to as residual emissions. Currently, net zero pledges refer to residual emissions without a clear definition, leaving room for companies to argue that most of their emissions are 'unavoidable' (Buck 2022).

Strictly speaking, no emissions are physically impossible to eliminate. However, for some sectors/activities [such as aviation](#), there may be limited to no options to decarbonise, and emissions will probably not be capped to 5 or 10 % of their 1990 levels. There is a large possibility that carbon removal will be the option that is cheapest and with the fewest negative side effects for aviation. Of course, not emitting at all is always the cheapest option but also carries alternative costs.

⁵ For more information see the European Parliamentary Research Services' in-depth analysis of [The Precautionary Principle](#)

Ideally, the decision of whether or not to deploy CDR instead of emissions reductions should be based on:

- the **cost, availability, side-effects** (including effects from continuing to use fossil fuels) and **co-benefits of the carbon removal methods;**
- the alternative **cost, availability, side-effects and co-benefits of emissions reduction options,** including demand reduction.

This analysis is complex and not all effects might be known. Therefore, it may be hard to set rules that let the market decide when CDR should be used, which may lead to rules designating certain sectors for CDR compensation and not others.

Once the level of residual emissions is controlled by regulations like the ones proposed above, the compensation of the 'credible' residual emissions should follow the like-for-like principle mentioned in use case A to guarantee sustainable carbon flows.

A different approach would be to implement solutions like a carbon takeback obligation where all fossil fuel use would be required to be removed and durably stored, but where there is disagreement on what the fossil fuel is used for.

Finally, we must consider **who controls emissions.** For example, some corporations could be compelled to use carbon removal to reach net zero for their Scope 3 emissions, even when emissions reductions would be theoretically cheaper, but these corporations lack the necessary control of the supply chain. For example, Scope 3 reductions are very challenging for a company whose emissions are spread over thousands of suppliers for whom they are just one of many customers. As more company and product specific emissions data becomes available, it will be easier for companies to select suppliers with lower carbon intensity, yet it is likely that a significant share of Scope 3 emissions will not be addressed without carbon removal.

2.3 Use case C: Dealing with carbon budget overshoot, facilitating net negative emissions after net zero to reduce temperatures

The third use case describes how CDR can be used to actively reduce the concentration of CO₂ in the atmosphere, effectively creating a net negative state bringing temperatures back down after a temperature overshoot.

Carbon removal could, in theory, be used to reach net negative emissions and reduce temperatures. This use case is an entirely different one for CDR than using it to reach net zero, requiring deployment at a scale several orders of magnitude larger if done in a short time span. Researchers [estimate](#) that we need on average 222 Gt of carbon removal to lower temperatures by 0.1°C. To put that number into context, humanity has emitted 1736 Gt of CO₂ since the start of the industrial revolution. To lower temperatures by 0.1°C today, ~13% of the CO₂ emissions ever emitted would need to be removed (given no more CO₂ is added), showing the extreme difficulty of dealing with overshoot through carbon removal.

Because reaching net negative emissions can address legacy emissions and restore some carbon budget, the responsibility to go beyond net zero will most probably fall onto countries with the largest historical emissions and ability to pay, adding further complexity in how countries plan their targets and negotiate the efforts needed to respect the carbon budget.

Key definitions

Overshoot means exceeding the remaining carbon budget to stay below a given threshold such as 1.5°C warming. For this target, current [best estimates](#) point to the budget being around 250 Gt CO₂ (billions of tonnes) at the beginning of 2023. [Reaching global greenhouse gas net zero ensures that warming stops](#), but the degree of overshoot of the budget determines at what temperature it stops. Carbon removal would be needed to reach net negative emissions on a global scale and bring temperatures back down after overshoot.⁶

⁶ Note that bringing temperatures back down does not mean the world returns to its prior state. For example, ecosystems may have crossed a tipping point from which they cannot return even if temperatures drop. Also, the relationship might not be 1:1 due to how the climate system works; there is a possibility that even more emissions need to be removed than what was released.

Solution 9: Set and implement targets that avoid, or minimise, overshoot

The availability of negative emissions for this purpose could, in theory, keep nations from setting targets that avoid or limit overshoot to a minimum.⁷ As Buck (2022) explains, currently, aggregated national climate targets lead, at best, to overshooting the 1.5°C carbon budget and [reaching at least 1.8°C warming](#). However, answering *who* is being deterred is key in determining if mitigation deterrence is happening.

When attempting to determine if a country is subject to mitigation deterrence in relation to overshoot, several factors must be considered, including the perceived feasibility of stricter emissions reductions, the country's interpretation of what constitutes a fair contribution to global emissions reductions efforts and their level of commitment to tackling climate change. For instance, countries that perceive it as impossible to further reduce their emissions beyond current plans are unlikely to primarily be influenced by the potential for CDR, since their lack of stricter targets is not driven by the availability of this technology. In this case, it is the perceived impossibility of stricter emissions reductions that makes the country fail to set a stronger target, not a reliance on CDR. Similarly, a country that is indifferent to whether the global temperature increase stays within the 1.5°C limit is unlikely to have emissions reductions deterred by CDR.

Furthermore, a country that has set targets in line with the 1.5°C limit based on their interpretation of a fair contribution could be viewed as not being influenced by mitigation deterrence. They may argue that they are already fulfilling their responsibility and any potential overshoot is the responsibility of others based on their interpretation of a fair allocation.

Explicit versus implicit mitigation deterrence

We find it helpful to differentiate between explicit and implicit mitigation deterrence. With explicit mitigation deterrence, we refer to planning to overshoot one's own budget and then using negative emissions to compensate. This type of direct mitigation deterrence seems rare. No countries have such explicit plans to our knowledge. Implicit mitigation deterrence appears to be more common and we define it as not explicitly planning for net negative emissions but overshooting budgets nonetheless.

It is important to note that even if countries only implicitly use carbon removal to deal with overshoot, it can still be intentional. Intentional implicit mitigation deterrence is hard, if not impossible, to prove. A country or company might overshoot their budget even if CDR did not exist. They might also use CDR as a convenient explanation for why they are overshooting. As Carton et al. (2023) explains, 'no amount of modeling or experimental studies can tell us what targets companies or countries would have set in the absence of carbon removal, under actually existing social, political, and economic conditions'.

An example of implicit mitigation deterrence could be Norway's continued oil production. While Norway is in many regards a leader in the green energy transition with ambitious domestic climate targets, they continue to extract and sell oil. The emissions from burning that oil are not attributed to Norway, but to the end consumers. Even though research clearly states that [no new oil fields can open if the world is to stay within 1.5°C](#) without overshoot, Norway is steadily [taking new fields into production](#). Norway does not explicitly say that carbon removal should be used to deal with the emissions from its oil production, but it could be said to implicitly ask for it.

Another example of implicit mitigation deterrence comes from countries with weak targets that do not plan to make any near-term emission cuts. Such examples include China, Russia, Mexico, Egypt and Singapore whose nationally determined contribution plans do not include emissions reductions until 2030. [According to Climate Action Tracker's analysis](#), these countries' targets are critically or highly insufficient for 1.5°C. Such countries are on their way to massively overshooting their share of carbon budgets (together with large historic emitters such as the US, but for actors such as the US and the EU, most emissions lie in the past rather than in the future). The insufficiency of the targets stands true even in a fair share analysis taking historic emissions into account. Such countries could be said to implicitly ask for large-scale carbon removal in the future to make up for the overshoot they are creating.

The greatest risk for implicit mitigation deterrence is arguably among the actors that currently have the least aggressive plans for reducing emissions, provided they are committed to achieving global climate goals in the first place. These actors have the most room to enhance their targets, which could potentially lead to a greater reliance on future carbon dioxide removal to deal with overshoot as a justification for not adopting more stringent targets. For instance, it is easier to make significant emissions reductions in the absence of ambitious reduction plans to begin with, as is the case with China and Norway's oil

⁷ Many countries have already exceeded their carbon budgets when taking historical emissions into account, so they could be said to only be able to limit overshoot to a minimum, not avoid it.

production. On the other hand, for those who have already committed to aggressive emissions reduction targets, like the European Union with its goal of 55% emission cuts from 1990 by 2030, further improvements are relatively harder (albeit far from impossible) to achieve, since they are already planning significant reductions.

Countries that already have 1.5°C-compliant emissions reductions targets that are not overly reliant on CDR could be said to not be mitigation deterred, at least not for their production-based emissions. The main concern for them is to deliver on their pledges, rather than on strengthening them. The obvious solution to the mitigation deterrence risks described above is to get countries and companies to **set and implement targets that avoid or minimise overshoot**. Targets that avoid mitigation deterrence are those that are followed, that are 1.5°C compliant, and do not include excessive amounts of CDR. However getting actors to set and implement such targets is easier said than done, given that actors with relatively weak targets plan to emit a large share of future emissions and might not have much interest in strengthening them⁸.

Solution 10: Demand detailed and fully transparent (accessible) carbon removal plans

Additionally, whenever an actor refers to carbon removal as a future solution, implying that the speed of emissions reductions might not need to increase, they **must be asked to be specific and provide detailed and accessible plans for how much and what type of CDR they are planning to use and how**. Such specificity makes it possible to determine whether CDR is used as a smoke screen for inaction, or part of a credible plan. It also makes it possible to see if real emission cuts are planned and if the strategy is over-reliant on CDR. As proposed in solution 7, countries and companies should only plan for a limited amount of CDR to be available.

Solution 11: Allocate the future responsibility for the negative emissions that are needed to reverse overshoot

Another way to reduce the drivers for mitigation deterrence is to **allocate the future responsibility for the negative emissions that are needed to reverse overshoot**.

Unallocated responsibilities for net negative emissions carry a much higher risk for permanent overshoot than allocated ones. Such allocation principles can also include the responsibility for historical emissions and principles of fairness. Fyson et al. (2020) explores allocations of negative emissions by looking at scenarios that take into account historical emissions, least-cost and the ability to pay. The approach either gives the US (historical emissions) or China (ability to pay) the greatest responsibility for CDR, illustrating the difficulty in agreeing on a principle for allocations.

The main advantage of allocating such quantified responsibility to countries would be that it would strongly incentivise them to police mitigation deterrence to ensure their CDR capacity is well used. Indeed, if they are committed to delivering certain amounts of removal, countries would probably monitor the uses of their CDR capacity to minimise the volumes of CDR dedicated to compensating avoidable emissions.

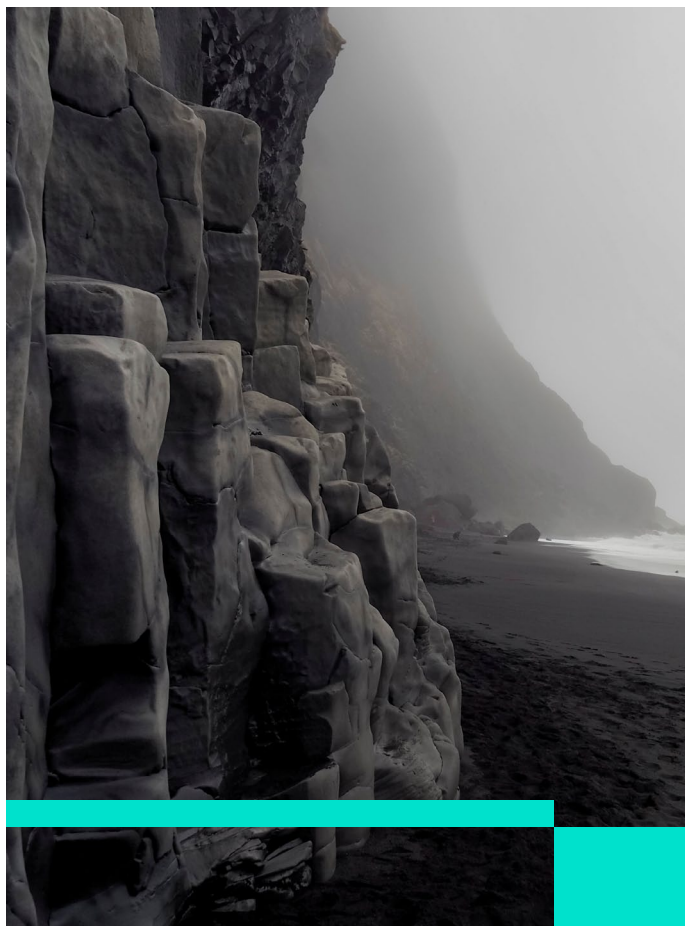
What else could actors who want to counter potential mitigation deterrence related to overshoot do? Convincing governments to disregard net negative emissions as a solution, as some CDR critics have suggested, would not be sufficient if mitigation deterrence is mostly implicit.



⁸ Authors own calculations based on countries NDCs and net zero targets to be presented in a forthcoming paper by Hahn, Höglund, Morfeldt, Karlsson and Fetzer.

Solution 12: Set complementary carbon targets that include upstream and downstream emissions from a country's activities

A partial solution could be to set complementary carbon targets that include upstream and downstream emissions from a country's activities. In this case countries would, like the private sector, have net zero targets that include not only their within-country, production-based emissions (Scope 1 in the corporate world), but also the upstream and downstream emissions from their imports and exports (Scope 2 and 3 for corporations). This solution, for example, would force Norway to take responsibility for the burning of the oil that it sells. It would also entail taking responsibility for consumption-based emissions, for example for products coming from emission-intensive countries like China, and ultimately help accelerate the transition in such countries as well.



Other types of mitigation deterrence

Although our approach covers the main risks of policy-borne mitigation deterrence when carbon removal is used (or planned to be used) by companies and countries, we acknowledge the existence and validity of a more abstract, discourse-driven form of mitigation deterrence. This form of deterrence is more nuanced and difficult to quantify, since it involves shifts in public perception and behaviour in response to the portrayal of carbon removal in media and public discourse. If carbon removal is excessively portrayed as a 'silver bullet' solution to climate change, then it could lead to weakened support for emissions reductions because people believe technology will simply 'fix' the problem in the future. Markusson et al. (2018) gives examples of such effects and suggests that CDR may create a false sense of security, justify inaction or lock-in high-carbon pathways and thus deter or delay mitigation. Stilgoe (2015) lists possible effects such as 'politicians losing interest in mitigation, consumers making unsustainable choices, researchers turning attention away from climate science, or engineers giving up on clean technology'. Most recently, oil companies buying CDR suppliers and using these acquisitions in their communication is an example of something that could spread a perception of CDR as a solution that negates the need for emissions reductions and creates a smokescreen for inaction.

It is important to note that policy-driven and discourse-driven aspects of mitigation deterrence can reinforce each other. The discourse on CDR can influence policy decisions and vice versa. For example, clearly communicated net zero plans that explicitly lay out a role for CDR would likely dampen public perception of CDR as a 'miracle' solution.

Crucially, while our approach does not directly address discourse-driven deterrence, our proposed solutions would limit its harm.

If countries and companies set separate targets, plan for limited amounts of CDR, use the like-for-like principle and lay out detailed carbon removal plans, they can limit the damage from faulty impressions of CDR as a silver bullet.

Conclusion

Currently, mitigation deterrence risks delaying both emissions reductions and CDR deployment, creating a dangerous situation. Yet the main takeaway of this discussion paper is that policy-makers can **manage mitigation deterrence by removing the drivers and strengthening the required safeguards.** There is a clear difference in the risk and type of mitigation deterrence depending on the use case of carbon removal, with proposed solutions to address each. The solutions proposed can also help avoid more indirect forms of mitigation deterrence based on the public discourse of carbon removal.

The first use case involves using CDR as a complement to emissions reductions. To counter the risk of any associated mitigation deterrence, policy-makers must remove obstacles for emissions reductions and set separate targets for CDR and emissions reductions in the short to medium term. Furthermore, by supporting carbon removal technologies today, they can reduce the risk of CDR failing to materialise to fulfill its planned role. Policy-makers must also require like-for-like compensation and regulate CDR related claims.

In the second use case, CDR is used to compensate for residual emissions. Actors can handle associated risks of mitigation deterrence by setting short term emissions reductions targets and considering carbon budgets in addition to long-term net zero targets. Policy-makers can also counter mitigation deterrence by only assuming a limited amount of removal technologies will be available for net zero targets, and developing clear principles for when it is preferable to deploy carbon removal instead of emissions reductions.

The third use case deals with CDR used to avoid tackling overshoot and is the hardest one to address. Solutions include pushing those countries and actors that have less ambitious targets to strengthen them, asking for specificity in how they plan to use CDR and introducing supplementary targets for actors that encompass all emissions they influence. Assigning responsibility for the deployment of negative emissions can also sharpen countries' monitoring and control of mitigation deterrence to preserve their CDR capacity.

Addressing mitigation deterrence today is critical to maximise the speed and scale of both emissions cuts and CDR deployment, but also to depart from the poor precedent set by the offsetting industry and set much higher standards to position CDR as a truly complementary and additional climate solution. It is critical that decision-makers start implementing these solutions today and tackle mitigation deterrence before it grows into a larger problem.

Acknowledgements

The authors warmly thank the following persons for the valuable inputs they have provided during the preparation of this paper:

Kayla Cohen, Matthias Honegger, Lydia Loopesko, Nils Markusson, Duncan McLaren, Luciana Miu, Mark Preston Aragonès, Codie Rossi, Wijnand Stoefs, Ulriikka Aarnio



References

- Allen, Myles R., Pierre Friedlingstein, Cécile A.J. Girardin, Stuart Jenkins, Yadvinder Malhi, Eli Mitchell-Larson, Glen P. Peters, et Lavanya Rajaman (2022).i. Net zero: Science, Origins, and Implications. *Annual Review of Environment and Resources* 47, no 1 : 849–87.
<https://doi.org/10.1146/annurev-environ-112320-105050>
- Austin, Maura M.K., et Benjamin A. Converse (2021). In Search of Weakened Resolve: Does Climate-Engineering Awareness Decrease Individuals' Commitment to Mitigation?, *Journal of Environmental Psychology* 78 : 101690. <https://doi.org/10.1016/j.jenvp.2021.101690>
- Buck, Holly Jean, Wim Carton, Jens Friis Lund, et Nils Markusson (2023). Why Residual Emissions Matter Right Now. *Nature Climate Change*.
<https://doi.org/10.1038/s41558-022-01592-2>.
- Carton, W., Hougaard, I. M., Markusson, N., & Friis Lund, J. (2023). Is carbon removal delaying emission reductions? *WIREs Climate Change*, 14(1), e826.
<https://doi.org/10.1002/wcc.826>
- De Coninck, H., Benson, S.M., (2014). Carbon dioxide capture and storage: Issues and prospects. *Annu. Rev. Environ. Resour.* 39, 243–270.
<https://doi.org/10.1146/annurev-environ-032112-095222>
- Forster, P. M., et al. (2023) Indicators of Global Climate Change 2022: annual update of large-scale indicators of the state of the climate system and human influence, *Earth Syst. Sci. Data*, 15, 2295–2327, <https://doi.org/10.5194/essd-15-2295-2023>
- Fyson, C. L., Baur, S. Schleussner, C. F., & Gidden, M. J. (2020). Fair-share carbon dioxide removal increases major emitter responsibility. *Nature Climate Change*, 10, 836–841. <https://doi.org/10.1038/s41558-020-0857-2>
- Goldberg, D.S., Lackner, K.S., Han, P., Slagle, A.L., Wang, T., (2013). Co-Location of Air Capture, Subseafloor CO₂ Sequestration, and Energy Production on the Kerguelen Plateau. *Environ. Sci. Technol.* 47, 7521–7529. <https://doi.org/10.1021/es401531y>
- Grant, N., Hawkes, A., Mittal, S., & Gambhir, A. (2021). Confronting mitigation deterrence in low-carbon scenarios. *Environ. Res. Lett.* 16 064099.
<https://doi.org/10.1088/1748-9326/ac0749>
- IPCC. (2023). The IPCC Sixth Assessment Report. A Report of the Intergovernmental Panel on Climate Change. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.
www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_LongerReport.pdf
- IPCC. (2018) Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty [Masson-Delmotte, V., P. Zhai, H.-O. Pörtner, D. Roberts, J. Skea, P.R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, J.B.R. Matthews, Y. Chen, X. Zhou, M.I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA, pp. 541–562, doi:10.1017/9781009157940.008.
- Kelemen, P., Benson, S.M., Pilorgé, H., Psarras, P., Wilcox, J., (2019). An Overview of the Status and Challenges of CO₂ Storage in Minerals and Geological Formations. *Front. Clim.* 1, 1–20. <https://doi.org/10.3389/fclim.2019.00009>
- Markusson, N., McLaren, D., & Tyfield, D. (2018). Towards a cultural political economy of mitigation deterrence by negative emissions technologies (NETs). *Global Sustainability* , Volume 1 , 2018 , e10. <https://doi.org/10.1017/sus.2018.10>
- McLaren, D. (2020). Quantifying the potential scale of mitigation deterrence from greenhouse gas removal techniques. *Climatic Change* 162, 2411–2428.
<https://doi.org/10.1007/s10584-020-02732-3>
- Merk, Christine, Geraldine Klaus, Julia Pohlers, Andreas Ernst, Konrad Ott, et Katrin Rehdanz (2019). Public Perceptions of Climate Engineering: Laypersons' Acceptance at Different Levels of Knowledge and Intensities of Deliberation. *GAIA - Ecological Perspectives for Science and Society* 28, no 4 : 348–55.
<https://doi.org/10.14512/gaia.28.4.6>
- National Academies of Sciences Engineering and Medicine, (2019). Negative Emissions Technologies and Reliable Sequestration. National Academies Press, Washington, D.C. <https://doi.org/10.17226/25259>
- Rogelj, Joeri, Taryn Fransen, Michel G. J. den Elzen, Robin D. Lamboll, Clea Schumer, Takeshi Kuramochi, Frederic Hans, Silke Mooldijk, et Joana Portugal-Pereira (2023). Credibility Gap in Net-Zero Climate Targets Leaves World at High Risk. *Science* 380, no 6649 : 1014–16.
<https://doi.org/10.1126/science.adg6248>
- Stilgoe, J. (2015). *Experiment Earth: Responsible Innovation in Geoengineering*. Routledge Earthscan.
- Snæbjörnsdóttir, S.Ó., Sigfússon, B., Marieni, C., Goldberg, D., Gislason, S.R., Oelkers, E.H., (2020). Carbon dioxide storage through mineral carbonation. *Nat. Rev. Earth Environ.* 1, 90–102. <https://doi.org/10.1038/s43017-019-0011-8>
- Ven, Dirk-Jan van de, Shivika Mittal, Ajay Gambhir, Robin D. Lamboll, Haris Doukas, Sara Giarola, Adam Hawkes, et al. (2023). « A Multimodel Analysis of Post-Glasgow Climate Targets and Feasibility Challenges ». *Nature Climate Change* 13, no 6 : 570–78. <https://doi.org/10.1038/s41558-023-01661-0>

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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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