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Report

Simulating CDR in the EU ETS: The Risks of Premature Integration

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Author

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About Sandbag

We are a think tank conducting data-driven and **evidence-based advocacy** to improve **EU climate policy**. We combine expertise in **decarbonisation** with **data analysis** to propose policies that drive impactful, cost-effective emissions reductions in the EU and beyond. Through our holistic approach, we make sure our recommendations are not only well-informed and effective but also inclusive, considering economic and geostrategic realities.

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Executive Summary

Carbon Dioxide Removals (CDR) are considered essential to achieving the EU's climate targets, and incentives to develop these technologies are needed. In July 2025, the European Commission signalled the potential inclusion of domestic permanent removals in the EU Emissions Trading System (ETS). However, integrating CDR into the ETS remains a highly contentious issue. While permanent removals may eventually play a role in compensating for residual emissions, many CDR technologies are still in early development stages, and present significant risks if scaled too quickly or without proper safeguards.

This report introduces **Sandbag's ETS + CDR simulator**, published on our website, and uses it to explore how different integration pathways could affect emissions reductions, carbon prices, and potentially lead to negative externalities. We find that **the ETS can function effectively through the 2030s without integrating CDR**. Even under ambitious abatement scenarios, sufficient EUA surplus is maintained to ensure market stability. The ETS may face scarcity in 2040, which could then be addressed through CDR integration, but only once environmental integrity is assured and robust monitoring, reporting, and verification (MRV) systems are fully in place.

Our simulation analysis reveals that **there is no straightforward or risk-free way to integrate CDR into the EU ETS without undermining its core function of driving emissions reductions.** Allowing CDR credits into the market from 2031 through any mechanism leads to significant trade-offs. Integrating CDR while maintaining a net cap (in which CDR credits can counterbalance additional emissions) sends the wrong signals to market participants and would deter crucial emissions abatement. Allowing CDR to enter while maintaining a gross cap avoids this, but still creates excessive demand for the cheapest CDR, particularly under price-based integration, where cheaper biomass-based removals dominate. Quantity limits are difficult to enforce practically and do not ensure a balanced CDR portfolio. Using CCfDs to create the portfolio would be expensive and introduce major governance challenges. Across all scenarios, early integration creates risks of mitigation deterrence, environmental harm, and market distortion, without delivering significant benefits in terms of system liquidity or cost-effectiveness before 2040.

We strongly recommend that CDR be developed outside of the ETS during the 2030s. A dedicated instrument for CDR would better support the development of high-integrity removals without jeopardising the ETS's primary goal of driving cost-effective decarbonisation. Integration into the ETS should only be considered post-2040 and under strict safeguards, and removals should complement, rather than substitute, real emissions cuts.

Contents

CDR and the question of ETS integration

Carbon Dioxide Removals (CDR) will be necessary to achieve the EU's climate neutrality goal, however, beyond this fact, a great deal of uncertainty remains. The term CDR encompasses a diverse array of technologies, each with their own trade-offs and many of which are still in their early stages of development. Presently, there is not an obvious business case to develop CDR, which has led to a debate on how best to incentivise investment them without diverting efforts away from emission reductions or creating negative externalities.

In July 2025, the European Commission signalled in its communication on EU's 2040 targets that *"the Commission envisages to provide for domestic permanent carbon removals in the EU ETS…to compensate for residual emissions from hard to abate sectors"*.[1] This raises several questions: *How might CDR be integrated into the EU ETS? What types of removals should be eligible, and under what conditions? And what would the environmental and market implications be?*

This report introduces Sandbag's ETS + CDR simulator, a tool designed to explore these questions through scenario modelling, and presents our key findings to inform the ongoing debate.

What are Carbon Dioxide Removals?

The Intergovernmental Panel on Climate Change (IPCC) defines CDR as *"anthropogenic activities that remove CO_2 from the atmosphere and store it durably in geological, terrestrial, or ocean reservoirs, or in products"*. [2] Methods of CDR vary in terms of their removal process, timescales of carbon storage, storage medium, cost, co-benefits, impacts and risks, and governance requirements.

The IPCC envisages CDR fulfilling **three different complementary roles**: lowering net CO_2 or net GHG emissions in the near term; counterbalancing 'hard-to-abate' residual emissions (e.g., emissions from agriculture, aviation, shipping, industrial processes) in order to help reach net zero emissions in the mid-term; and achieving net negative emissions in the long term if deployed at levels exceeding annual residual emissions.

Permanent removals are methods of CDR which are deemed to store CO_2 in a stable form for centuries to millennia, minimising the risk of re-release into the atmosphere. These are typically methods which rely on geological storage, such as direct air carbon capture and storage (DACCS) or bioenergy with carbon capture and storage (BioCCS), or

[1] European Commission, 2025, Proposal for a Regulation of the European Parliament and of the Council amending Regulation (EU) 2021/1119 establishing the framework for achieving climate neutrality Available here
[2] Intergovernmental Panel on Climate Change (IPCC), Climate Change (2022), Mitigation of Climate Change. Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, ed. P.R. Shukla et al. (Cambridge: Cambridge University Press, 2022), accessed June 16, 2025, Available here.

permanent storage in materials, although biochar carbon removal (BCR) and enhanced rock weathering (ERW) also have the potential to be considered permanent CDR methods.

CDR and the ETS

The Commission is required[3] to submit a report to the Parliament and the Council by July 2026 on how negative emissions could be accounted for and covered by emissions trading in the EU. This has led to a number of research papers being published on the topic in recent months, reflecting a broad range of views

Table 1. Selected views and recommendations reflecting the diversity of opinion regarding the issue of CDR integration in the EU ETS

Study	Recommendations
ESABCC (2025)	Recommends that the EU consider a progressive integration of permanent removals into the EU ETS, under strict conditions to prevent mitigation deterrence, address environmental risks, support distributional fairness and enhance dynamic cost-effectiveness.
Clean Air Task Force and Concito (2024)	Highlights that integration would require a careful balancing of trade-offs between environmental integrity, cost-effectiveness, and administrative and fiscal impacts.
Carbon Market Watch and Oeko-Institut (2025)	Suggests inclusion of CDR in the ETS would undermine incentives to reduce emissions. If criteria are not stringent, cheap and uncertain natural removals could flood the market and undermine the hard won integrity of the ETS. Any integration of CDR in the EU ETS creates a moral hazard and indicates to polluters that they can scale back mitigation efforts today in anticipation of relying upon removals in the future, delaying urgent climate action.
ERCST (2025)	Recommends CDRs should be introduced in the ETS 1 (and ata later date ETS 2). A centralized system for acquiring and introducing CDRs in the EU ETS should be used initially, imposing quantitative and qualitative limitations

On the surface, so-called ‘integration’ of CDR into the EU ETS has many benefits; dealing with liquidity issues during the ETS ‘endgame’, counterbalancing residual emissions in the ETS and simultaneously creating demand for CDR. However, integration would not come without risks and the timing of any integration is crucial. Most notably, CDR technologies are yet to reach technological maturity and robust definitions of the scope of CDR activities and clear rules for monitoring, reporting and verification (MRV) of their actual net carbon removal benefit are still in development. MRV of permanent removals in the ETS would likely be based on the methodologies currently being established under the **CRCF**, the first-ever government-led regulatory framework to monitor, verify and certify CDR. There are **concerns that the methodologies do not account for the true net removal “benefit”-** or otherwise- of CDR activities.

[3] By Art 30(5)a of Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading system (text with EEA relevance) PE/9/2023/REV/1.

In February 2025, the **European Scientific Advisory Board on Climate Change** (ESABCC) published its much-anticipated 329-page report "*Scaling up Carbon Dioxide Removals – Recommendations for navigating risks and opportunities in the EU*". [4]The report asserts that **"direct and unconstrained integration of removals into the EU ETS is not a viable option"** due to the high risk of mitigation deterrence. The unsuitability of temporary removals for ETS integration are also recognised: "**integrating temporary removals into the existing EU ETS would create significant risks and governance challenges that cannot be effectively managed in the short term**".

The ESABCC also recommended **"gradual and conditional integration"** of **permanent removals into the EU ETS.** However, this recommendation is notably short of practical details and anticipated timescales, although "robust certification" is cited as "a critical precondition for any integration, ensuring durability and additionality". While putting a robust MRV framework in place is a crucial (and sizeable) step, several other obstacles must also be overcome. Most notably, permanent removals need to mature and demonstrate real net removal benefits at scale before integration can be considered. Sustainability constraints must also be carefully considered and the "conditional" aspect of integration must not be overlooked.

The Advisory Board recommends an intermediary institution which "should manage supply and demand of removal credits, including the conditions, volumes and timing by which different removal methods are integrated" in order to "prevent mitigation deterrence and environmental risks". However, **the presence of an intermediary institution does not automatically prevent mitigation deterrence**. Managing the supply and demand of removals will be very challenging in practice and negates the benefits of market integration. The key advantage of using a market is to let 'natural' forces attract private investment where it is most cost-effective, by arbitrage between technologies. **If supply of removals is controlled, this optimisation role is lost** and the on-sale of removal units in the market is not a driving force for investment, calling into question the benefits of integrating removals at all. Furthermore, an intermediary institution would require a substantial up-front economic endowment.

There is a need for **further studies to model different integration pathways and assess the possible consequences of CDR integration in the EU ETS**. The present analysis represents an attempt to quantitatively assess this issue and it is hoped will be a useful tool for policymakers ahead of their recommendations on the issue.

[4] European Scientific Advisory Board on Climate Change, 2025, Scaling up Carbon Dioxide Removals – Recommendations for navigating risks and opportunities in the EU

Exploring options for CDR integration

We have developed a simulator to help **visualise and explore the impact that CDR integration could have on the ETS**, assess the demand it could create for CDR, and highlight the potential consequences of this demand.

Developing a simulator to assess the impact of integrating CDR into the EU ETS presents significant challenges. The interaction between removals and emissions reduction involves multiple layers of complexity, from market dynamics to policy design. To capture this, the tool allows for **flexible modelling of key variables**—including the overall cap trajectory, the nature of this cap (i.e. net or gross), the methods and quantity of CDR allowed, and the chosen integration approach (e.g. price-based). The simulator enables a wide range of policy scenarios to be explored to support evidence-based decision-making on this critical issue.

The simulator is an exploratory tool and should not be taken as a prediction of likely outcomes. There are several uncertainties associated with the development of both the ETS and CDR methods. As such, the simulator is built on several assumptions. For further detail on these underlying assumptions, see Appendices 1-3.

Several different methods of CDR integration have been proposed, and there are a multitude of possible permutations. Here, we consider each element in turn and clearly define the scenarios which can be selected in the simulator.

Cap

The "**Current**" cap follows a trajectory that reaches near zero by 2039, as per the current ETS design. In the "**Reduced ambition**" scenario, however, the cap reaches 209Mt in 2040 – equivalent to the emissions level in 2040 from Scenarios 2 of the Impact Assessment for the 2040 target. [5]

CDR Options

These options enable the user to select how the CDR is integrated in the context of the chosen cap. In the "**No CDR**" scenario, no CDR enters the ETS. In the "**Net cap**" scenario, each CDR credit entering the ETS means emissions can increase by 1 tCO_2. The "**Gross cap**" scenario represents a 'one in, one out' cap in which an allowance is cancelled for each CDR credit entering the ETS, so emissions do not increase in line with entry of CDR credits.

[5] European Commission, (2024), Commission Staff Working Document, *Impact Assessment Report accompanying the document Securing our future Europe's 2040 climate target and path to climate neutrality by 2050 building a sustainable, just and prosperous society*

CDR Methods

"**BioCCS & DACCS**" are the default permanent removal methods allowed to enter the ETS in our simulator. BioCCS includes both bioenergy carbon capture and storage (BECCS) and CCS on biogas upgrading. We also include scenarios in which biochar carbon removals ("**+BCR**") and, in addition to BCR, enhanced rock weathering ("**+BCR + ERW**") are able to enter the ETS. The possibility of these methods entering the ETS is dependent on these methods being certified as permanent removals under the Carbon Removals and Carbon Farming Regulation (CRCF), neither of which remains certain.

The durability of **BCR** remains the subject of scientific debate. Indeed, there is not yet even scientific consensus on the approach to assess the durability of biochar. Some consider an inertinite fraction of biochar which can be considered as truly 'permanent', the amount of which could be determined for each batch through testing. Alternatively, others suggest a decay function could be employed, which estimates the remaining amount of biochar after a certain duration based on the expected average temperature for the location of biochar application. The CRCF methodologies are, confusingly, set to allow both these approaches to be used.

The European Commission is considering **ERW** among other permanent removal techniques under CRCF, although the methodologies are in an earlier stage of development. While ERW has potential benefits for agricultural soils and may increase crop and forestry yields, there remains a high level of uncertainty in the extent to which ERW would overlap with other removal practices in the land sector. There is also uncertainty around the rate of CO_2 removal, timescales involved, and the efficiency of transport to the ocean, with the potential for some carbon to be re-released.[6] For the highest scale up scenarios, there are likely to be significant challenges around scaling up rock extraction, crushing and transport and there would likely be adverse environmental impacts due to the extent of quarrying required. A better understanding of the future environmental and practical implications of this method is needed, especially before considering for inclusion of this method in the ETS.

Temporary 'nature-based' removals, such as afforestation, are not included in our simulator. We consider these as not well-suited for integration into the ETS due to their inherent impermanence, which introduces the risk of CO_2 re-release, and their typically lower cost, which could dilute the carbon price signal and disincentivise permanent emission reductions. These issues could undermine the ETS's ambition to drive deep, lasting decarbonization. This is not to say that nature-based removals should not be incentivised, but because we do not consider it is appropriate for them to be included in a market which also includes emissions reductions. A separate framework should be developed for incentivising these nature-based removals.

[6] POST (UK Parliamentary Office of Science and Technology), 2024, *Enhanced rock weathering: Potential UK greenhouse-gas removal*

Integration Methods

A multitude of different options for integration could be envisaged, especially if integration is managed by an intermediary body. We attempt to represent the different options through the following three methods of integration (further details can be found in Appendix 3):

- In our "**Price-based**" integration method, the full potential of the cheapest options is utilised first, with extreme upper limits on potential deployment imposed. For further details of these limits, see Appendix 2.

- In contrast, under the "**Quantity limits**" scenario, the potential of the CDR methods is capped at a 'central' deployment estimate, due to factors such as sustainable biomass availability and more realistic – rather than optimistic – assumptions about deployment potential.

- In both the previous scenarios, only the volume of CDR that is more cost-effective than further emission reductions is integrated into the system. However, in the "**CCfD scenario**", all available CDR (central estimate of deployment potential) is included, regardless of whether it is cheaper than emission reductions, with the cost made up by a CCfD (Carbon Contract for Difference).

What does the ‘ETS + CDR simulator’ show?

Without CDR integration

Our modelling shows that, if emissions reductions by covered sectors take place in line with the S3 scenario in the 2040 target Impact Assessment, there would still be a **surplus of 157m EUAs in 2040**. Therefore, CDR integration is not technically necessary for the market to function up to 2040, although the scarcity of allowances in the market may lead to some price volatility and risks of market manipulation as we approach 2040. We recommend a review take place around 2035 to address these risks.

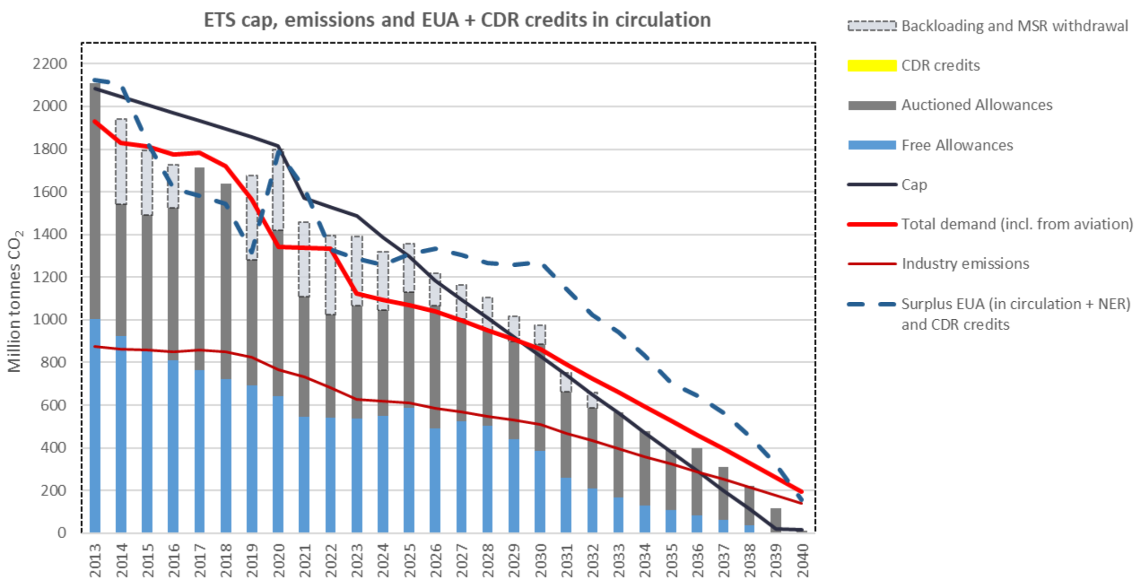

Figure 1. ETS + CDR simulator, with “No CDR” and “Current” cap trajectory

If the linear reduction factor (LRF) is relaxed in line with our “Reduced ambition” scenario to follow expected emissions reductions in covered sectors in line with the S2 Impact Assessment scenarios, we would see a **large surplus of 794m EUAs** in 2040, equivalent to 2.5 years of demand. We therefore conclude that introducing additional supply for compliance, by loosening the cap **risks creating a repeat of the oversupply issues that have dogged the ETS for decades**. We no longer have time for such setbacks if the EU’s climate commitments are to be upheld.

With CDR integration

Integration under a "Net cap"

Integrating CDR credits without corresponding adjustments to the supply of EUAs (the 'net cap' scenario), inevitably **leads to deterred emissions abatement** as emissions could decrease further if CDR credits were not allowed to enter the ETS.

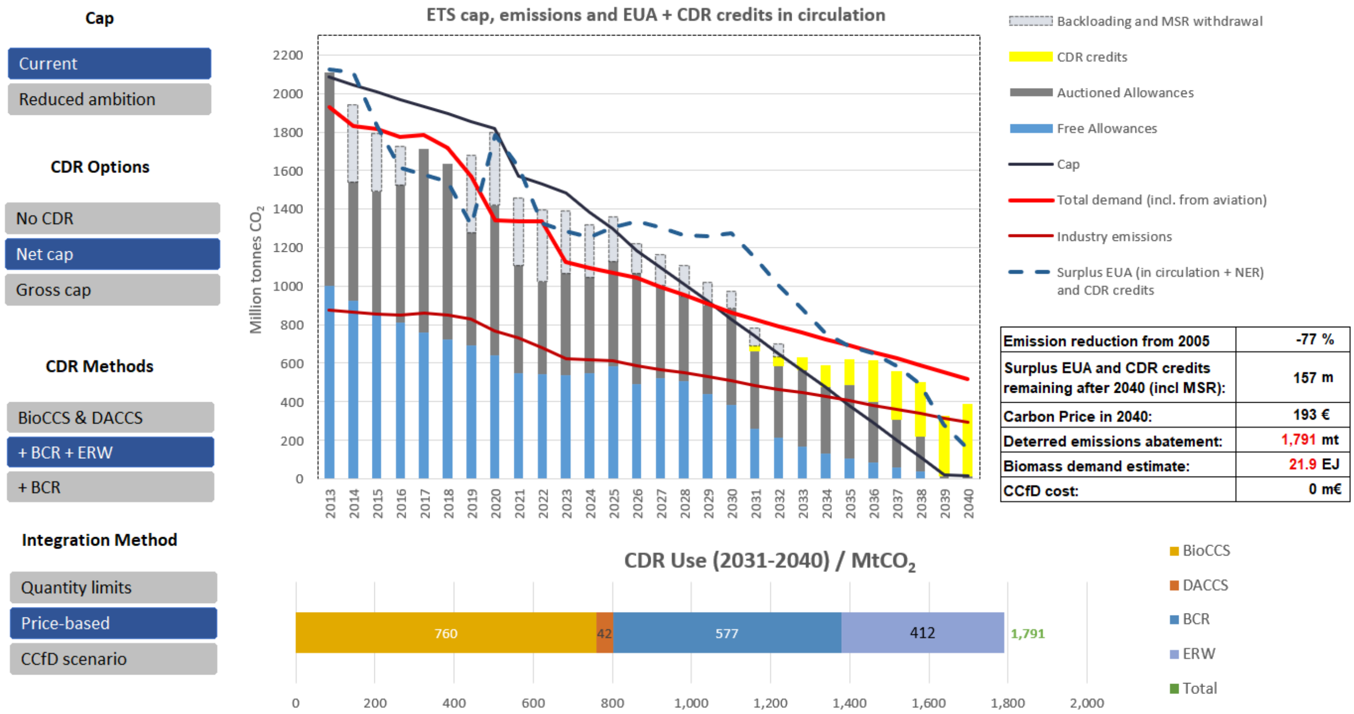

Figure 2. ETS + CDR simulator, with "Price-based" integration of CDR methods ("BioCCS & DACCS + BCR + ERW") under a "Net cap" with "Current" cap trajectory

If the current cap were maintained as a net cap, up to 1.8 $GtCO_2$ of abatement which would have otherwise taken place would not, if BioCCS, DACCS, BCR and ERW are allowed within the ETS (see Table 2). This leads a high risk of creating unsustainable biomass demand, especially in the "Price-based" integration scenario, which we estimate would lead to biomass demand of 20.4 EJ across the decade if BioCCS and BCR are both integrated (see Box 1 for a full discussion of risks associated with biomass).

This further calls into question the idea that integration should be purely price-based to allow "technology neutrality" between emissions and removals. There are inherent differences between emission reductions and removals which must be recognised, not least the fact that the climate benefit of CDR credits is far less certain than that of non-emitted CO_2. This presents risks of oversupply, causing the market to crash without achieving desired climate objectives. This has of course been seen before, for example when forestry credits were allowed in the New Zealand ETS[7] or when international offsets caused the price of EUAs to crash in the EU ETS.

Table 2. Mitigation deterrence under a net cap, with current cap trajectory

Scenario	Deterred emissions abatement 2031-2040 ($MtCO_2$) under different "CDR Method" scenarios		
	BioCCS & DACCS	BioCCS & DACCS + BCR	BioCCS & DACCS + BCR + ERW
Price-based	903	1,379	1,791
Quantity limits	353	608	871
CCfD scenario	433	767	1,128

A reduction in carbon price is evident when more CDR credits enter the ETS under a net cap. This is most evident in the "price-based integration" scenario, in which, for example, the price reduces from €314 with no CDR to €245 if BioCCS and DACCS is integrated. This is unsurprising, given the expected low cost of CDR credits relative to the marginal abatement cost of residual emissions in 2040, from which the carbon price for the 2031-2040 is calculated. This should not be interpreted as a justification for integration of CDR into the ETS, as the mitigation deterrence that would not be compensated by equivalent climate benefit from CDR credits. Just because it may be cheaper to carry out CDR than abate emissions does not mean that CDR should be done instead. As stressed by the ESABCC, removals must contribute effectively to climate goals without deterring emission reductions. Therefore, we maintain that if CDR is to be allowed into the ETS, it should be carried out while maintaining the current trajectory as a gross cap. Some have suggested the ambition of the cap could be increased (i.e. imposing a steeper LRF) by the amount of CDR entering the system. However, this would create a high level of uncertainty for market players, as the supply of CDR credits would be uncertain.

Integration under a "Gross cap"

If CDR is integrated while a **gross cap** is maintained, the overall supply of allowances (including CDR credits) in the market remains the same. No 'new headroom' is created under the cap so the EUA price does not decrease, unlike under a net cap, thus preventing mitigation deterrence. However, as an allowance is cancelled when a CDR credit enters the system, this may create uncertainty for ETS installation operators about future auction volumes. CDR

[7] Organisation for Economic Co-operation and Development, 2024, *OECD Economic Surveys: New Zealand 2024*, OECD Publishing, Paris, Available here.

project developers might also find it hard to operate under a gross cap unless removals are subsidised or separately incentivised (e.g. via CCfDs), especially if EUA prices are too low to cover CDR costs.

Some have suggested that the ambition of the cap should be reduced if CDR is allowed under a gross cap. In our simulator, the ‘Reduced ambition’ cap can be used in conjunction with the ‘Gross cap’ “CDR Option” to give an idea of what such a scenario could mean for the ETS, although the trajectory of the cap simply reflects a less ambitious emission reduction scenario rather than changing in response to CDR supply. This reflects a perhaps more realistic situation than adapting the cap in line with CDR supply, as there would be no certainty of achieving the expected CDR supply.

Price-based integration

In our “**Price-based**” integration method, the ‘full’ potential of the cheapest CDR method is utilised first, with extreme upper limits on the deployment of these methods imposed (see Appendix 2).

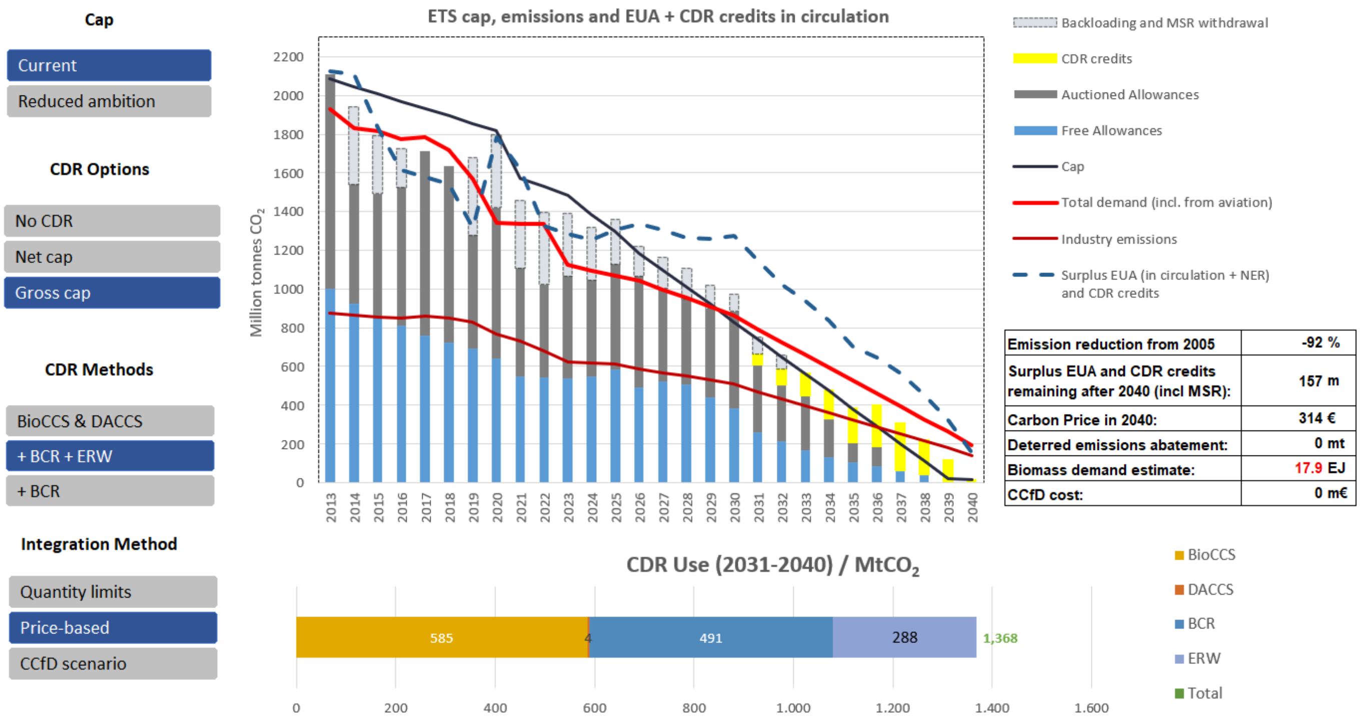

Figure 3. ETS + CDR simulator, with “Price-based” integration of CDR methods (“BioCCS & DACCS + BCR + ERW”) under a “Gross cap” with “Current” cap trajectory

Our simulator shows that **allowing unconstrained supply of CDR credits under a gross cap would not lead to the desired balanced portfolio of CDR**. DACCS would only be incentivised towards the end of the decade, and only in small amounts, especially if CDR credits from BCR and ERW are also permitted in the ETS. Instead, there is a high risk of creating unsustainable demand for biomass, with the cheapest CDR methods being over-incentivised.

Table 3. CDR entering the ETS under a gross cap, with current cap trajectory

CDR Method	CDR entering EU ETS 2031-2040 ($MtCO_2$) under different "CDR Method" scenarios		
	BioCCS & DACCS	BioCCS & DACCS + BCR	BioCCS & DACCS + BCR + ERW
BioCCS	701	585	585
DACCS	63	29	4
BCR	N/A	491	491
ERW	N/A	N/A	288
Total	**764**	**1,105**	**1,368**

It is important to also consider the biomass demand created and the broader implications of scaling biomass-based CDR within the EU ETS. The extent of biomass required to meet compliance demand depends not only on the type of CDR methods used, but also on how integration is designed (see Table 4).

Table 4. Estimated demand for biomass under a gross cap, with different types of integration and biomass-reliant CDR methods

Cap	Integration method	Estimated biomass demand 2031-2040 (EJ) if different CDR methods are integrated	
		BioCCS	BioCCS + BCR
Current	Price-based	8.2	17.9
	Quantity limits / CCfD scenario	2.9	9.1
Reduced ambition	Price-based	9.7	22.6
	Quantity limits / CCfD scenario	3.2	10.7

These results show **CDR integration could create demand for biomass of up to 22.6 EJ** over the period 2031-40 in a scenario with a gross cap of reduced ambition. This represents a significant proportion of expected biomass demand and risks exacerbating the growing pressures on land use.[8] As eligible feedstocks for BioCCS and biochar will likely not be limited to residues, increased demand could drive additional logging in forests, dedicated crops and large-scale biomass plantations and a further degradation of the land carbon sink and pressure on food security.

[8] Modelling for the EU's 2040 climate target adopted an overall cap on the gross available energy from biomass of 9 EJ on biomass based on the "environmental risk level" identified by the ESABCC.

Box 1. Risks associated with biomass-based CDR

There are significant risks that must be carefully considered when assessing integration of biomass-based CDR into the ETS. This includes creating **excessive demand for limited biomass resources**, which could lead to land-use change, biodiversity loss, and competition with other sectors like heating or bio-based materials. The draft methodologies currently being established for biomass-based removals under the CRCF contain some limited safeguards against excessive biomass consumption but have also been **criticised for lacking rigour**, especially around accounting for use of biogenic carbon.

By setting the **baseline of emissions from biomass to zero**, the methodologies assume that an increase of biomass use does not lead to greater emissions (or fewer removals) elsewhere, as the carbon payback period for biomass regrowth is not considered. Researchers have shown that, when initial carbon losses from land conversion are taken into account, it can take between 30 to 80 years before a BECCS facility actually delivers net negative emissions.[9]

The **type and source of biomass** being consumed is also crucial to consider. The European Academies Science Advisory Council (EASAC) recommends that to achieve the EU's 2050 targets, "*negative emissions can only be achieved by limiting biomass to that harvested from fast-growing crops on unused or degraded land, or with the limited amounts of forest residues that would otherwise degrade swiftly in situ and are consistent with maintaining biodiversity*".[10]

Supply of such biomass is likely to be in high demand. According to the Impact Assessment for the EU's 2040 target, domestic supply of agricultural and forest residues, lignocellulosic crops and forest stemwood for bioenergy is expected to rise from 2.2 EJ per year in 2030 to 5.9 EJ per year by 2040. Notably, domestic supply of forest stemwood is not expected to increase and is considered by many to be inappropriate for CDR at scale due to carbon debt due to slow regrowth.

However, **the CRCF methodologies do not provide confidence that biomass use will be limited to genuine residues or lignocellulosic crops grown on land which is truly "unusable" for other purposes**. Creating high demand for these cheap forms of CDR through integration into the ETS therefore presents sizeable risks in terms of incentivising unsustainable biomass production practices and forest degradation, both inside and outside EU borders.

[9] S.V. Hanssen et al. (2020), The Climate Change Mitigation Potential of Bioenergy with Carbon Capture and Storage, *Nature Climate Change* 10: 1023–1029.
[10] European Academies Science Advisory Council (2022), Forest Bioenergy Update: BECCS and Its Role in Integrated Assessment Models

Quantity limits

While imposing limits would avoid creating runaway demand for the cheapest forms of CDR, **it would not create a balanced portfolio of CDR approaches**. Even when limiting quantities of the cheapest CDR to a central estimate of their potential, we still don't see DACCS entering the market in significant quantities. Instead, the quantity limits of the cheapest CDR (BCR, BioCCS) are reached, again putting considerable strain on the land sector (up to 9.1 EJ), even with our more conservative estimate of deployment.

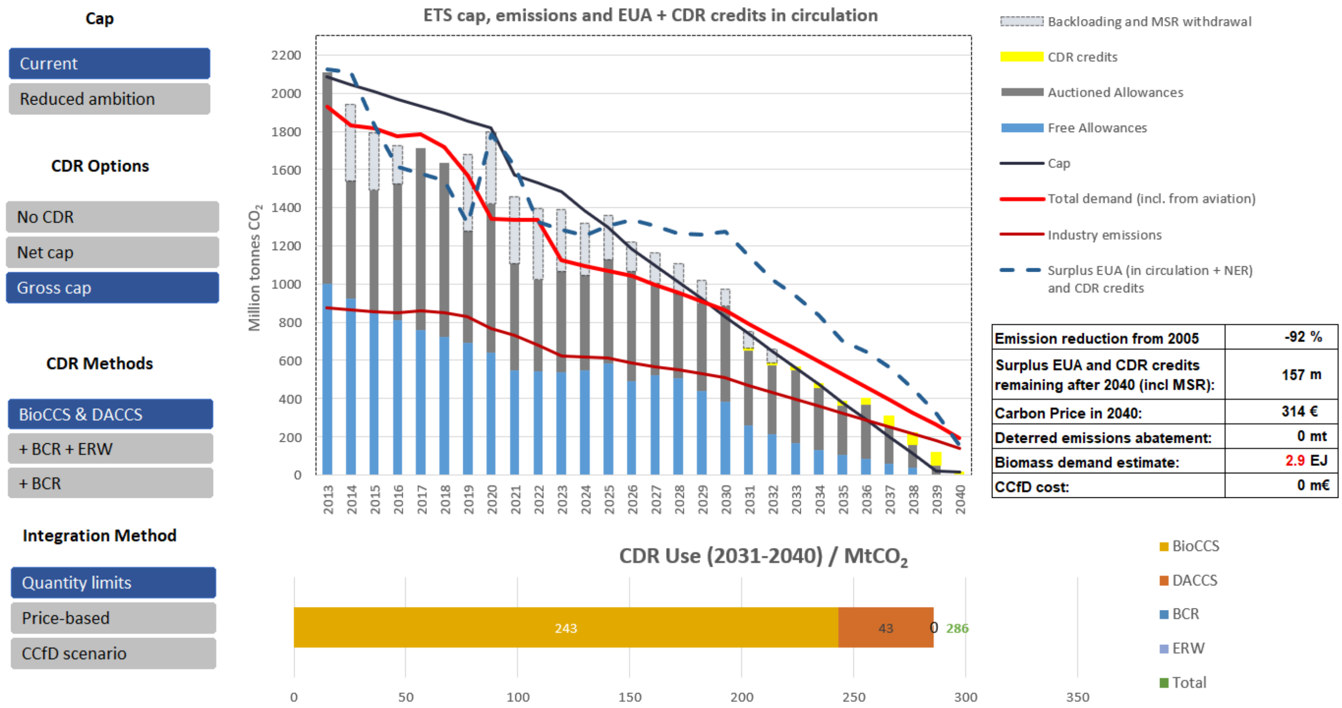

Figure 4. ETS + CDR simulator, with integration of CDR methods with "Quantity limits" imposed ("BioCCS & DACCS") under a "Gross cap" with "Current" cap trajectory

Table 5. CDR entering the ETS under a "Gross cap" with "Quantity limits" imposed and "Current" cap trajectory

CDR Method	CDR entering EU ETS 2031-2040 ($MtCO_2$) when the following CDR methods are permitted		
	BioCCS & DACCS	BioCCS & DACCS + BCR	BioCCS & DACCS + BCR + ERW
BioCCS	243	229	229
DACCS	43	63	63
BCR	N/A	287	287
ERW	N/A	N/A	257
Total	**286**	**579**	**816**

Imposing quantity limits on CDR integration in the ETS may seem like a safeguard but it would still not lead to the balanced portfolio of CDR which is desirable and also present several administrative challenges. If supply controls were imposed **after crediting** (once the CDR certificate is issued), there would be a **decorrelation between the prices of removal units and EUAs**: only a limited number of already issued removal units would be eligible for the ETS, and this limited fungibility would be priced in CDR prices as a discount from EUA prices. This is what happened in 2008-12 to the Certified Emission Reduction (CER) market, which traded at a growing discount from EUAs as CER supply forecasts got closer to the maximum import amount. This could become highly problematic for CDR project owners if their investments were relatively more costly.

If the limit was set **at the crediting stage** (once the project is fully developed), investors in the project would face the risk of their project not yielding any certificate, so they would be **reluctant to invest**. If a limit was set at a **very early stage** (e.g. guaranteeing full eligibility to the project before investment), there would be a risk of either **overshooting the limit** (if this guarantee was given to too many projects) or giving this guarantee to projects that will never reach crediting stage. The model of credit issuance is also important to consider in this context. Some have proposed ex-ante crediting as a way to facilitate early investment by providing upfront revenue streams, however this would severely risk undermining the environmental integrity of the system if projects fail to deliver as expected.

CCfD scenario

It has been suggested that **Carbon Contracts for Difference (CCfD) could ensure more expensive methods of CDR are also incentivised**. CCfDs offer companies additional revenues if the strike price is above the market price at signature and hedges against price risks that stand in the way of investment in emerging climate technologies. In the case of CDR in the ETS, CCfDs could allow project developers to remove carbon at a price that covers its costs at the so-called 'strike price' while a government counterparty, likely the envisaged intermediary institution in our case, guarantees to pay the difference between this strike price and the market price.

This would provide the long-term revenue certainty needed to mobilise investment in early-stage, capital-intensive CDR projects, accelerating deployment and scale-up of these technologies. However, **CCfDs could prove to be extremely costly for the public purse**, as it commits public funds to bringing removals onto the market. Depending on the scenario, our simulator shows it would cost between € 2.63 bln to € 6.44 bln (see Table 6) to achieve additional CDR deployment of just 51 - 79 $MtCO_2$ respectively. The majority of the cost would be for DACCS, although if ERW were allowed to enter the ETS, CCfDs would also be needed for this. BCR is sufficiently cheap to not require CCfDs throughout the decade.

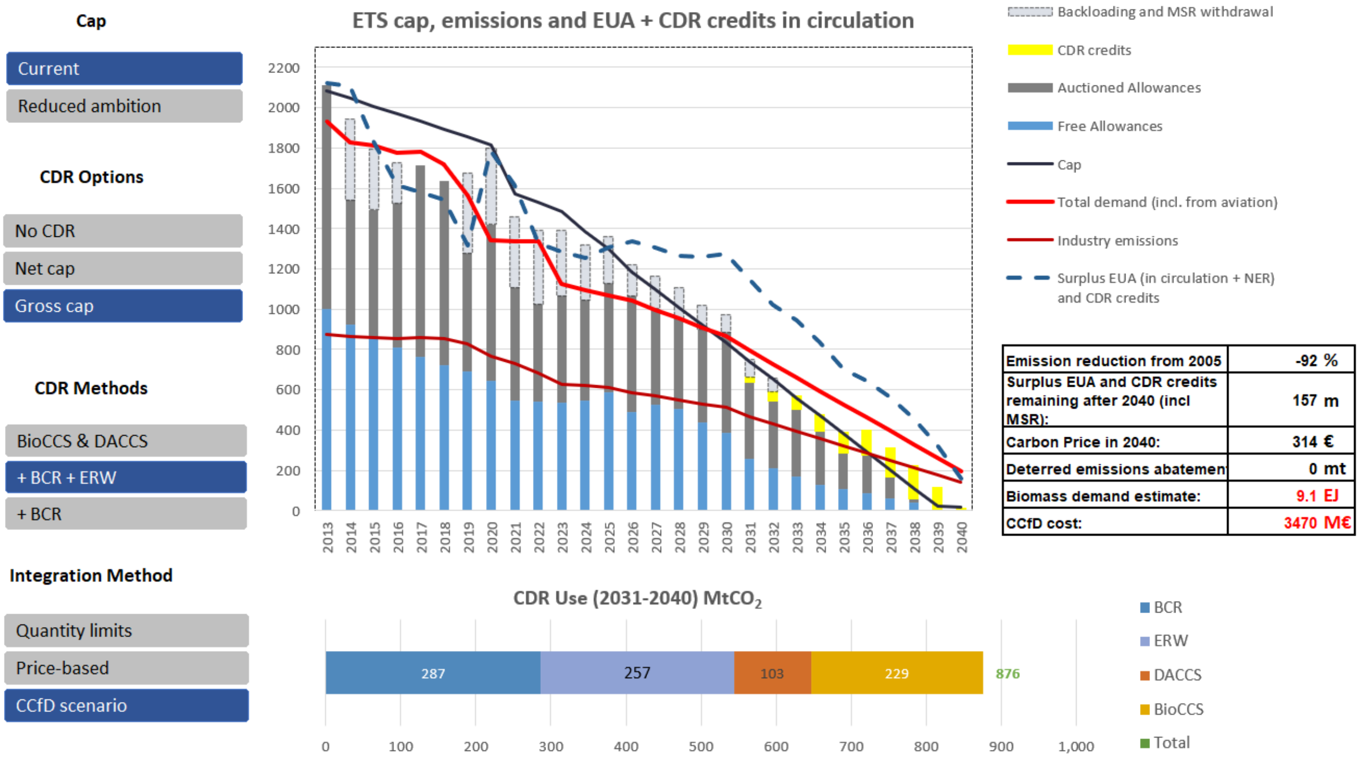

Figure 5. ETS + CDR simulator, with integration of CDR in a "CCfD scenario" with all CDR methods ("BioCCS & DACCS + BCR + ERW") permitted under a "Gross cap" with "Current" cap trajectory

Table 6. Estimated cost of CCfDs in "CCfD scenario" under a gross cap, assuming integration of the specified CDR methods

Cap	CCfD cost 2031-2040 (bln EUR)		
	BioCCS & DACCS	BioCCS & DACCS + BCR	BioCCS & DACCS + BCR + ERW
Current	2.63	2.63	3.47
Reduced ambition	5.55	5.55	6.80

Managing the implementation of CCfDs would also create serious governance and market design challenges. Matching uncertain CDR supply with future ETS demand requires forecasting and procurement capabilities that few public institutions currently possess. If the intermediary institution over-incentivises CDR with CCfDs, it risks distorting price signals in the carbon market by artificially inflating supply, potentially undermining the ETS's efficiency. Conversely, under-procurement could weaken confidence in the removals market and stall investment.

Beyond these technical risks, there are also other, more behavioural impacts to consider. By shielding certain CDR technologies from normal market forces, the use of CCfDs, particularly if administered through a politically directed intermediary, could signal to market actors that removals are being politically and financially prioritised over genuine abatement. This would **risk undermining trust in the ETS and encouraging strategic delay in emissions reductions in the hope of future subsidies**. Careful design, transparency, and strict limitations on scope and scale would be essential if CCfDs were to play a role in integration of CDR into the ETS. However, even with these safeguards in place, we maintain that the risks of CDR integration outweigh the benefits.

Alternatives to ETS integration

Our conclusion that ETS integration is not yet appropriate for CDR does not detract from the need to scale permanent CDR methods in the next 15 years. Furthermore, as we highlighted in our previous policy brief[11], we foresee a role whereby CDR could counterbalance residual emissions beyond 2040. Therefore, in the short- to medium-term, **an instrument is needed to incentivise development of high-quality CDR** which can perform this role and help the EU achieve its climate ambitions up to 2050 and beyond. Sandbag, along with other CSOs, is currently working on developing recommendations for appropriate instruments as part of the CO2oL Down project.[12] Several alternative policies have been envisaged to incentivise development of CDR.

A **purchasing programme**[13] could procure permanent removals on the EU's behalf from suppliers based in the EU, with public funding matched or extended by private investments. This could support a portfolio of CDR methods and procure a range of volumes of removed carbon at different price points. While there is certainly merit in such a programme, if implemented in the short-term it may face similar challenges to those mentioned for CCfDs. As the subsidies would be given ex post, they still require initial investment in the projects, which might not come easily to projects with high technological or MRV risk and no initial infrastructure. The future use of removal credits purchased by such an instrument must also be carefully considered and clearly communicated to market participants by the public authority or intermediary institution implementing the instrument in order to avoid distorting price signals in compliance markets such as the EU ETS, in which removal units might be permitted in the future.

An EU **Removal Trading Scheme** (RTS) presents a market-based option to incentivise the delivery of CDR. Such a scheme would create independence from emissions levels, and avoid reliance on public subsidies, with the potential to drive net-negative emissions and stimulate demand for novel CDR. However, it could be a complex market to manage, with limited initial liquidity and risks of power imbalances. Moreover an RTS could add financial strain on industries that could hinder broader climate investment.

Alternatively, an **obligation could be placed on producers or emitters of CO_2**. In such a scheme, an extended emitter responsibility (EER) is attached to emissions over the original GHG budget, which are then required to be counterbalanced by net-negative emissions at a later stage. While an EER could incentivise long-term carbon removal and align responsibility with emissions, its effectiveness depends on robust governance, clear enforcement, and careful design to manage risks of market speculation and delivery shortfalls

[11] Sandbag (2024) In or Out: What's best for carbon removals and the EU ETS? Available here
[12] Carbon Market Watch (2025) CO2ol-Down (Phase 2) campaign page, accessed 3 July 2025. Available here
[13] DG CLIMA (2025), Workshop: Perspectives on a Purchasing Programme for CRCF Permanent Carbon Removal Credits. Available here

A more top-down approach could also be envisaged. **Member State-level targets** for permanent removals could be imposed, possibly as part of a revised Effort Sharing Regulation (ESR). This would create a signal for market players, accountability, and could be aligned with specific climate targets. However, determining which Member States should bear what level of responsibility is likely to be a politically fraught process. Furthermore, **enforcement at national level could be challenging**, as shown by experiences with the LULUCF regulation and ESR (with 19 Member States openly planning to miss their 2030 ESR reduction target[14]). Robust monitoring, penalties, and support mechanisms would need to be put in place if this approach were followed. Alternatively, if the targets were only aspirational, they may not prove to be effective.

This discussion highlights some of the several alternatives to ETS integration currently being discussed. In the short-term, we consider a purchasing programme, which invests in learning, leads to cost reductions and builds confidence in permanent CDR and the underlying MRV, to be appropriate. In the medium term, several options for possible policy instruments are on the table, which could support the scale-up of high-quality, permanent CDR. Each presents distinct trade-offs and implementation challenges but, we consider, offer greater control over the amount of CDR being incentivised, and with lower risk of deterring emission reductions, than ETS integration. The European Commission should undertake a thorough impact assessment of these different policy pathways to determine which instruments are best suited to effectively incentivise CDR development while maintaining coherence with the broader EU climate policy framework. **Only when CDR has matured and confidence has improved in these methods improves, should integration in the ETS be considered**.

[14] Transport & Environment (2024), National climate targets off track: Six years left to course correct and avoid penalties, accessed December 11 2024, Available here.

Summary: CDR should develop outside the ETS

Our analysis leads us to conclude that **the ETS is not the correct framework in which to develop CDR** during the 2030s. The core purpose of the ETS is to drive cost-effective emissions reductions, and **prematurely shoehorning CDR into the market risks undermining that goal while diverting demand away from abatement**. After years of missteps and oversupply issues, the ETS is only now just starting to function as it should. A carbon price that reflects climate ambition is needed to drive investment in effective solutions and premature integration of CDR credits would only jeopardise this.

CDR should not be integrated from 2031: the ETS must not be undermined by CDR

We reiterate our previous assertion that there is **no need to panic about the end of the ETS.** The ETS should drive emissions reductions in covered sectors rather than substitute them for credits with uncertain climate benefits. We show that neither introducing CDR nor reducing ambition of the cap is needed for the market to function up to 2040. Although allowances will become scarce towards 2040, this could be addressed by allowing certain CDR to enter when the environmental integrity and robustness of MRV has been demonstrated, and with strict safeguards, most likely around 2040. However, it is highly premature to consider allowing CDR credits to enter into the market from 2031.

Integrating CDR while maintaining a net cap would be catastrophic in terms of emissions deterrence.

Maintaining the current cap as a net cap, would lead to emission reductions being foregone for the sake of CDR credits, and should not be considered. While it may desirable to lower the carbon price, the limited benefits in terms of cost-efficiency are heavily outweighed by the inequivalence of removals, mitigation deterrence and incentivising unsustainable use of biomass. Unchecked CDR integration could be highly damaging in the short term, given initial carbon debt of many CDR methods

Even if the cap is maintained as a gross cap, there are no easy, risk-free ways to manage CDR integration

Price based integration would lead to significant biomass-based CDR and significant strain on land sector. Imposing quantity limits would be extremely challenging in practice and still would not lead to the balanced portfolio of CDR needed. Attempts to create such a portfolio with CCfDs would be costly to EU taxpayers and distort price signals in the ETS.

Table 7. Qualitative analysis of different methods of integrating CDR in the EU ETS

Cap	Type	Integration method	Avoid mitigation deterrence	Create balanced portfolio of CDR	Avoid administrative burden	Avoid public cost	Avoid price distortion
Current	Net cap	Price-based					
		Quantity limits					
		CCfD scenario					
	Gross cap	Price-based					
		Quantity limits					
		CCfD scenario					
Reduced ambition	Gross cap	Price-based					
		Quantity limits					
		CCfD scenario					

Sending the wrong signals could negatively influence the behaviour of market actors.

Our modelling focuses on the quantitative dynamics of supply and demand, assuming rational market behaviour under defined policy scenarios. However, it does not explicitly capture the behavioural responses of market participants to policy signals. Signalling that CDR credits will enter the market, especially without clear caveats on restrictions, could send a soft signal that weakens the incentive to invest in emissions reductions, even if CDR volumes remain limited in the near term. These anticipatory responses can significantly impact the market, jeopardising a cornerstone of the EU's climate ambition. The Commission must clearly indicate that CDR integration is not a silver bullet for the ETS.

A dedicated instrument makes sense, as additional instruments are likely to be needed anyway

The challenges highlighted by the simulator lead us to conclude that **it is best to develop CDR outside the ETS**. For CDR developers, especially those of the most expensive (i.e. DACCS), ETS integration will likely not be enough to incentivise development of CDR, unless costly and distorting CCfDs are employed. This calls into question the merits of jeopardising emission reductions by integrating CDR prematurely. The ETS is not obliged to be a market to scale up removals. This is not to say that CDR should never play a role in the ETS. In the longer term, i.e. possibly from around 2040, the lack of liquidity and risk of market manipulation we foresee a role for permanent, high-integrity removals to counterbalance the last residual emissions and support progression beyond net zero. However, for now, focus should be on developing high integrity, durable CDR. For this, we consider a non-market instrument such as a purchasing programme to be more appropriate.

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Appendices

Appendix 1: ETS assumptions

The emission projections for the power, industry, aviation, and shipping sectors are derived from the European Commission's Impact Assessment for 2040 targets and correspond to Scenario 3 (S3) from 2030 onward. In the "Reduced ambition" cap scenario, the emissions follow the Scenario 2 (S2) from 2030 onward.

The carbon price calculation is based on the assumptions for marginal abatement cost in 2040 provided in the Impact Assessment for Scenario 1, Scenario 2, and Scenario 3, respectively. Carbon prices corresponding to other emission levels than those in the Impact Assessment (e.g. where CDR inflows allow for higher levels of emissions), are extrapolated linearly from the prices given by the Impact Assessment.

We assume that the marginal abatement cost indicated by the Impact Assessment for 2040 is reflected in the carbon price over the 2031-2040 period. The carbon price is therefore considered as constant and should be driven by subsequent changes in expectations about CDR supply, ETS emissions or ETS design features, which are not modelled here. Inflation is ignored and the natural "contango" shape of the EUA forward curve is approximated to a flat line.

The current cap follows a trajectory that reaches near zero by 2039, as per current ETS design. In the reduced ambition scenario, however, the cap reaches 209Mt in 2040 – equivalent to the emissions level in 2040 from Scenarios 2 of the Impact Assessment.

We assume continued functioning of the MRV based on current design. The surplus of EUAs corresponds to the number of EUAs issued and not used for compliance over the years since 2008. It covers all EUAs "in circulation" (i.e. owned by market operators), plus EUAs locked in the NER (New Entrants Reserve) and the MSR (Market Stability Reserve). Under the "net cap" scenario, emissions increase in line with the issuance of CDR credits, leaving the surplus unchanged compared to a no-CDR scenario. Under a gross cap, emissions remain fixed, while additional credits are issued — leading to an increase in the surplus. We report the resulting EUA surplus in 2040, including the impact of NER and MSR mechanisms.

Appendix 2: CDR assumptions

CDR potential assumptions

The simulator relies on some assumptions about the potential deployment of CDR. For this, we have used literature estimates, as shown in Table A- 1Table A- 1.

Table A- 1 Annual removal potentials and limits in $MtCO_2/y$

CDR Method		2030	2040					
			CDR annual removal potential ($MtCO_2/y$)					
			S2 [15]	S3 [15]	Low	High	Central [16]	Max limit [17]
BioCCS	BECCS	4.4	33.9	32.6	32.6	33.9	33.3	77.6
BioCCS	CCS on biogas upgrading	0.089	-	-	4	22	13	50
DACCS		0	14.9	42.0	14.9	42.0	28.4	42
BCR		0	-	-	36.9	84.5	60.7	100
ERW		0	-	-	28.5	103	65.8	103

The annual carbon removal potentials presented are drawn from scenario analyses in the European Commission's Impact Assessment and supplemented by recent literature. For BECCS, Biogas + CCS, and DACCS, values for 2030 and 2040 correspond to Scenarios 2 (S2) and 3 (S3) of the IA, which reflect different assumptions about the speed of technological deployment. S2 relies primarily on the full rollout of existing decarbonisation solutions (e.g. renewables, electrification), with more limited use of novel technologies, while S3 assumes earlier and faster deployment of innovative technologies such as DACCS and biogenic CCS, resulting in higher potential for these options. The maximum limit of BECCS is from POTEnCIA modelling (S3 scenario) in the 2040 Impact Assesment and represents a scenario in which "the cap on the amount of sustainable biomass supply for bioenergy is relaxed". The maximum limit of DACCS is set equal to the high deployment estimate, but is not relevant as it is not reached due to the high cost of the technology.

For CCS on biogas upgrading, high and low estimates are derived from Figure 9 of the Impact Assessment (S2 and S3 scenarios). The maximum limit in 2040 (50 $MtCO_2$) is in line with *Concito & CATF (2024)* which reflects more optimistic but still assuming sustainable access to biomass, while remaining more conservative than other assessments (e.g. Rosa et al., which estimate 51–73 $MtCO_2$).

Constraints related to storage of CO_2 are implicitly considered in the projected potentials. While the technical potential of biogas CCS exceeds the 2040 value used here, we adopt a linear scale-up from 0.089 Mt in 2030 to the central estimate (or maximum limit in the case of "Price-based integration") in 2040, reflecting anticipated limitations in access to CO_2 storage infrastructure around 2030, but easing over the following decade.

[15] European Commission, 2040 target Impact Assessment

[16] Applied in "Quantity limits" and "CCfD scenario" integration methods

[17] Applied in "Price-based" integration

For BCR (Biochar Carbon Removal) and ERW (Enhanced Rock Weathering), 2040 potentials are based on linear interpolation between 2030 and 2050, using estimates from literature collated by ESABCC (2025):

- For BCR, the central estimate averages a low scenario (Roe 2021)[18], based on limited, sustainable biomass use), and a high scenario (Tisserant et al. 2023)[19] which assumes more expansive resource allocation and may compete with BECCS, forestry, or biogas use). The maximum limit (100 Mt by 2040) is based on industry projections[20], and likely conservative, as the authors note that the actual potential could be "well above" that level.
- For ERW, ranges are derived from Beerling et al. (2020).[21] The central estimate is based on an average of partial deployment (10% of cropland in the five largest EU countries), and the upper limit corresponds to a more intensive rollout (38–57% of cropland),. Assumptions around mineral availability and land use practices influence this range.

CDR costs

The costs of CDR methods used in our simulator are provided in the table below.

Table A- 2. Cost estimates used in modelling of CDR integration

CDR Method		Cost (USD)			
		2024	2040		
			Low	High	Central
BioCCS	BECCS	300	100	200	150
	Biogas CCS	100	50	150	100
DACCS		715	100	300	200
BCR		131	65	120	92.5
ERW		371	150	150	150

The cost estimates for BECCS and DACCS are based on a review of various assumptions compiled in *Fuss et al. (2018)*. For DACCS in particular, we recognise that costs are highly sensitive to factors such as proximity to CO_2 storage sites, access to low-cost renewable energy, and the pace of technology development and deployment. Faster innovation and infrastructure build-up can significantly reduce unit costs by 2040. Cost estimates for CCS on biogas upgrading are based on *Concito and CATF (2024)*. These reflect current infrastructure and process costs associated with biogas upgrading and CO_2 capture from biogenic sources. Cost estimates for BCR are derived from *Fuss et al. (2018)*, with low-end values aligned with *Kalra et al. (2022)*[22]. These estimates reflect uncertainty around the availability and cost of sustainable biomass feedstock. Lower estimates assume optimistic technological progress and feedstock availability, while higher costs may reflect supply constraints and competing uses for biomass (e.g., BECCS, forest management). The cost of ERW is derived from *Kalra et al. (2022)*, who assume technological advancements by 2040 that reduce the costs of mineral sourcing, grinding, and land application. In the simulator, all values were converted from EUR to USD using a conversion factor of 0.85, in line with the exchange rate applied in *Fuss et al. (2018)*.[23]

[18] Roe, S., et al., 2021, 'Land-based measures to mitigate climate change: Potential and feasibility by country', *Global Change Biology* 27(23), pp. 6025-6058 (DOI: 10.1111/gcb.15873).
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Appendix 3: ETS+CDR simulator

Scenarios

For "CDR Options", there are three options for integrating: "No CDR", "Net cap", and "Gross cap". In the "Net cap" scenario, each ton of CDR counts as an additional EUA, allowing emissions to increase compared to the no-CDR scenario. In the gross cap scenario, for each ton of CDR entering the system, one auctioned allowance is withdrawn, keeping gross emissions the same as in the no-CDR option.

For the "CDR Methods", under the "BioCCS & DACCS" CDR method option, credits generated from CCS on biogas upgrading, BECCS, and DACCS are available. In the "+ BCR" option, biochar carbon removal is added to the available methods alongside BioCCS and DACCS. CDR credits from enhanced rock weathering also become eligible in the "+ BCR + ERW" option.

The simulator also enables choice of "Integration Method". In the "Price-based" integration method, the full potential of the cheapest option is utilised first, with maximum technical potential values as the upper limit which can be integrated. This approach reflects the assumption that sufficiently high carbon prices can unlock full deployment, unconstrained by political, infrastructural, or economic barriers.

In contrast, under the "Quantity limits" approach, the amount of CDR entering the is capped at more conservative 'central' estimates of their potential. In both approaches "Price-based" and "Quantity limits" – only the volume of CDR that is more cost-effective than further emission reductions is integrated into the system. However, in the "CCfD scenario", the central estimate of all available CDR is integrated, regardless of whether it is cheaper than emission reductions, due to CCfDs making up the difference in cost.

Method: Matching ETS supply-demand with entry of CDR credits

The underlying ETS simulator shows a projection of the emissions from industry, power, aviation, and shipping and how the number of available allowances change in response to this. Depending on the selected scenario, CDR credits enter the system.

In **Net cap** scenarios, CDR is treated as additional allowances and is added to both free and auctioned allowances. This effectively increases the total number of allowances available, allowing emissions to rise concurrently. Since the carbon price in 2040 depends on total emissions, equilibrium emissions were calculated such that all CDR options cheaper than the price corresponding to those emissions are included in the system. Under a net cap we find the equilibrium carbon price between CDR integration and total emissions. In this scenario, the integration of CDR leads to an equivalent increase in emissions from ETS installations, reflecting the assumption that CDR creates room for additional emissions elsewhere in the system. To allocate these additional emissions across sectors, the following logic is applied: CDR is assumed to displace CCS deployment, then if there is a surplus of CDR beyond this, the corresponding increase in emissions is attributed to the power sector. The additional emissions, based on total CDR potential from 2031 to 2040, are distributed linearly over the period with a factor of 2. While not matching annual CDR potential, this approach avoids unrealistic year-to-year fluctuations. As a result, surplus EUA differs between the 'No CDR' and 'Net Cap' scenarios, though cumulative emissions is equal. This assumes that additional CDR enables more fossil-based electricity generation, which is the most flexible emitter in the system.

In the **Gross cap** scenarios, each ton of CO_2 removed through CDR replaces one auctioned allowance. As a result, total emissions remain constant and the maximum amount of CDR that can enter the system is limited to the number of auctioned allowances. The cheapest CDR options are prioritised, and only those with costs below the carbon price corresponding to the 2040 emissions level are included. The only scenario, in which CDR credits which are more expensive than the carbon price can still enter the system is the CCfD scenario integration method. In this scenario, the central estimate of each CDR method is deployed regardless of its cost relative to EUAs.

Simulator readouts

Emissions reduction compared to 2005

The emissions reductions achieved as a percentage of emissions compared to 2005. Note, carbon removals are not included in this figure. This allows a clear assessment of the extent to which emissions are reduced at source, rather than compensated for with CDR. It provides a consistent benchmark to compare the ambition level of emission reductions across scenarios.

Surplus EUA and CDR credits remaining in 2040

This indicator expresses the combined volume of unused EU Allowances (EUAs) and CDR credits remaining in the market by the end of 2040. A surplus may reflect overallocation or underutilisation of available credits, which can have implications for future market functioning, price stability, and investment incentives. This metric is a key signal of whether the market is in balance or oversupplied, which can influence the carbon price trajectory beyond 2040.

Carbon price in 2040

This is the simulated carbon price in 2040, derived from the marginal abatement cost (MAC) curve based on emissions levels and the cost of removals in that scenario. In our modelling, perfect foresight is assumed, meaning the market participants are assumed to optimise based on full knowledge of future prices and constraints. As a result, the 2040 carbon price is used consistently throughout the simulation period (2031–2040) to reflect this long-term price signal.

Deterred emissions abatement

This metric estimates the amount of emissions reductions that would have occurred between 2031 and 2040 in the absence of CDR integration, but are instead displaced due to the use of CDR credits. In other words, it reflects how much direct emissions abatement is forgone because market actors choose to meet compliance obligations using CDR credits rather than reducing emissions.

Biomass use

The estimated demand for biomass comes from estimates for biomass use from BioCCS and BCR, using the following assumptions:

BioCCS: Ecologic estimate that, for BECCS to remove 34 Mt CO_2 in 2040, the biomass input required is around 0.4 EJ.[24] Based on this, we then estimate 0.0117 EJ/MtCO_2 removed

BCR: Life cycle assessments indicate that 1 tonne of biochar (produced from lignocellulosic biomass) can remove approximately 2.68 tCO_2.[25] Assuming a 30% biochar yield from biomass,[26] and 18 MJ/kg dry biomass[27], we calculate an estimated 0.0224 EJ/MtCO_2 removed.

CCfD Cost Estimate.

The Carbon Contracts for Difference (CCfD) cost is defined as the cumulative subsidy required to bridge the gap between the carbon price and the cost of CDR technologies. It is calculated as the difference between the technology-specific cost and the carbon price, multiplied by the amount of CDR used each year, and summed across all CDR deployment between 2031 and 2040.

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[24] Ecologic, 2025, Industrial Removals Resource Use.

[25] Fawzy, S., Osman, A. I., Mehta, N., Moran, D., Al-Muhtaseb, A. H., & Rooney, D. W., 2022, "Atmospheric carbon removal via industrial biochar systems: A techno-economic-environmental study," Journal of Cleaner Production 371, Article 133660..

[26] IEA cite biochar yields of 25–35%, depending on biomass type and pyrolysis technology (IEA Bioenergy Task 34).

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sandbag

smarter climate policy